TRANSIMS DEPLOYMENT
CASE STUDY:

SACOG DaySim-TRANSIMS
Integrated Model Development

TRANSIMS: Applications & Development Workshop
April 8 - 9, 2010

Resource Systems Group
Mark Bradley Research & Consulting
John Bowman Research & Consulting
SACOG staff
FHWA
Project Team

- Brian Gardner & Supin Yoder - FHWA
- Gordon Garry & Bruce Griesenbeck - SACOG
- Resource System Group (RSG)
  - TRANSIMS implementation experience
    - Burlington, VT & Jacksonville, FL (in-progress)
- John Bowman & Mark Bradley
  - Developers of activity-based demand model (DaySim)
  - Implemented in Sacramento, Seattle, Denver, San Francisco, Portland
Project Objectives

1. Advance the current state of the practice by integrating an existing activity-based model with a dynamic traffic assignment model
   ▪ DaySim - provides enhanced demand sensitivities
   ▪ TRANSIMS - provides enhanced supply sensitivities

2. Test integration strategies and effects on calibration & forecasting
   ▪ How should convergence criteria be calculated and implemented
   ▪ What is the impact on calibration

3. Demonstrate advanced capabilities and policy sensitivities of the integrated model system
   ▪ Evaluate alternative Watt Avenue Bridge configurations
   ▪ Compare to SACOG’s SACSIM model sensitivities
Component Overview

- **DaySim**
  - Simulates detailed itinerary for each person in the region
  - Spatial detail: Parcel-level (781,907 in SACOG)
  - Temporal detail: Half hour simulation allocated to minute-level within the selected half hour

- **TRANSIMS - Router Only**
  - Network built off existing SACOG CUBE network (collector & up)
    - To maintain some SacSim consistency for testing
    - Network details synthetically generated and checked
  - Spatial detail: 22,050 activity locations in SACOG
  - Temporal detail: Path assignment routes DaySim minute-level activity list using second-by-second network travel times
SacSim versus Integrated Model

Spatial detail:
Parcel info aggregated to zones

Temporal detail:
Assign/skim aggregated demand at four broad time periods (AM, MD, PM, EV)

Spatial detail:
Parcel info aggregated to activity locations

Temporal detail:
Assign minute-level demand at 15-min increment
Skims developed for varied time periods (4-periods, 22-periods)
Project Status – Completed:

- Built and debugged regional TRANSIMS network to support both TRANSIMS Router and Microsimulator
- Integrated DaySim and TRANSIMS by configuring file structures for each environment and controlling model flow with a Python program
- Validated integrated model which included calibration tests at the daily and hourly level
- Tested convergence criteria at both the assignment and system level
- Performed policy test with the integrated model (Watt Ave Bridge - Before & After)
## DaySim Input & Output Data Files

### INPUT DATA FILES

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Representative Population</td>
<td>Parcel/Point Data</td>
</tr>
<tr>
<td></td>
<td>External Trips by Purpose</td>
</tr>
<tr>
<td></td>
<td>LOS Skim Matrices, by Period and Mode (from prior loop)</td>
</tr>
</tbody>
</table>

### OUTPUT FILES

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PERSON FILE</td>
<td>TOUR FILE</td>
<td>TRIP FILE</td>
</tr>
<tr>
<td>(one record per person-day)</td>
<td>(one record per person-tour)</td>
<td>(one record per person-trip)</td>
</tr>
</tbody>
</table>

- Synthetic/Representative population created by DaySim
  - Population could be synthesized using other population generators
    - TRANSIMS PopGen, ASU PopGen, others
  - Auxiliary trips not modeled in DaySim - special generators, externals, commercial vehicles, etc.
  - Output in the same general form as household travel diary data
Critical Model Linkages

- Two key linkages in the model flow:
  1) DaySim to TRANSIMS integration
     - Pass activity list to Router
  2) TRANSIMS to DaySim integration
     - Pass zonal travel time skims to DaySim
DaySim Trip List – TRANSIMS Activity File

