TRANSIMS DEPLOYMENT CASE STUDY:

SACOG DaySim-TRANSIMS Integrated Model Development

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

Resource Systems Group
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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

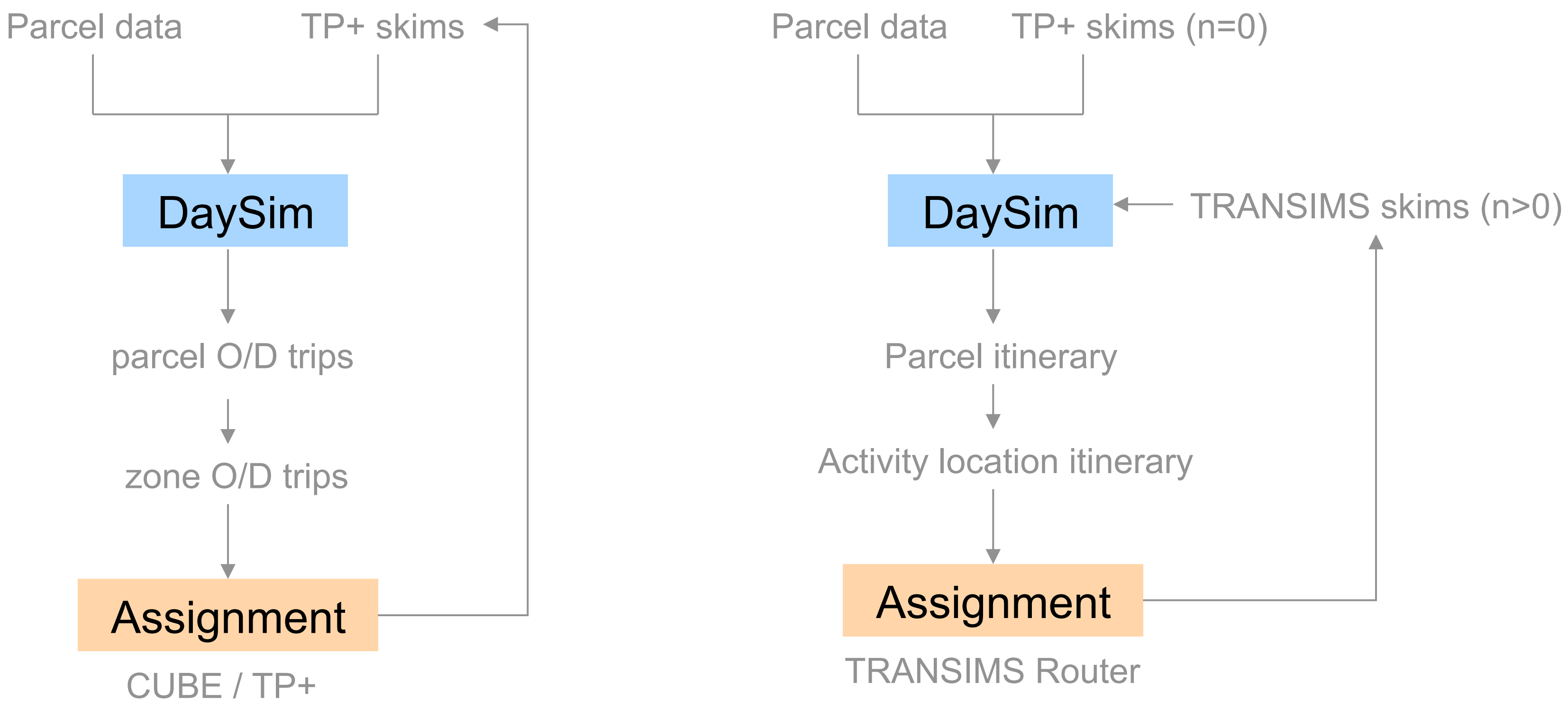
Project Objectives

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)

