Forum Agenda

- Land Use Modeling
- Active Transportation Modeling
- Dynamic Traffic Assignment
Proposed Model Structure

Transportation Policy

Special Models
CTM

Enhanced ABM

Transportation System

Land Use Model

Active Transportation

Bike & Ped. Route Choice

Traffic Assignment

Transit Assignment

Regional Transportation Plan (RTP)

System Performance

Economic Analysis

Environmental Impact

Transportation System

1

2

3
Land Use Modeling

Daniel Flyte
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Background

- Provides a representation of future development, socioeconomic conditions in an urban setting
- Essential to numerous planning activities
  - Housing, jobs, transportation, education, utilities, emergency response services, public finance, policy analysis, etc.
- ‘Land-use’ modeling an obsolete term
  - Supplanted by ‘socioeconomic modeling’
Historical Context

‘Integrated’ land-use/transportation models conceived in the 1960s

– Growing recognition of land use-transportation interaction

– Amid backdrop of advances in regional science, location theory, and spatial economics (Isard, Lösch, Ponsard)

– Lowry gravity model (1964)
  • Spatial interaction based on mass, friction of distance
  • Identified basic, non-basic, household sectors
  • Employment drives residential location choice
Historical Context

- Evolved from aggregate, zonal models to disaggregate microsimulation
  - ITLUP: DRAM/EMPAL (Putnam, 1983)
  - MEPLAN (Echenique, 1985)
  - TRANUS (de la Barra, 1989)
  - MUSSA (Martínez, 1992)
  - UrbanSim, PECAS (2000s)

- Shaped by advances in computing capability, economic theory, and GIS
  - Economic input-output models (Leontieff)
  - ‘New Economic Geography’, agglomeration economies (Krugman, Fujita)
  - Discrete choice theory (McFadden, Train)
Land Use Model Evolution

- 1960: Lowry: Gravity Model
- 1970: Spatial Interaction Models (DRAM/EMPAL, HLFM II+)
  - Spatial Input-Output Models (MEPLAN, TRANUS)
  - McFadden: Discrete-Choice Models
- 1990: Aggregate Equilibrium Discrete Choice (METROsim, MUSSA)
  - Aggregate Dynamic Discrete Choice (HUDS)
- 2000: Microsimulation Dynamic Discrete Choice (UrbanSim)
  - Spatially Detailed Rule-based Planning Tools
  - Geographic Information Systems
- 2010: PECAS

Institute for Transportation Studies, University of California, Los Angeles.

Regional Planning and Urban Analysis Group, SANDAG.
MPO Land Use Models

Source: FAMPO, 2009
Forecasting Process

- Land-use modeling begins with a regionwide socioeconomic forecast
  - Provides control totals for subregional allocation
  - Detailed demographic and economic characteristics based on trends in fertility, life expectancy, migration, and economic growth rates
    - Population
    - Employment
    - Housing
    - Economic output by industry sector
  - Most MPOs purchase a forecast (REMI, Global Insight) or are provided one by a state agency (e.g., DOT, DOF)
    - SANDAG has produced its own since early 1970s
Forecasting Process

Regionwide Forecast (DEFM)
- Historical data
- Current demographics
- National forecast
- Demographic trends
- Expert review

Subregional Forecast (PECAS)

Detailed Demographic Forecast (PASEF and PopSyn)
- skims, logsums

Transportation Model (ABM)
- population, employment, commodity flows

- Current housing, jobs, population, and sq. ft.
- Local land use plans, policies, zoning
- Market conditions
- Local review
Demographic and Economic Forecasting Model (DEFM)

- Simultaneous nonlinear econometric model
  - Set of equations that produces over 700 demographic and economic variables

- Cohort-component population forecast (eight race/ethnic cohorts, single year of age)
  - fertility rates
  - life expectancies
  - migration rates
  - headship rates

- Driven by national forecast, historical time-series data
  - Estimated by regression analysis, ARMA models

- Assumptions, results validated by expert review panel

- Proven to be highly accurate
Subregional Forecast

- SANDAG’s subregional forecasts produced using Urban Development Model (UDM) prior to Series 13
  - Derivation of DRAM/EMPAL
  - Parcel-level allocation of
    - housing by structure type
    - employment
  - MGRA-level detailed socioeconomic variables
    - Population by age, sex, race/ethnicity
    - Households, household population, GQ population
    - Household income
  - Data easily available: general plans, parcel land use, capacity
  - Solid accounting system to allocate growth, but did not consider land economics (rents)
    - Poor at modeling redevelopment, gentrification, intensification
PECAS