DaySim Trip List Output Example

<table>
<thead>
<tr>
<th>SAMPN</th>
<th>PERSN</th>
<th>TOURNO</th>
<th>TOURHALF</th>
<th>TRIPNO</th>
<th>OTAZ</th>
<th>OCEL</th>
<th>DTAZ</th>
<th>DCEL</th>
<th>OPURP</th>
<th>DPURP</th>
<th>DEPTIME</th>
<th>ARRTIME</th>
<th>EACCTIM</th>
<th>TRAVTIM</th>
<th>TRAVDIST</th>
<th>EXPFACT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>445</td>
<td>429711</td>
<td>1088</td>
<td>133524</td>
<td>8</td>
<td>4</td>
<td>1222</td>
<td>1238</td>
<td>1556</td>
<td>16.09</td>
<td>8.56</td>
<td>1.00</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1088</td>
<td>133524</td>
<td>445</td>
<td>429711</td>
<td>4</td>
<td>8</td>
<td>1556</td>
<td>1615</td>
<td>2659</td>
<td>18.65</td>
<td>8.56</td>
<td>1.00</td>
</tr>
</tbody>
</table>

TRANSIMS Activity File Input Example

<table>
<thead>
<tr>
<th>HHOLD</th>
<th>PERSON</th>
<th>ACTIVITY</th>
<th>PURPOSE</th>
<th>PRIOTITY</th>
<th>START</th>
<th>END</th>
<th>DURATION</th>
<th>MODE</th>
<th>VEHICLE</th>
<th>LOCATION</th>
<th>PASSENGER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>111110</td>
<td>0</td>
<td>9</td>
<td>1</td>
<td>44520</td>
<td>44519</td>
<td>1</td>
<td>0</td>
<td>5937</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>111111</td>
<td>4</td>
<td>9</td>
<td>45480</td>
<td>57360</td>
<td>11880</td>
<td>2</td>
<td>1</td>
<td>13688</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>11121</td>
<td>0</td>
<td>9</td>
<td>58500</td>
<td>97140</td>
<td>38640</td>
<td>2</td>
<td>1</td>
<td>5937</td>
<td>0</td>
</tr>
</tbody>
</table>

- Modified DaySim code to generate vehicle and activity files
- Added a new record for each person within each household to represent the “start travel day at home” activity
  - Highlighted Record
  - Start time set to 0, end time set to 1 minute prior to first trip start time
TRANSIMS to DaySim Integration

- TRANSIMS provide estimates of network travel times (skims) to DaySim

- 3 Stage Implementation
  - Stage 1:
    - TAZ-level information
    - 4 broad time periods - AM (3hrs), MD (5hrs), PM (3hrs), EV (13hrs)
  - Stage 2:
    - TAZ-level information
    - 22 time periods - additional temporal detail (more slices)
  - Stage 3:
    - Activity location-level
    - Up to 48 time periods or specific departure times
Stage 1 & 2 Skim Development

- Computational / technical challenges associated with building skims by activity-level and detailed time period
- TRANSIMS is already configured to produce skims analogous to those produced by current static assignment based method
- Use of “dummy” activity locations to represent TAZs
  - To accommodate skimming to 1,500 locations instead of 22,000 locations
- Much spatial and temporal detail embedded in TRANSIMS link delay files is discarded in Stage 1 & 2
  - Implications for model sensitivity
  - To be addressed in Stage 3
TRANSIMS to DaySim Integration

Final Link Delays

CPU #1  CPU #2  CPU #3  CPU #4

(Zone range)  (1 – 400)  (400 – 800)  (800 – 1200)  (1200 – 1533)

Route SOV  Route SOV  Route SOV  Route SOV

PlanSum (AM)  PlanSum (MD)  PlanSum (PM)  PlanSum (EV)

SOV AM Skim  SOV MD Skim  SOV PM Skim  SOV EV Skim

7am-10am  10am-3pm  3pm-6pm  6pm-7am
Stage 2 Skims – Intermediate Temporal Detail

- 30-min skims in AM and PM peak periods
- Hourly skims in midday and AM, PM shoulder periods
- A single 8-hr evening period skim
Stage 3 Skim Development

- Increased spatial resolution (activity-level)
- Increased temporal resolution (15- /30-minute-level)
- Provide enhanced sensitivities
  - Level of service
  - Time-of-day
- Challenges
  - Developing method of retrieving specific skims “on the fly” due to computation, memory, storage issues
  - Sampling
  - Flexibility to accommodate multiple spatial and temporal resolutions simultaneously
### Stage 3 Skim Development

#### Issue: Vast number of skim values causes storage and computation problem

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>modes (SOV, HOV2, HOV3+)</td>
<td>3</td>
</tr>
<tr>
<td>attributes (distance, cost, time, congested time)</td>
<td>4</td>
</tr>
<tr>
<td>toll/VOT classes (1 non-toll class, 3 VOT toll classes)</td>
<td>1 to 5</td>
</tr>
<tr>
<td>time periods</td>
<td>15 to 30</td>
</tr>
<tr>
<td>origin activity locations</td>
<td>20,000</td>
</tr>
<tr>
<td>destination activity locations</td>
<td>20,000</td>
</tr>
<tr>
<td>Total number of skim values</td>
<td>72 billion values</td>
</tr>
</tbody>
</table>
Model Implementation