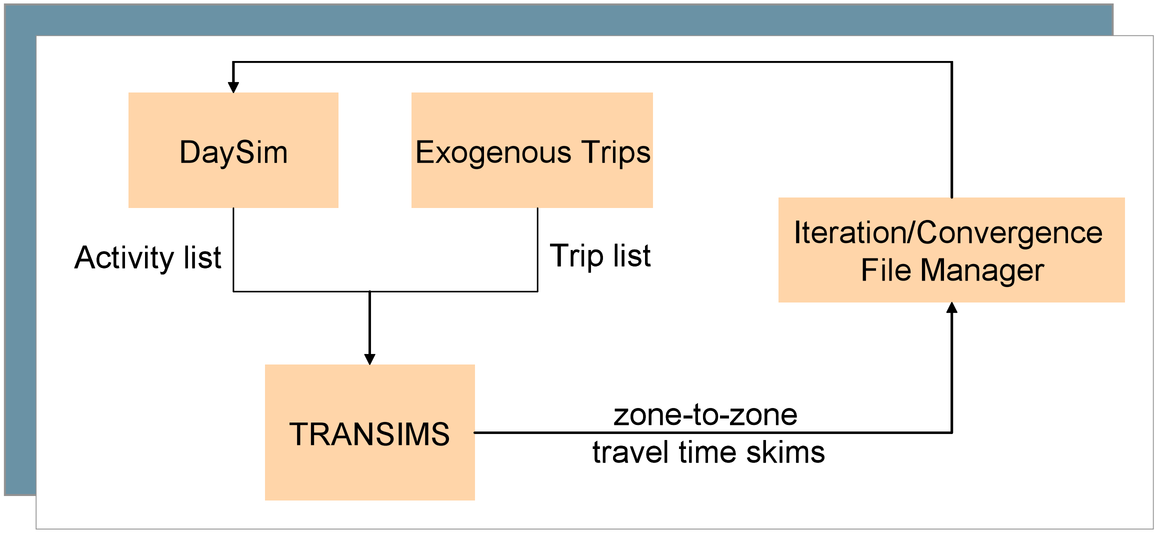
DaySim Input & Output Data Files

INPUT DATA FILES			
Representative Population	Parcel/Point Data	External Trips by Purpose	LOS Skim Matrices, by Period and Mode (from prior loop)

OUTPUT FILES	PERSON FILE (one record per person-day)	TOUR FILE (one record per person-tour)	TRIP FILE (one record per person-trip)

- 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

SAMPN	PERSN	TOURNO	TOURHALF	TRIPNO	OTAZ	OCEL	DTAZ	DCEL	OPURP	DPURP	DEPTIME	ARRTIME	EACTTIM	TRAVTIM	TRAVDIST	EXPFACT
1	1	1	1	1	445	429711	1088	133524	8	4	1222	1238	1556	16.09	8.56	1.00
1	1	1	2	1	1088	133524	445	429711	4	8	1556	1615	2659	18.65	8.56	1.00

TRANSIMS Activity File Input Example

HHOLD	PERSON	ACTIVITY	PURPOSE	PRIOTITY	START	END	DURATION	MODE	VEHICLE	LOCATION	PASSENGER
1	1	111110	0	9	1	44520	44519	1	0	5937	0
1	1	11111	4	9	45480	57360	11880	2	1	13688	0
1	1	11121	0	9	58500	97140	38640	2	1	5937	0