- **Production, Exchange, and Consumption Allocation System** (Hunt & Abraham)
- Motivated by increased shortage of developable land
- **Spatial input-output model with parcel-based microsimulation of development activity**
  - Activity Allocation (AA) module
  - Space Development (SD) module
- **Simulates markets for all goods, services, labor, and real estate in the economy**
  - Exchanges between producers and consumers and the goods exchanged (commodities) through input-output model
  - Dynamic computable general equilibrium (CGE) solution
  - Results in commodity flows between zones in the region
Production, Exchange, Consumption Interactions

For each economic actor:

buying allocation process

selling allocation process

total consumption

exchange zone

total production

exchange zone

total production

exchange zone

total production
PECAS Choice Models

- Built upon random utility discrete choice theory to predict production, consumption, and location choices
  - Multinomial nested logit (MNL) formulation
- Provides
  - Theoretical foundation for all economic activity in the region
  - Linkage between production and consumption of goods: commodity flows
  - Simulated real estate markets
  - Land economics: hedonic rent model
  - Social equity measures, consumer welfare
PECAS Nested Logit Structure

production allocation

technology choice selection

selling allocations

buying allocations
AA Choice Models

• PECAS spatially disaggregates economic activity, linking exchanges through transportation network
  • Requires I-O model, existing land use, rents, and employment
    – Explicitly treats cost of transporting commodities from producer to consumer, specifying who bears the cost
      • Incorporates vehicle operating costs and value of time measures
    – Applies these costs into the buying, selling, and location utility functions for each decision maker
**Economic Input-Output Model**

**TABLE 2-1**  
Hypothetical Transactions Table  
*Industry Purchasing*

<table>
<thead>
<tr>
<th>Processing Sector</th>
<th>Final Demand</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>(1) A</td>
<td>(2) B</td>
<td>(3) C</td>
<td>(4) D</td>
<td>(5) E</td>
<td>(6) F</td>
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<tr>
<td>Industry A</td>
<td>10</td>
<td>15</td>
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<td>2</td>
<td>5</td>
<td>6</td>
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<td>4</td>
<td>7</td>
<td>1</td>
<td>3</td>
<td>8</td>
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<td>7</td>
<td>2</td>
<td>8</td>
<td>1</td>
<td>5</td>
<td>3</td>
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<tr>
<td>Industry D</td>
<td>11</td>
<td>1</td>
<td>2</td>
<td>8</td>
<td>6</td>
<td>4</td>
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<tr>
<td>Industry E</td>
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<td>0</td>
<td>1</td>
<td>14</td>
<td>3</td>
<td>2</td>
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<tr>
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<td>6</td>
<td>7</td>
<td>6</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>(7) Gross inventory accumulation (+)</td>
<td>(8) Exports to foreign countries</td>
<td>(9) Government purchases</td>
<td>(10) Gross private capital formation</td>
<td>(11) Households</td>
<td>Total Gross Output</td>
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<td>Industry A</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>3</td>
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<td>64</td>
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<td>3</td>
<td>1</td>
<td>3</td>
<td>5</td>
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<td>2</td>
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<td>39</td>
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<td>3</td>
<td>9</td>
<td>40</td>
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<tr>
<td>Industry F</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>8</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>(7) Gross inventory depletion (−)</td>
<td>(8) Imports</td>
<td>(9) Payments to government</td>
<td>(10) Depreciation allowances</td>
<td>(11) Households</td>
<td>Total Gross Outlays</td>
</tr>
<tr>
<td>Industry A</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Industry B</td>
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<td>1</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Industry C</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Industry D</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Industry E</td>
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<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Industry F</td>
<td>19</td>
<td>23</td>
<td>7</td>
<td>5</td>
<td>9</td>
<td>12</td>
</tr>
</tbody>
</table>

1Sales to industries and sectors along the top of the table from the industry listed in each row at the left of the table.  
2Purchases from industries and sectors at the left of the table by the industry listed at the top of each column.
PECAS Structure

- Region-wide aggregate demographic & economic conditions
- Economic and demographic changes
- Region-wide aggregate demographic & economic conditions

Space Development

Activity Allocation

Transportation Model

Changes in transportation conditions

Activity allocation

Transportation Model

Year t

Year t + 1
Space Development

- SD choice module simulates developer actions on each parcel in response to AA modeled rents, ROI calculations
  - No change (most common)
  - Addition
  - Renovation
  - New construction
    - Type of space
      - Quantity
    - Demolition or derelict

- Developers tend to optimize their ROI in light of all development costs, constraints

- Changes in floor space fed back to AA, influencing location choices, rents
  - Developers do not have perfect information: they historically overbuild, under-build, causing construction cycle
Data Requirements