- Model implementation effort focused on three principal elements:
  - TRANSIMS network preparation
    - Developing a detailed network for SACOG
  - Auxiliary demand conversion
    - Converting travel demand not represented by DaySim
  - Development of Router Stabilization process
    - Configuring an iterative router-assignment approach
TRANSIMS Network Preparation

- Derived from SacSim 2005 base year CUBE highway network

- Network preparation tools used to build network files
  - GISNet
  - TransimsNet
  - ArcNet

- Limited debugging to errors encountered during calibration/validation

- Additional network checking likely required for reasonable microsimulation
To fully integrate DaySim and TRANSIMS, an equivalency between the SACOG parcels and the TRANSIMS Activity Locations must be created.

Automated GIS procedure which assigns each parcel in the 6-county SACOG region to an Activity Location in the TRANSIMS network.

Procedure generates a list of all parcels in the 6-county region tagged with an Activity Location ID.

Activity location IDs replace parcel IDs as the origins & destinations in the DaySim output activity list.
Router Stabilization Process

- Microsimulator was not applied as part of this research (DaySim-TRANSIMS Router integration only)

- New Router Stabilization which achieves network convergence and approximates a user equilibrium condition was therefore required

- Enhanced Router Stabilization process:
  - Re-route *all* travelers during each router-assignment iteration instead of only a subset
  - Apply a successive averaging of link delays
  - 25 router-assignment iterations are performed
Router Stabilization Process

Initial routing:
- Router
  - Route activity list
- Router
  - Route auxiliary demand
- PlanPrep
  - Merge activity and auxiliary plans
- PlanSum
  - Calculate initial link delays

Iterative routing:
- Router
  - Route all travelers again with updated delays
- PlanSum
  - Calculate new link delays
- LinkDelay
  - Successively average link delays
- PlanSum
  - Re-skim with new averaged delays to calculate convergence
- PlanCompare
  - Compare travel plans to calculate disaggregate gap measure

Until \(N=25\)

Final Travel Plans & Link Delays
Integrated Model System Convergence

- Convergence necessary to ensure integrity of the model system
- Attained through iterative feedback within:
  - Network assignment
  - Overall model system
  - Link averaging

3 Phase Implementation:
- Achieve assignment convergence within the Router
- Achieve system convergence
- Optimize/coordinate to reduce runtimes
  - Only re-route households contributing to system disequilibrium
Trip Gap Measure

\[
\sum_{s} \left( c_{xs} \left( \{c_{at}\} \right) - c_{ys} \left( \{c_{at}\} \right) \right) / \sum_{s} c_{xs} \left( \{c_{at}\} \right)
\]

where:
- \( s \) indexes trips
- \( \{c_{at}\} \) is an updated set of time-dependent link costs after combining new trip routes for a subset of household with previous iterations’ routes for the other households
- \( c_{xs} \) is the cost of the trip \( s \) along the path that was used for the calculation of \( \{c_{at}\} \)
- \( c_{ys} \) is the cost of the trip \( s \) along its shortest path, assuming \( \{c_{at}\} \)
Trip Gap vs Network Gap

Comparison of Assignment Convergence Measures

Graph showing the comparison of assignment convergence measures with different lines representing different scenarios.
System Convergence

- After each iteration, final link volumes are averaged, link delays updated, and reskinned.
- District flows evaluated at different geographic scales:
  - RAD: 70 x 70
  - District: 40 x 40
  - PUMA: 15 x 15
- Need to run additional system iterations, but runtime issues.
Regional Calibration

- Calibrated to the same 2005 SacSim base year
- Calibration based on SacSim count sets
  - Daily (24 hr)
  - AM (7am-10am)
  - Midday (10am-3pm)
  - PM (3pm-6pm)
  - Evening (6pm-7am)
- System-wide validation measures
  - Estimated vs observed link volumes, % difference, RMSE, etc
- River crossing screenline
  - Sacramento River & American River
- Comparisons against SacSim model validation statistics
### Daily Validation by Facility Type