- 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

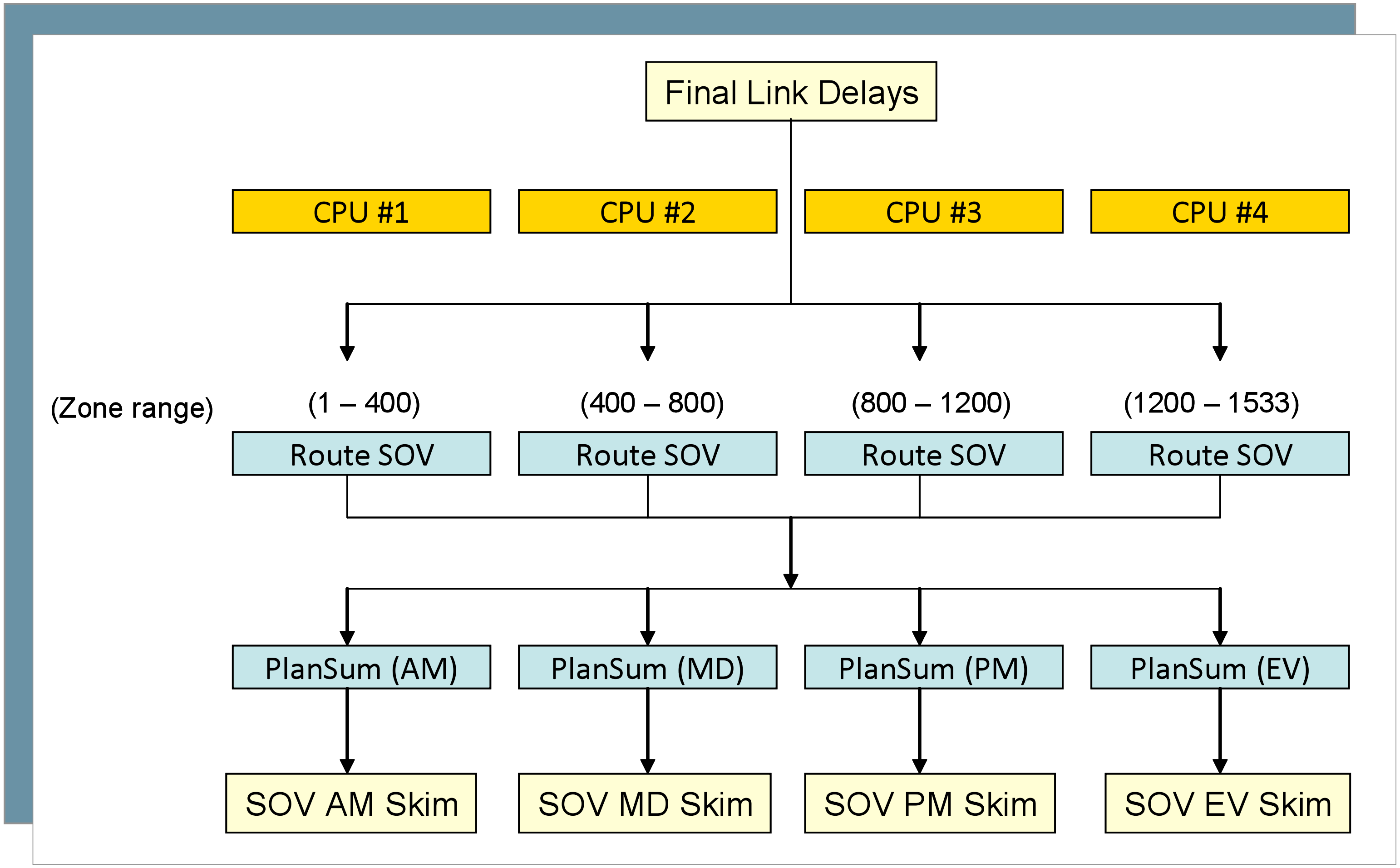
TRANSIMS to DaySim Integration

- 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

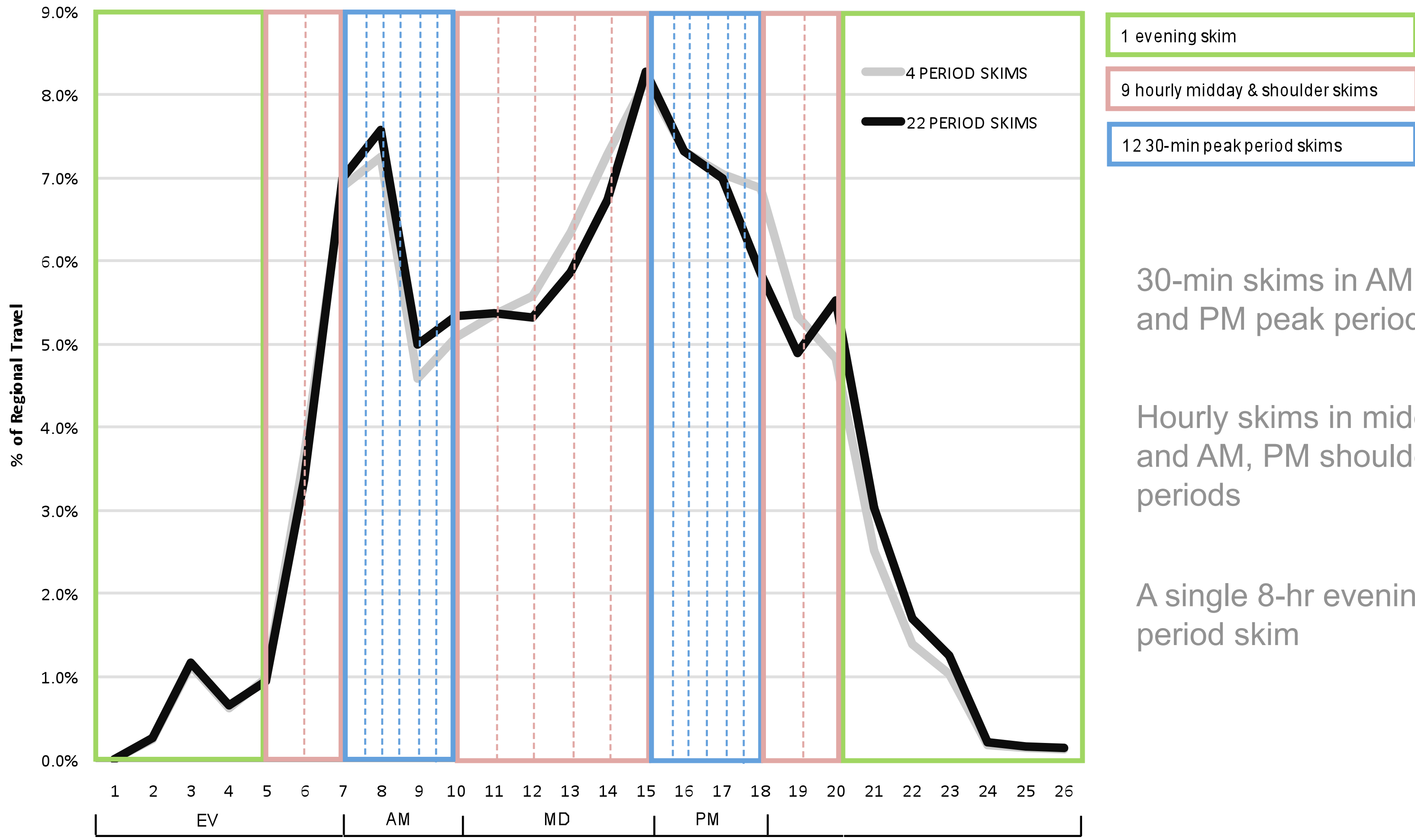
- Computational / technical challenges associated with building skims by activity-level and detailed time period
- TRANSIMS is already configured to produce skims analogous to those produced by current static assignment based method
- Use of "dummy" activity locations to represent TAZs
  - To accommodate 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



