An Application of TRANSIMS to the Analysis of Multimodal Corridors in the Greater Phoenix Metropolitan Area

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Outline

• Background
• Project Objectives
• Project Approach
  – Highway Network
  – Transit Network
  – Light Rail Subarea
  – Travel Demand Input
  – Simulation
  – Ongoing Work
• TRANSIMS Documentation
• Upcoming Activities
Welcome to the Greater Phoenix Area
About the Phoenix Metropolitan Area

- Population of 4.28 million
  - 12th most populated metropolitan area in the country
- The City of Phoenix is the 5th largest in the U.S.
- Phoenix is the most populated capital city in the U.S.
- 8 cities in the area have 100,000+ people
  - Phoenix
  - Mesa
  - Tempe
  - Gilbert
  - Chandler
  - Peoria
  - Scottsdale
  - Glendale
Line Rail Transit

- Light Rail service began in December 2008
- Starter line ~20 miles long
- Serves West Mesa, North Tempe, and Central Phoenix
- Additional lines being planned for the future
- Important service stops
  - Arizona State University
  - Mill Avenue Shopping district
  - Sky Harbor Airport
  - Professional Sports Facilities
  - Phoenix CBD
Plan for Future Light Rail Corridors

Legend:
- **Initial 20-mile Light Rail Alignment (Scheduled to open Dec. 2008)**
- **Northwest Extension – Phase 1 (Scheduled to open 2012)**
- **Future High Capacity / Light Rail Corridors for Further Study**

Note: Dates indicate calendar year openings.
Metropolitan Planning and Modeling Challenges

• Urban sprawl
  – Residential areas sprouting along the edges

• Heavy congestion during peak hours
  – Serious environmental and quality of life implications

• Rating Corridor Performance

• Incorporating multiple modes of transportation
  – Interaction between highway and transit networks
  – Modeling the addition/presence of a new mode

• Simulation run times in large metropolitan areas are prohibitive
Specific Challenges to the Phoenix Area

- Large regional scale
  - High run times and computational effort required
  - Provision of regional transit services
- High population of seasonal residents
- Mountain preserves and parks interspersed
- Shared borders with Native American Reservations
Project Objectives

• To implement TRANSIMS for a large scale region with a multi-modal network
• To apply TRANSIMS for operational analysis of a multi-modal corridor
• To develop documentation to aid the TRANSIMS user community
• This project aims to apply TRANSIMS as a tool to overcome two challenges:
  – Microsimulation on a large scale network
  – Microsimulation in a multi-modal environment
Project Phases

• Phase I: Network and Input Database Creation
  – Build a highway network
  – Build a transit network
  – Demand from Maricopa Association of Governments 4-step model

• Phase II: Calibration and Validation of Router/Microsimulator
  – Run Router/Microsimulator to convergence
  – Validate simulated traffic
  – Validate simulated transit ridership

• Phase III: Simulating Demand and Network Dynamics
  – Use validated network from phases I and II
  – Apply PopGen synthetic population generator
  – Apply TRANSIMS activity generator/scheduler
Summary of Completed Project Tasks

- Highway Network
- Transit Network
- Subarea selection and creation
- Origin-Destination matrices applied
- Creation of time-of-day distributions by purpose
- Simulation process completed
  - Router Stabilization
  - Microsimulation Stabilization
  - User Equilibrium
- Several Chapters of TRANSIMS Documentation
- Router/Microsimulator validation in progress
The Highway Network
Highway Network Inputs

* All Input Data provided by Maricopa Association of Governments

- 1,995 Internal TAZs
  - Area type ranging from 1-5, 5 being most rural
- 11 External TAZs
  - All area type 5
- 10,436 Nodes
  - First 11 correspond to external zone centroids
- 13,210 Links
  - 40% of these are one-way links
Input Highway Statistics

Frequency of Zone Area Types

Input Link Type Frequencies

Hourly Capacity per Lane on Input Links
### Highway Network Parameters & Results

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Number of Input Node Records = 10436  
Number of Input Link Records = 13210  
Number of Input Zone Records = 2006  

Highest Zone Number = 3010  
Number of New Node Records = 10436  
Number of New Link Records = 13210  
Number of New Link Shapes = 0  
Number of New Shape Records = 0  
Number of New Activity Location Records = 45443  
Number of New Parking Lot Records = 45443  
Number of New Process Link Records = 90886  
Number of New Pocket Lane Records = 0  
Number of New Lane Connectivity Records = 63194  
Number of New Unsignalized Node Records = 1221  
Number of New Signalized Node Records = 2081  

Number of External Connections = 11  
Number of Short Links Increased in Length = 169  
Number of Stop Signs = 691  
Number of Yield Signs = 530  
Number of Demand Actuated Single Ring Signals = 2081
Activity Location Zone Assignments