<table>
<thead>
<tr>
<th>Facility</th>
<th># of counts</th>
<th>Estimated</th>
<th>Observed</th>
<th>Difference</th>
<th>% Difference</th>
<th>Avg Error</th>
<th>% Avg Error</th>
<th>% RMSE</th>
<th>R-Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeway</td>
<td>168</td>
<td>8,653,123</td>
<td>8,516,310</td>
<td>136,813</td>
<td>1.6</td>
<td>8,785</td>
<td>17.3</td>
<td>25</td>
<td>0.851</td>
</tr>
<tr>
<td>Expressway</td>
<td>73</td>
<td>717,783</td>
<td>737,554</td>
<td>-19,771</td>
<td>-2.7</td>
<td>1,712</td>
<td>16.9</td>
<td>23.8</td>
<td>0.95</td>
</tr>
<tr>
<td>Major Arterial</td>
<td>404</td>
<td>5,673,462</td>
<td>4,961,118</td>
<td>712,344</td>
<td>14.4</td>
<td>3,523</td>
<td>28.7</td>
<td>39.9</td>
<td>0.797</td>
</tr>
<tr>
<td>Minor Arterial</td>
<td>160</td>
<td>1,704,318</td>
<td>1,686,904</td>
<td>17,414</td>
<td>1</td>
<td>3,374</td>
<td>32</td>
<td>44.2</td>
<td>0.385</td>
</tr>
<tr>
<td>Collector</td>
<td>103</td>
<td>587,447</td>
<td>562,274</td>
<td>25,173</td>
<td>4.5</td>
<td>1,855</td>
<td>34</td>
<td>50.2</td>
<td>0.689</td>
</tr>
<tr>
<td>Ramp</td>
<td>227</td>
<td>1,024,553</td>
<td>1,009,510</td>
<td>15,043</td>
<td>1.5</td>
<td>2,710</td>
<td>60.9</td>
<td>96.8</td>
<td>0.419</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>1,135</td>
<td>18,360,686</td>
<td>17,473,670</td>
<td>887,016</td>
<td>5.1</td>
<td>3,850</td>
<td>25</td>
<td>41.1</td>
<td>0.91</td>
</tr>
</tbody>
</table>

#### Graph:
- **SacSim Model**
- **DaySim-TRANSIMS**

The graph compares the estimated traffic counts with the observed traffic counts for different facility types. The Y-axis represents the ratio of estimated to observed traffic counts, while the X-axis represents different facility types: Freeway, Expressway, Major Arterial, Minor Arterial, Collector, Ramp, and ALL. The red line indicates the ideal ratio of 1, where 1 indicates perfect agreement between estimated and observed traffic counts.
Run Times & Distributed Processes

- **DaySim-TRANSIMS Integrated Model runtime is ~80 hours**
  - DaySim - 3 hours per system iteration
  - Router Stabilization - 12 hours per system iteration
  - Skim Development - 5 hours per system iteration
  - 4 total system iterations

- **DaySim supports parallelization but is currently being run on a single processor**

- **TRANSIMS tools that can be parallelized are running concurrently on 4 processors**
  - Accomplished by partitioning Household list so that each CPU is only processing a subset of the region’s travelers

- **Skim Process has been parallelized by specifying unique zone ranges and creating time period specific skims on separate CPUs**
TRACC Sensitivity Testing

Router Run Time Reduction

- Linear Response
- Actual Response

RunTime Reduction Ratio vs. Computation Nodes
Lessons Learned

1. Integrating an advanced activity based demand model with a detailed network assignment model which produces reasonable validation is achievable.

2. Time scheduling issues arose from the discrepancy between the skim values used as input to DaySim and the network travel times experienced during Routing.

3. Integrated model used “off-the-shelf” components - would likely benefit from re-calibration of parameters and coefficients used in both demand and supply side models.

4. Temporally detailed count and speed data is essential for validation and is not always available.

5. Jumping to a new version of Transims can sometimes resolve particular issues but can also cause unforeseen problems.

6. Parallelization is essential as temporal and spatial detail increases along with the total amount of demand.
Next Steps

1. Improve spatial and temporal disaggregation
   - Have TRANSIMS provide DaySim temporally and spatially sensitive information in real time
   - Do this by more closely integrating the two software packages

2. Continue testing of integrated convergence strategies
   - Test different TRANSIMS rerouting options
   - Only resimulate in DaySim the households that require rerouting

3. Improve and refine approaches to reducing runtimes
   - What is the impact of loosening the assignment convergence criteria for early internal iterations
   - Is there a strategy to operate at higher levels of spatial and temporal aggregation in early iterations
   - How will the system respond to DaySim sampling in early iterations