- SD (like UrbanSim) has extensive data requirements:
  - Existing floor space, buildings inventory
  - Historic rents, vacancy rates
  - Pipeline projects (‘site-spec’)
  - General plans, densities
  - Comprehensive zoning permissions
  - Construction costs
  - Maintenance costs
  - Permit/entitlement fees
  - Availability of services (water, sewage, electrical)
  - Time-series building permit data
Model Estimation

- SD estimated with iterative Bayesian estimation routine
  - Transition coefficients
- Predicts ROI using hedonic rent model
  - Distance to coast
  - Distance to park
  - Distance to onramp
  - ¼ mile density
  - Distance to transit
  - Distance to school
Detailed Socioeconomic Characteristics

- PECAS provides subregional totals of households, labor, floor space
- Disaggregated to provide MGRA-level population, housing units, HH by structure type, HH income, etc.
- SANDAG’s Population, Age, Sex, Ethnicity Forecast generates detailed population forecast
  - Subregional shift-share analysis
Future Developments

- Currently improving integration between PECAS, ABM
- Major effort underway to modernize and enhance DEFM
  - Make it better informed of capacity constraints
  - Bidirectional feedback to PECAS
- Scoping enhanced population synthesizer to be more consistent with PECAS, offer household evolution
Active Transportation Modeling

Wu Sun
Background

- Regional Bicycle Plan
- ABM & Non-Motorized (NM) Travel
- Active Transportation (AT) Model
- Project Team
Project Goal

- Develop an AT Model (Phase I)
  - Bicycle and pedestrian route choices
  - Sensitive to bicycle facility type & applicable at project level
  - Integrated with ABM

- Enhance ABM Mode Choices
  - NM impedance
  - Transit access/egress
  - Bicycle logsum in mode choices
Scope of Work & Schedule

- **Oct 2013**: Build Supply Representation
- **Nov 2013**: Develop Software
- **Nov 2013**: Develop Bicycle Count Dataset
- **Dec 2013**: Revise and Recalibrate Mode Choice Models
- **Dec 2013**: Calibrate Bicycle Route Choice Model
- **Jan 2014**: Perform Sensitivity Tests
- **Jan 2014**: Prepare Documentation
## Existing Bikeways

<table>
<thead>
<tr>
<th>Facility Type</th>
<th>Miles</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I: Off-Street Path</td>
<td>159.3</td>
<td>11.9%</td>
</tr>
<tr>
<td>Class II: On-Street Lane</td>
<td>890.2</td>
<td>66.4%</td>
</tr>
<tr>
<td>Class III: On-Street Signed Route</td>
<td>243.9</td>
<td>18.2%</td>
</tr>
<tr>
<td>Freeway Shoulders</td>
<td>47.4</td>
<td>3.5%</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td><strong>1,340.8</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>
Integrated ABM & AT Model

- Trans. Policy
- Trans. System
- LU Models
- Enhanced ABM
- Improved NM Impedance
- Improved Mode Choices
- Traffic Assignment
- Bicycle & Ped Route Choices
- Special Models
- CTM
- Environmental Impact
- System Performance
- Economic Analysis

AT Model
Non-Motorized Impedance

Improved walk access path to TAP
Current walk access path to TAP
Bicycle Network

- SANGIS all street network
- bicycle routes
- Off street path
- On street lane
- On street signed route
- All street link
<table>
<thead>
<tr>
<th>Variable</th>
<th>Coef.</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance, total (mi.)</td>
<td>−0.858</td>
<td>Monterey</td>
</tr>
<tr>
<td>Distance on class I bicycle paths</td>
<td>0.610</td>
<td>Portland</td>
</tr>
<tr>
<td>Distance on class II bicycle lanes</td>
<td>0.314</td>
<td>Monterey</td>
</tr>
<tr>
<td>Distance on class III bicycle routes</td>
<td>0.085</td>
<td>Monterey</td>
</tr>
<tr>
<td>Distance on arterials without bicycle lanes</td>
<td>−1.050</td>
<td>Monterey</td>
</tr>
<tr>
<td>Distance on “cycle track” class II bicycle lanes</td>
<td>0.120</td>
<td>None</td>
</tr>
<tr>
<td>Distance on “boulevard” class III bicycle routes</td>
<td>0.430</td>
<td>Portland</td>
</tr>
<tr>
<td>Distance wrong way</td>
<td>−3.445</td>
<td>San Francisco</td>
</tr>
<tr>
<td>Cumulative gain in elevation, ignoring declines (ft.)</td>
<td>−0.010</td>
<td>San Francisco</td>
</tr>
<tr>
<td>Turns, total</td>
<td>−0.083</td>
<td>Portland</td>
</tr>
<tr>
<td>Traffic signals, excluding right turns and through T junctions</td>
<td>−0.040</td>
<td>Portland</td>
</tr>
<tr>
<td>Un-signalized left turns from principal arterial</td>
<td>−0.360</td>
<td>Portland</td>
</tr>
<tr>
<td>Un-signalized left turns from minor arterial</td>
<td>−0.150</td>
<td>Portland</td>
</tr>
<tr>
<td>Un-signalized crossings of / left turns onto principal arterial</td>
<td>−0.480</td>
<td>Portland</td>
</tr>
<tr>
<td>Un-signalized crossings of / left turns onto minor arterial</td>
<td>−0.100</td>
<td>Portland</td>
</tr>
<tr>
<td>Access of interstate, freeway, or expressway</td>
<td>−999.999</td>
<td>Constrained</td>
</tr>
<tr>
<td>Log of path size</td>
<td>1.000</td>
<td>Constrained</td>
</tr>
</tbody>
</table>
Count Locations