• All Activity Locations are assigned a zone
• Zone assignments based on proximity to centroid
• Areas of Phoenix where no major roadways exist
  – Mountain preserves
  – Borders with Salt River-Pima and Gila River Reservations
• Many Phoenix-area TAZ’s not allocated any Activity Locations
  – Result: failure to process trips to/from those zones
• Activity Location file was enhanced manually
  – Zone allocations of some activity locations were re-assigned
• Python Script created to automate this process
Traffic Analysis Zones

Zone assignment of activity locations based on proximity to highway link

[Map of a region with numerous points marked on it, representing activity locations.]
Transit Network Inputs

- **225 Routes**
  - Bus, Express Bus, and Light Rail
- **7 transit time periods**
  - Service runs from 4:00 am to 11:00 pm
  - AM Peak from 6:00 – 9:00 am
  - PM Peak from 3:00 – 6:00 pm
- **Dwell Times**
  - 20 seconds for all Bus Routes
  - 10 seconds for all Express Bus and Light Rail Routes
- “TIME” and “SPEED” between transit stops are calculated within TRANSIMS
Input Transit Statistics

Frequency of Headways in Peak Hour Transit Service

Frequency of Headways in Off-Peak Transit Service
Transit Network Parameters & Results

RANDOM_NUMBER_SEED: 12345
MAX_WARNING_MESSAGES: 10000000
TRANSIT_TIME_PERIODS: 4:00, 6:00, 9:00, 15:00, 18:00, 23:00
TRANSIT_TRAVEL_TIME_FACTOR: 1.0, 1.1, 1.22, 1.1, 1.25, 1.1, 1.0
MINIMUM_DWELL_TIME: 5
INTERSECTION_STOP_TYPE: FARSIDE

Number of Activity Location Records = 53641 (7518 new)
Number of Process Link Records = 107532 (15286 new)
Number of Transit Stop Records = 7643
Number of Transit Route Records = 14055
Number of Transit Schedule Records = 433085
Number of Transit Driver Records = 12426
U-Turns in Bus Routes and “Must Stop” Warnings

• When bus reaches its last stop, turns around to continue in opposite direction
  – Result: Route Node file contains the same node number twice in succession
  – Error Returned: No Lane Connectivity from Node X to Node X
  – Route Node file enhanced
  – The node at the end of the line is listed only once

• Bus routes that travel on freeways
  – No bus stops on freeways in Route Node file
  – Warning Returned: Route X must stop on link Y
  – Does not seem to interfere with network creation
Current 20-Mile Light Rail Line
# Light Rail Specifications

- Must identify rail in the input link file

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<th>NODE</th>
<th>NODE</th>
<th>LENGTH</th>
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<th>LINES_A</th>
<th>FSPD_A</th>
<th>CAP_A</th>
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- Must identify rail in the input route header file

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</table>
Light Rail Subarea Creation

• The MAG region is a very large scale area
  – Microsimulation best done for the specific area of interest, i.e., the Light Rail Corridor

• A 5-mile buffer deemed appropriate to capture the market of the Light Rail line

• Subarea creation process:
  – Create a 5-mile buffer around the existing 20-mile Light Rail Line and its planned extensions
  – Expand the buffer to include the extents of any TAZs that lie partially within the buffer
    • This step was done to avoid trip assignment issues involving zones only partially in the subarea
Example of Expanding the Buffer

5-mile Buffer

Subarea
Future Planned Extensions

Northwest Extension and Mesa Extension are being considered.
Light Rail Buffer: Existing and Future
Origin-Destination Matrices

- **O-D matrices provided by MAG**
  - 24 hr Drive Alone
  - 24 hr HOV
  - Local Bus Peak & Off Peak
  - Express/Rapid Bus Peak & Off Peak
  - Light Rail Peak & Off Peak
  - 24 hr Light, Medium, and Heavy Truck

- **Purpose distributions created from MAG-provided data**
  - ASU
  - HBO
  - HBU
  - NHW
  - HBW
  - NHO

*Note: Express/Rapid Bus only included HBW trips*
Origin-Destination Matrices

• Result: 26 O-D Matrices entered into TRANSIMS
  – Each has specific mode and purpose
• Matrices are zone-to-zone trip tables
• TRANSIMS does not accept fractional trips
  – Bucket Rounding was applied to each matrix to avoid loss of trips
• Results of Convert Trips
  – 15,092,164 Trips
  – 14,910,781 Vehicles
• Convert Trips Run Time = 18 minutes
Time-of-Day Distributions

- Time-of-day distributions created from NHTS 2009 Data
- Distributions by purpose
  - NHTS trips were categorized to match MAG model trip purpose labels
- One time-of-day distribution specifically for truck trips
- Smoothing time distributions:

```
SMOOTH_FIELD_NUMBER   3
SMOOTH_GROUP_SIZE     3
PERCENT_MOVED_FORWARD 20
PERCENT_MOVED_BACKWARD 20
NUMBER_OF_ITERATIONS  10
CIRCULAR_GROUP_FLAG   TRUE
```
Smoothed Time Distributions