4. Can the microsimulator be incorporated without producing unworkable / unreasonable runtimes?
## AM & MD Period Validation by Facility Type

<table>
<thead>
<tr>
<th>Facility</th>
<th># of counts</th>
<th>Estimated</th>
<th>Observed</th>
<th>Difference</th>
<th>% Difference</th>
<th>Avg Error</th>
<th>% Avg Error</th>
<th>% RMSE</th>
<th>R-Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeway</td>
<td>167</td>
<td>1,375,889</td>
<td>1,430,360</td>
<td>-54,471</td>
<td>-3.8</td>
<td>1,839</td>
<td>21.5</td>
<td>30.3</td>
<td>0.837</td>
</tr>
<tr>
<td>Expressway</td>
<td>53</td>
<td>92,387</td>
<td>107,028</td>
<td>-14,641</td>
<td>-13.7</td>
<td>569</td>
<td>28.2</td>
<td>37.9</td>
<td>0.91</td>
</tr>
<tr>
<td>Major Arterial</td>
<td>311</td>
<td>856,507</td>
<td>761,876</td>
<td>94,631</td>
<td>12.4</td>
<td>854</td>
<td>34.9</td>
<td>48.4</td>
<td>0.623</td>
</tr>
<tr>
<td>Minor Arterial</td>
<td>128</td>
<td>255,366</td>
<td>245,310</td>
<td>10,056</td>
<td>4.1</td>
<td>643</td>
<td>33.5</td>
<td>46.7</td>
<td>0.413</td>
</tr>
<tr>
<td>Collector</td>
<td>67</td>
<td>84,091</td>
<td>82,032</td>
<td>2,059</td>
<td>2.5</td>
<td>540</td>
<td>44.1</td>
<td>61.2</td>
<td>0.416</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td><strong>726</strong></td>
<td><strong>2,664,240</strong></td>
<td><strong>2,626,606</strong></td>
<td><strong>37,634</strong></td>
<td><strong>1.4</strong></td>
<td><strong>994</strong></td>
<td><strong>27.5</strong></td>
<td><strong>42.7</strong></td>
<td><strong>0.871</strong></td>
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</table>

<table>
<thead>
<tr>
<th>Facility</th>
<th># of counts</th>
<th>Estimated</th>
<th>Observed</th>
<th>Difference</th>
<th>% Difference</th>
<th>Avg Error</th>
<th>% Avg Error</th>
<th>% RMSE</th>
<th>R-Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeway</td>
<td>167</td>
<td>2,129,422</td>
<td>2,032,987</td>
<td>96,435</td>
<td>4.7</td>
<td>2,705</td>
<td>22.2</td>
<td>30.3</td>
<td>0.82</td>
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<tr>
<td>Expressway</td>
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<td>142,421</td>
<td>149,460</td>
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<td>-4.7</td>
<td>564</td>
<td>20</td>
<td>29.4</td>
<td>0.941</td>
</tr>
<tr>
<td>Major Arterial</td>
<td>312</td>
<td>1,349,234</td>
<td>1,307,701</td>
<td>41,533</td>
<td>3.2</td>
<td>1,127</td>
<td>26.9</td>
<td>35.4</td>
<td>0.733</td>
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<tr>
<td>Minor Arterial</td>
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<td>398,568</td>
<td>433,498</td>
<td>-34,930</td>
<td>-8.1</td>
<td>1,087</td>
<td>32.1</td>
<td>41.5</td>
<td>0.345</td>
</tr>
<tr>
<td>Collector</td>
<td>67</td>
<td>137,515</td>
<td>140,242</td>
<td>-2,727</td>
<td>-1.9</td>
<td>710</td>
<td>33.9</td>
<td>47.5</td>
<td>0.565</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>727</strong></td>
<td><strong>4,157,160</strong></td>
<td><strong>4,063,888</strong></td>
<td><strong>93,272</strong></td>
<td><strong>2.3</strong></td>
<td><strong>1,403</strong></td>
<td><strong>25.1</strong></td>
<td><strong>38.2</strong></td>
<td><strong>0.877</strong></td>
</tr>
</tbody>
</table>
PM & EV Period Validation by Facility Type

<table>
<thead>
<tr>
<th>Facility</th>
<th># of counts</th>
<th>Estimated</th>
<th>Observed</th>
<th>Difference</th>
<th>% Difference</th>
<th>Avg Error</th>
<th>% Avg Error</th>
<th>% RMSE</th>
<th>R-Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeway</td>
<td>167</td>
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