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

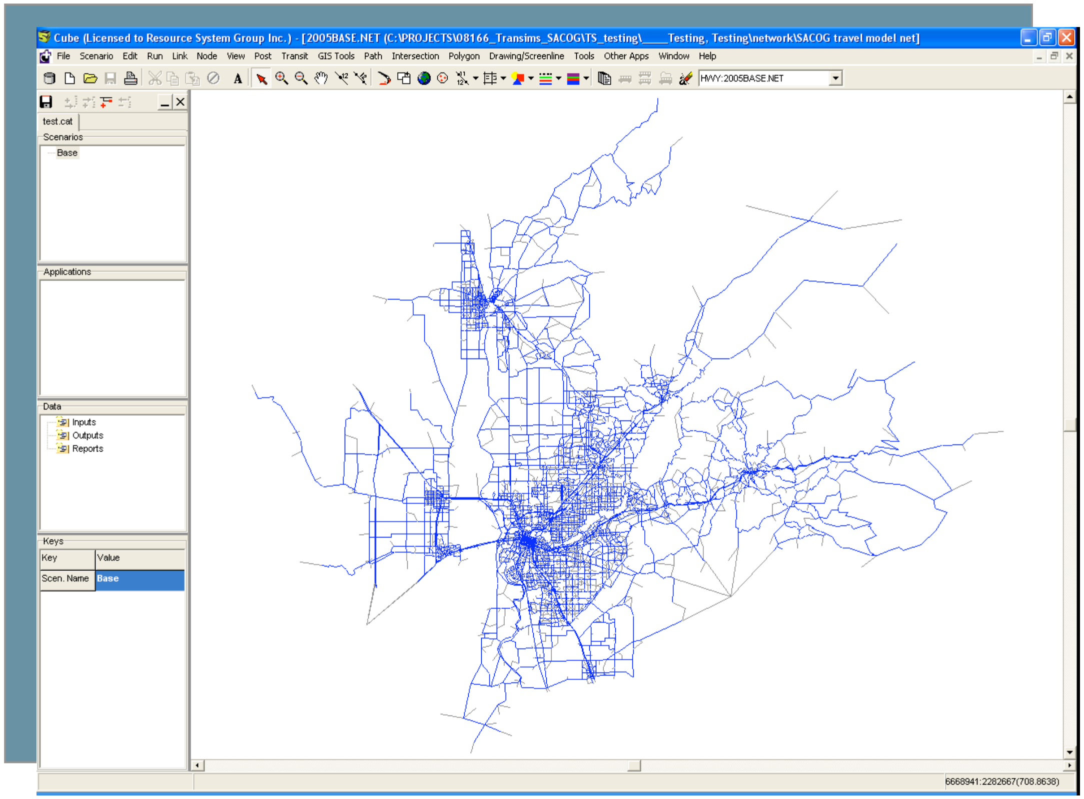
modes (SOV, HOV2, HOV3+)	3
attributes (distance, cost, time, congested time)	4
toll/VOT classes (1 non-toll class, 3 VOT toll classes)	1 to 5
time periods	15 to 30
origin activity locations	20,000
destination activity locations	20,000
	72 billion values