Region (78 Count Locations)
Bicycle Accessibility Map

Accessibility calculated as bicycle path choice logsum

Legend
logsum3959
TAZ13
-126.3493 - -125.0862
-122.5601 - -121.2971
-111.1927 - -109.9296
-101.0883 - -99.8252
-90.9839 - -89.7208
-80.8795 - -79.6164
-70.7751 - -69.5120
-60.6707 - -59.4076
-50.5663 - -49.3032
-40.4619 - -39.1988
-30.3575 - -29.0944
-20.2531 - -18.9900
-10.1487 - -8.8856
-1.3073 - 0.0443
Sensitivity Tests

- **Goals:**
  - Sensitivity to bicycle facility types and network attributes
  - Sensitivity to project scales
  - Impact of bicycle ridership
  - Diversion of riders

- **Two sensitivity tests in SOW**
  - Uptown/North Park projects (20 miles)
  - One more to be identified
Potential Applications

- Evaluate impact of bicycle projects on regional VMT and air quality
- Evaluate impact of bicycle projects on physical activity and public health
- Compare and rank infrastructure for bicycles and pedestrians
Next Steps

- San Diego bicycle route choice survey
- Re-estimate bicycle route choice model
- Re-calibrate ABM mode choice model
- Improve network attributes
- Improve sensitivity to socio-demographic characteristics
Questions?

- For AT model related questions contact: Wu.Sun@sandag.org
- For AT planning related questions contact: Christine.Eary@sandag.org
Dynamic Traffic Assignment

Rick Curry
Project Goal

- Develop Region-Wide Dynamic Traffic Assignment (DTA) Model
- Integrate DTA Model with the SANDAG Activity-Based Model (ABM)
- Desired Outcome:
  - Better measure the effects of travel time and reliability improvements
Proposed Model Structure

Transportation Policy

Enhanced ABM

Transit Assignment

Traffic Assignment

Special Models

CTM

Transportation System

Land Use Model

Active Transportation

Bike & Ped. Route Choice

Transportation System

Environmental Impact

System Performance

Economic Analysis

Regional Transportation Plan (RTP)
Assignment Hierarchy

- **Macroscopic**
  - Static User Equilibrium used in 4-step and ABM

- **Mesoscopic**
  - Time-dependent user equilibrium with realistic, but simplified vehicle simulation

- **Microscopic**
  - Realistic simulation of driver behavior and interactions
Current Assignment Method

- Static User Equilibrium Traffic Assignment
- Demand Based
  - Volume can exceed capacity
  - No queuing
- Simple Network Representation
- Time of Day
  - ABM: 5 Periods
- Instantaneous Average Travel Times
Dynamic “Traffic” Assignment

- Highway traffic is the focus of DTA
- Transit vehicles simulated, but transit demand not modeled

Experienced Travel Times

- Time dependent shortest paths (TDSP)

Dynamic User Equilibrium (DUE)

- “Equilibrium condition established for each departure time rather than over the entire analysis period.” – DTA Primer
DTA Traffic Simulation

- Simulation-Based Network Loading
- Network Details
  - Additional details for controls
    - Signal phases, green times, synchronization
    - Approach lane information
- Mixture of Properties from Macro and Micro
  - Simplified or no intervehicle interactions
  - Does allow for queuing
Mesoscopic Traffic Simulation

- Capacity respected
  - Calibrate to volumes and speed
## Time-Dependent Effects