HBW Purpose Time Distribution

ASU Purpose Time Distribution

NHW Purpose Time Distribution

Time Distribution for Trucks
Simulation Process

ROUTER STABILIZATION

- Router → Travel Plans
  - PlanSum* → LinkDelay*
    - PlanSelect* → HouseholdList*
    - Router* → Plans*
    - PlanPrep* → TravelPlans*

MICROSIMULATOR STABILIZER

- SubareaPlans* → SubareaPlans*
  - Microsimulator* → LinkDelay*
    - PlanSelect* → HouseholdList*
    - Router* → Plans*
    - PlanPrep* → TravelPlans*

USER EQUILIBRIUM

- PlanSum* → LinkDelay*
  - SubareaPlans* → SubareaPlans*
  - Microsimulator* → SubareaLinkDelay*
  - LinkDelay* → TotalLinkDelay*
  - Router* → Plans*
  - PlanCompare* → SelectedPlans*
  - PlanPrep* → TravelPlans*

Trip File
Router Stabilization Process
Router Stabilization

- 15 iterations of the process are run
  - 1st Router Run: About 1,808,000 Problems
  - Problems are eliminated by 15th iteration

- Majority of Router Problems are “Time Schedule” Problems

- Initial Router Run Time = 12 Hours (single core Dell Inspiron D630 laptop)

- Entire Router Stabilization process run time = 20:55:38
## Router Stabilization Parameters

- **Router**

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- **Plan Select**

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Microsimulation Stabilization Process
Microsimulation Stabilization

- 10 iterations of the process
- Entire Microsimulation Stabilization process run time = 6:25:04
- First Microsimulator Run returned 3,065 problems
  - Majority were departure time problems
- Subarea Plans
  - Need to ensure that the external offset length in Subarea Network is sufficient

Microsimulator Parameters

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User Equilibrium Process
User Equilibrium

- Process was established similar to the White House Area Transportation Study
- 10 iterations of the process
- Entire User Equilibrium process run time = 42:37:34
- LinkDelay.exe
  - Inputs are subarea link delay and average link delay from region
  - Output is a regional average link delay
Validation in Progress

- First validation revealed problems with the network
  - All previously listed information on simulation processes could change with new network enhancements implemented recently
- Most recent validation: traffic volumes under-estimated

### Summary Statistics by Volume Level

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<th>---Difference---</th>
<th>--Abs.Error--</th>
<th>Std. %</th>
<th>R</th>
<th>----V/C----</th>
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<td>4544</td>
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<td>25000 to 50000</td>
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<td>515343</td>
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<td>23831</td>
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<td><strong>TOTAL</strong></td>
<td>84</td>
<td>2853262</td>
<td>4800474</td>
<td>-1947212</td>
<td>-40.6</td>
<td>25410</td>
<td>20478</td>
</tr>
</tbody>
</table>

### Summary Statistics by Facility Type

<table>
<thead>
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<th>Facility Type</th>
<th>Num.</th>
<th>-----Volume-----</th>
<th>---Difference---</th>
<th>--Abs.Error--</th>
<th>Std. %</th>
<th>R</th>
<th>----V/C----</th>
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<tr>
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<td>Minor Arterial</td>
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<td>-15752</td>
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<td>2849</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td>84</td>
<td>2853262</td>
<td>4800474</td>
<td>-1947212</td>
<td>-40.6</td>
<td>25410</td>
<td>20478</td>
</tr>
</tbody>
</table>
Validation in Progress

- Just received more accurate and complete validation file from MAG
- In the meantime, checking network connectivity and making enhancements
  - Dummy trip file from Activity Location 1 to all other Activity Locations
  - Entered into router and then Arcview Plans
TRANSIMS Documentation

• Learning phase of the project suggested need for more comprehensive documentation
• Prompted the creation of “TRANSIMS for Dummies”
  – The goal: to create a one-stop document that includes all the information user will need to know about the system in informal language
  – Will facilitate quick learning and hopefully wider use of TRANSIMS
• Eventual Goal with TRANSIMS for Dummies
  – Allow user community to access via wiki and make enhancements
Project Wiki Site

• Please visit our project Wiki site:
  http://simtravel.wikispaces.asu.edu/TRANSIMS+Application+and+Deployment

• TRANSIMS for Dummies
  http://simtravel.wikispaces.asu.edu/TRANSIMS+For+Dummies

• Weekly Progress Updates on this Project
  http://simtravel.wikispaces.asu.edu/TRANSIMS+Project+Updates

• Details on other SimTRAVEL Projects
  – SimTRAVEL: Simulator of Transport, Routes, Activities, Vehicles, Emissions, and Land
    http://simtravel.wikispaces.asu.edu/
Where We Are Going…

- **Large-scale multimodal network successfully created**
  - Minor issues related to poor connectivity
- **Ongoing validation checks**
  - Router testing reveals approximately 12% of trips are experiencing problems
  - Accounting of HOV lane trips
- **Phase 3 tasks underway**
  - Synthetic population created using PopGen
  - NHTS2009 add-on survey data for MAG being processed
  - Plan to apply TRANSIMS Activity generator
  - Plan to use MAG mode choice model
Acknowledgements

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