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

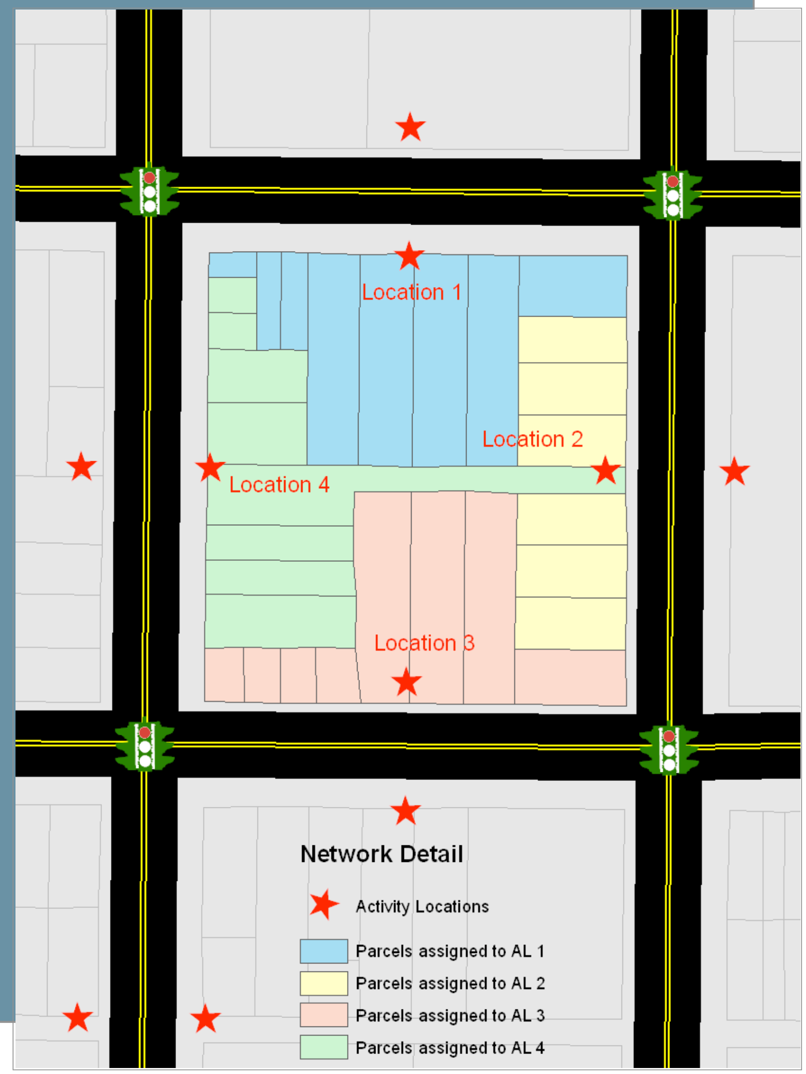
TRANSIMS Network Preparation

- 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



Parcel – Activity Location Equivalency

- 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



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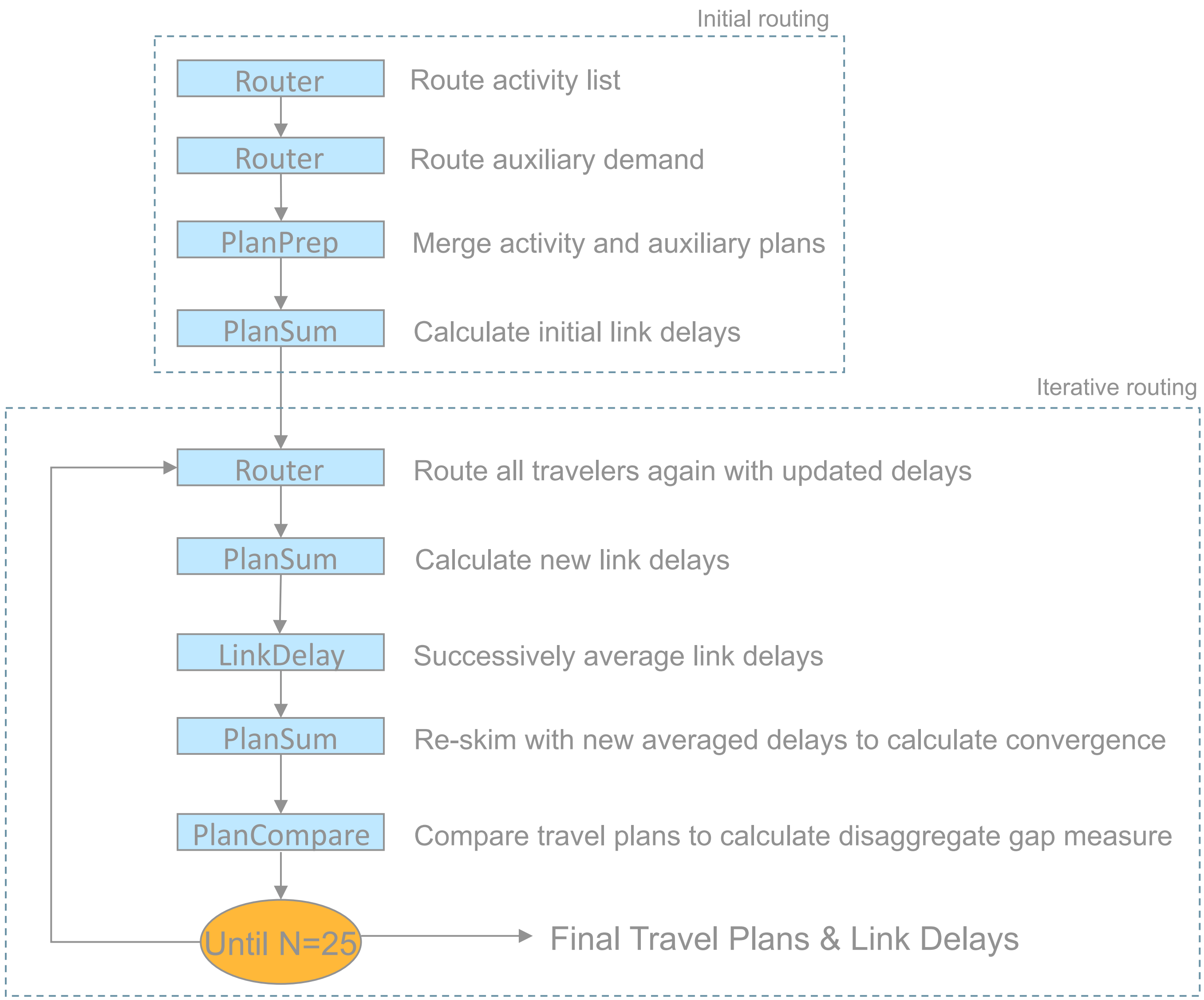
Router Stabilization Process