### Travel Time

<table>
<thead>
<tr>
<th>Time</th>
<th>Segment 1-2</th>
<th>Segment 2-3</th>
<th>Segment 3-4</th>
<th>Travel Time</th>
</tr>
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<tbody>
<tr>
<td>7:10</td>
<td>11</td>
<td>19</td>
<td>10</td>
<td>40</td>
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<tr>
<td>7:20</td>
<td>22</td>
<td>25</td>
<td>15</td>
<td>62</td>
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<td>7:30</td>
<td>30</td>
<td>40</td>
<td>17</td>
<td>87</td>
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<td>7:40</td>
<td>27</td>
<td>37</td>
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<td>7:50</td>
<td>20</td>
<td>35</td>
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<tr>
<td>Average</td>
<td>22</td>
<td>31</td>
<td>17</td>
<td>70</td>
</tr>
</tbody>
</table>

- **Instantaneous:** 40 Minutes
- **Average:** 70 Minutes
- **Time-Dependent:** 55 Minutes
**DTA / Mesoscopic Benefits**

- **System Management Strategies**
  - Traffic signal synchronization
  - Variable speed limits
  - Ramp metering
  - Traveler information systems

- Intelligent vehicles
- Transit
  - Signal preemption
  - Transit-only lanes
  - Schedule adherence
DTA / Mesoscopic Benefits

- Dynamic Tolling
- ABM Temporal Integration
  - Choice models
- Congestion Duration
- Travel Time Reliability
- Refined Speeds for Air Quality Analysis
- Launching Point for New ICM Corridors
Network Travel Speed

I-5 NB @ Del Mar Heights (November, 2013)
DTA Challenges

- Few Regional 24-HR DTA Applications
- DTA – ABM Integration Leading Edge Innovation
- More Effort Required
  - Network Maintenance
  - Data
  - Calibration
  - Validation
  - RUNTIME
DTA Model Data

- **Traffic Control Data**
  - 75% of signal data available
  - Control settings for fixed or actuated signals
  - Actuated max / min setting from approach flow proportions

- **Network**
  - Modifications
    - HOV access
    - Centroid connectors
    - Eliminate short links
Demand Data

- Multi-user class time-dependent trip lists
  - Person including:
    - Visitor
    - Airport
    - Cross Border
  - Commercial/Truck
- Individual vehicles value-of-time
DTA Model Calibration/Validation

- **Traffic Control Settings**
  - 75% of signal data available
  - Identify failing intersections due to traffic imbalances

- **Network**
  - Identify artificial bottlenecks and resolve
DTA Model Calibration/Validation (cont.)

- **Traffic Flow Model Calibration**
  - Parameter adjustment by facility type
  - Individual link adjustments for local conditions

- **Validation Data**
  - Time-dependent traffic counts
    - ADT insufficient
  - Time-dependent travel times/speeds
    - INRIX speed data
Tasks Continued

1. Kickoff and Requirements (Complete)
2. DTA Software Assessment (Complete)
3. Model Development Plan
4. Network Development
   – New network attributes
5. Validation Data Development
   – Assemble data from sources
   – 15 minute counts, vehicle speeds, location and length of queues
6. **Initial DTA Model**
   - Assignment of existing ABM demand without integration
   - Gradually increase complexity of DTA settings
   - Find and fix network errors, path-finding parameters
   - Gauge runtime requirements

7. **Performance Metrics**
   - Model validation
   - Policy evaluation
Tasks Continued

7. Full ABM\DTA Integration
   – Computational complexity\runtime
   – Managing risk
     • Recognize that region-wide DTA projects and ABM\DTA projects are in their infancy

8. Sensitivity Tests\Additional Calibration
   – Toll road & managed lane
   – Severe capacity constraints

10. Training and Outreach
Consultants and Software

- DTA Prime Consultant - PB
- Software - Aimsun
  - TSS - http://www.aimsun.com/wp/
  - Coordination with existing ICM work including:
    - already developed procedures
    - existing license
    - staff knowledge
  - Comprehensive policy analysis
  - Good user interface
  - Good reporting metrics
  - MRM (Multi-resolution model)
DTA Resources

- Transportation Research Circular: Dynamic Traffic Assignment, A Primer
  - June 2011
  - Number E-C153

- Traffic Analysis Toolbox Volume XIV: Guidebook on the Utilization of Dynamic Traffic Assignment in Modeling
  - Nov 2012
  - Publication No. FHWA-HOP-13-015
Open Discussion
Forum Agenda Recap

- Land Use Modeling
- Active Transportation Modeling
- Dynamic Traffic Assignment

Next Transportation Modeling Forum:
June 11, 2014