- 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



Integrated Model System Convergence

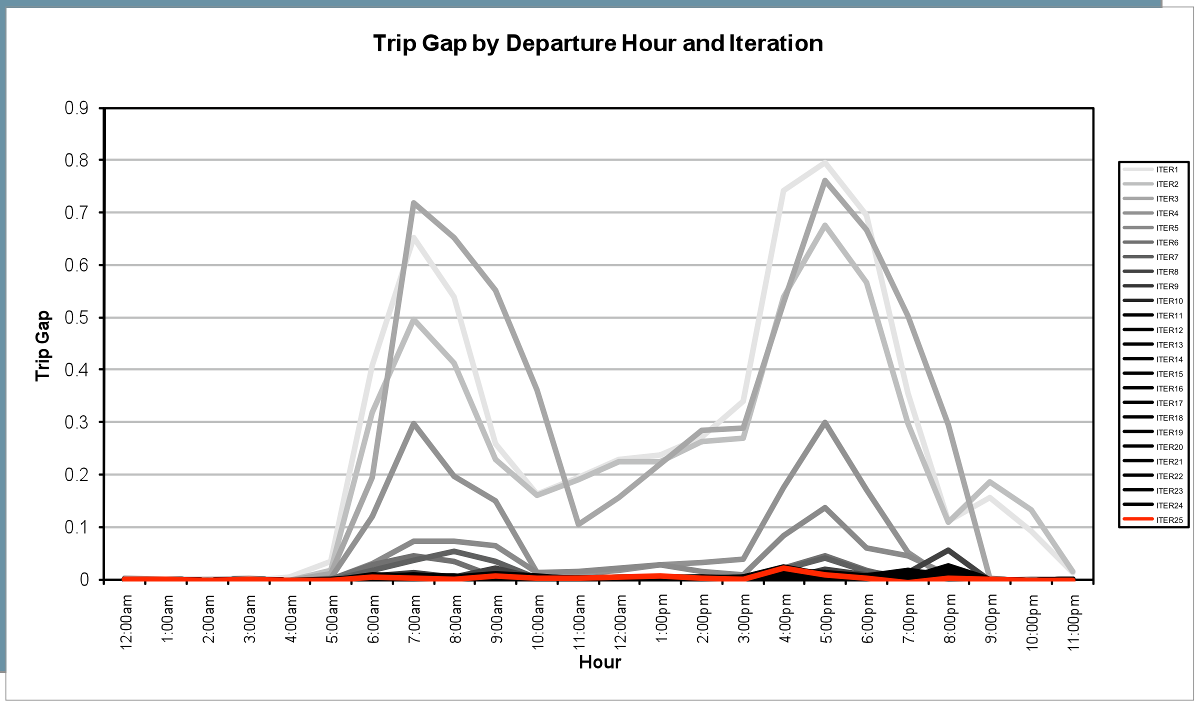
- Convergence necessary to ensure integrity of the model system
- Attained through iterative feedback within:
  - Network assignment
  - Overall model system
  - Link averaging
- 3 Phase Implementation:
  - Achieve assignment convergence within the Router
  - Achieve system convergence
  - Optimize/coordinate to reduce runtimes
    - Only re-route households contributing to system disequilibrium

Trip Gap Measure

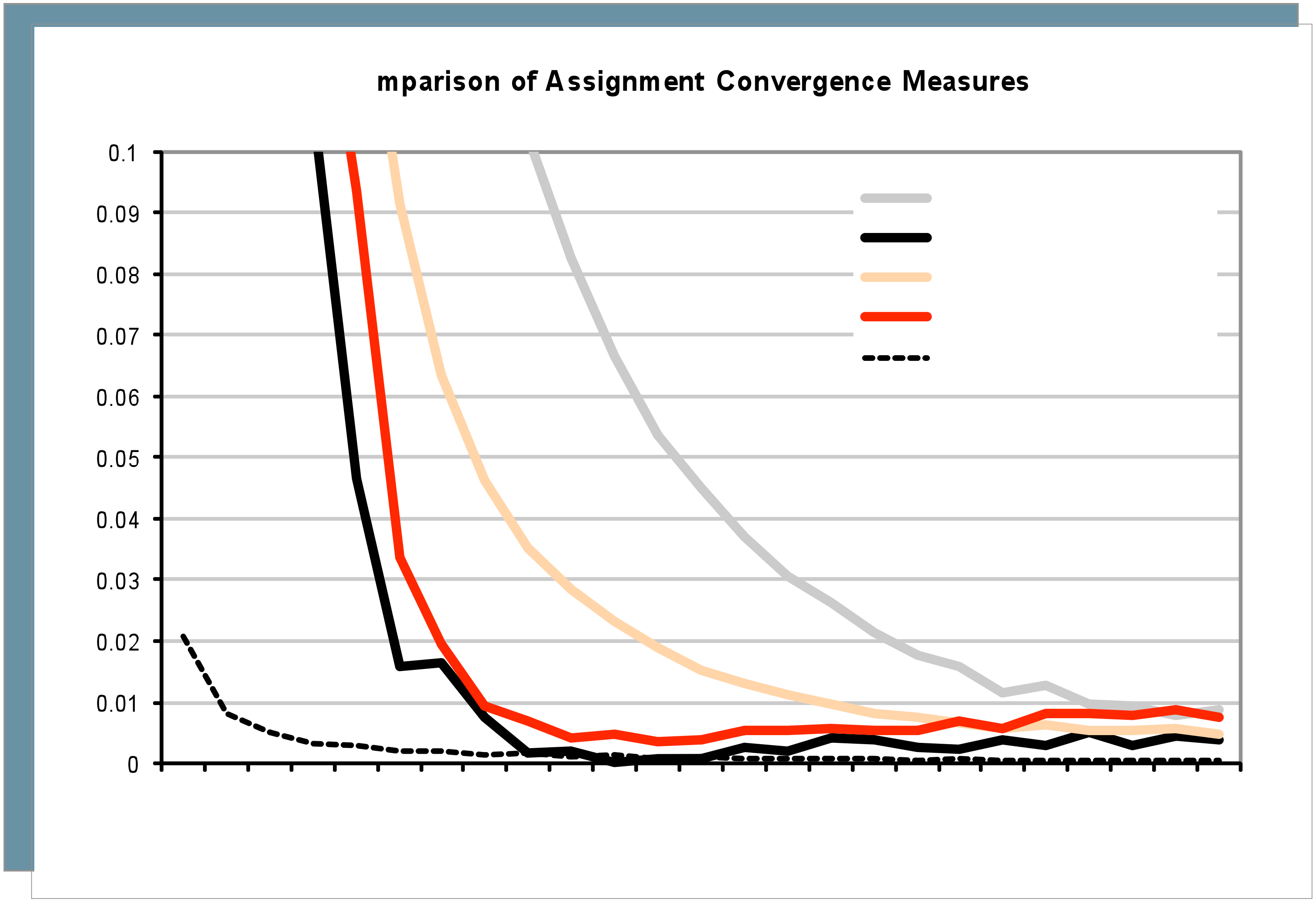
$$\frac{\sum_{s}(c_{xs}(\{c_{at}\}) - c_{ys}(\{c_{at}\}))}{\sum_{s} c_{xs}(\{c_{at}\})}$$

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 pervious 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 $\{c_{at}\}$

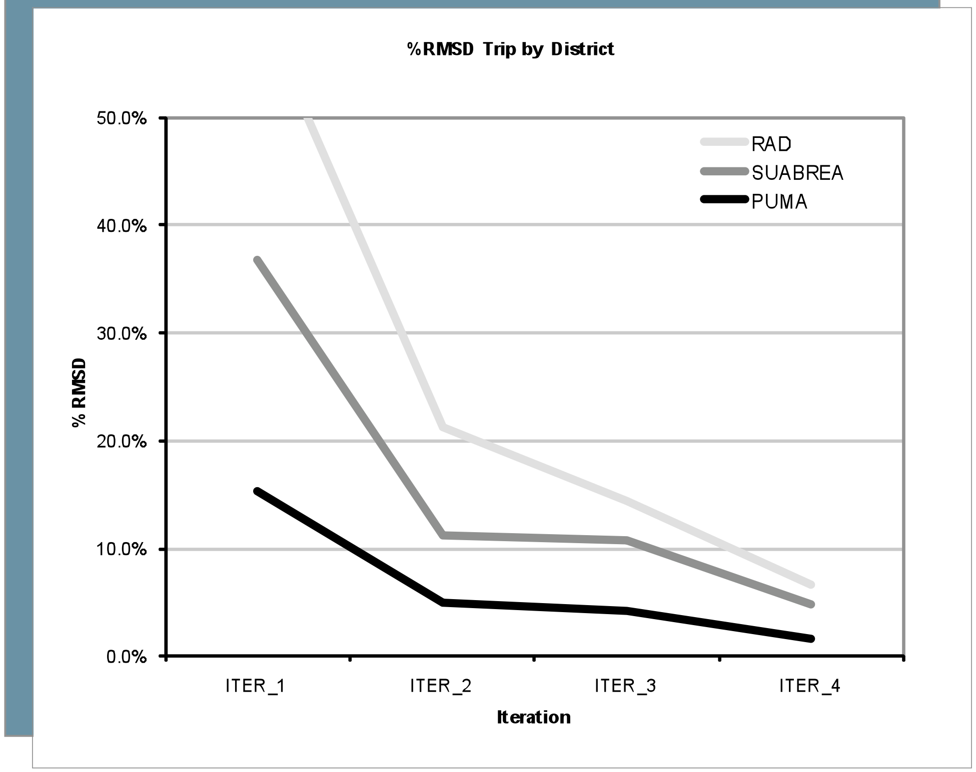


Trip Gap vs Network Gap



System Convergence

- After each iteration, final link volumes are averaged, link delays updated, and reskimmed
- 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

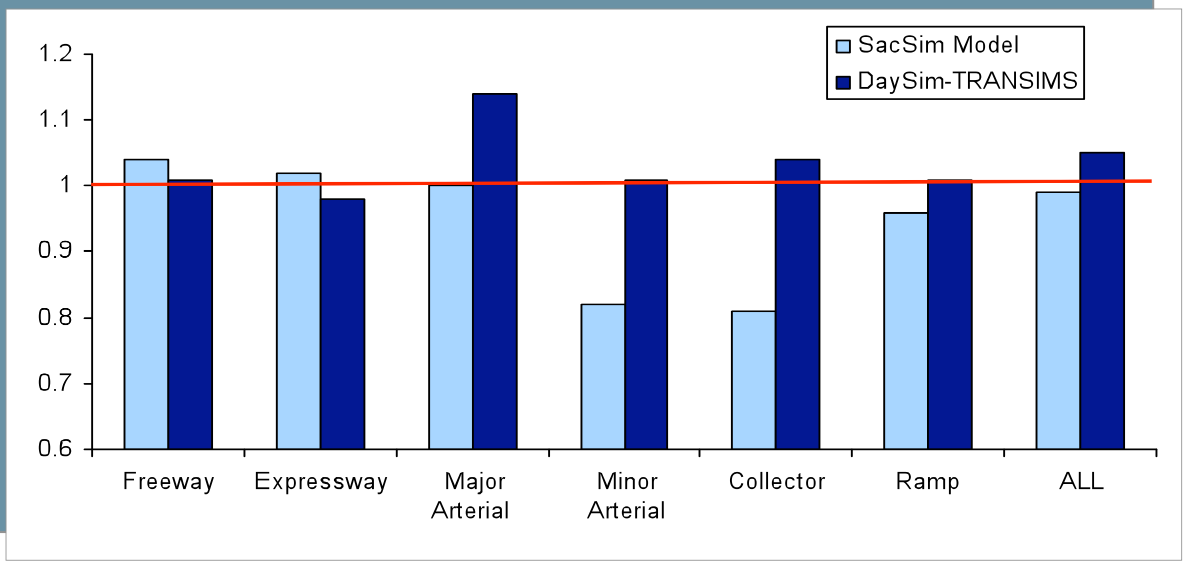


Regional Calibration

- 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

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



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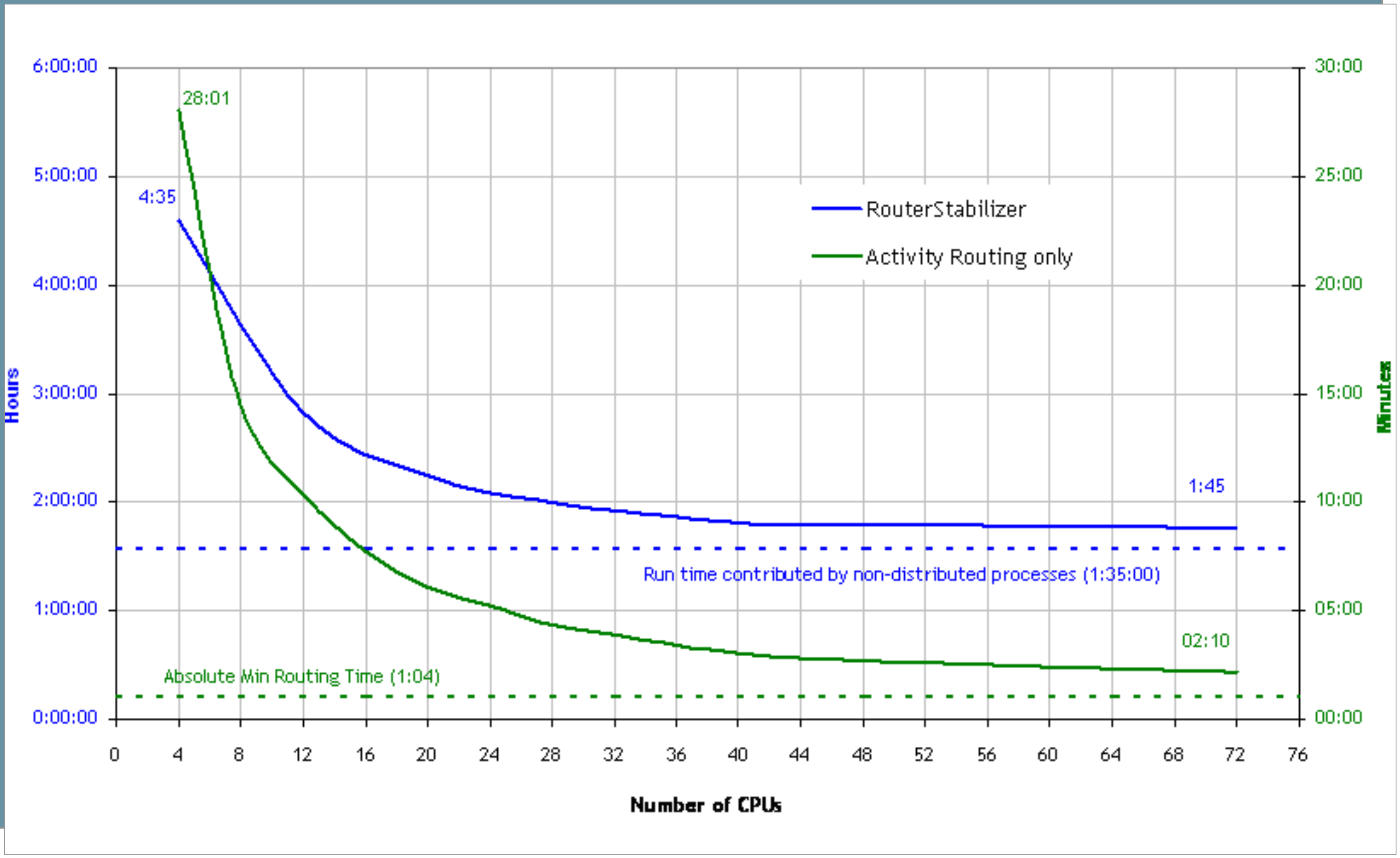
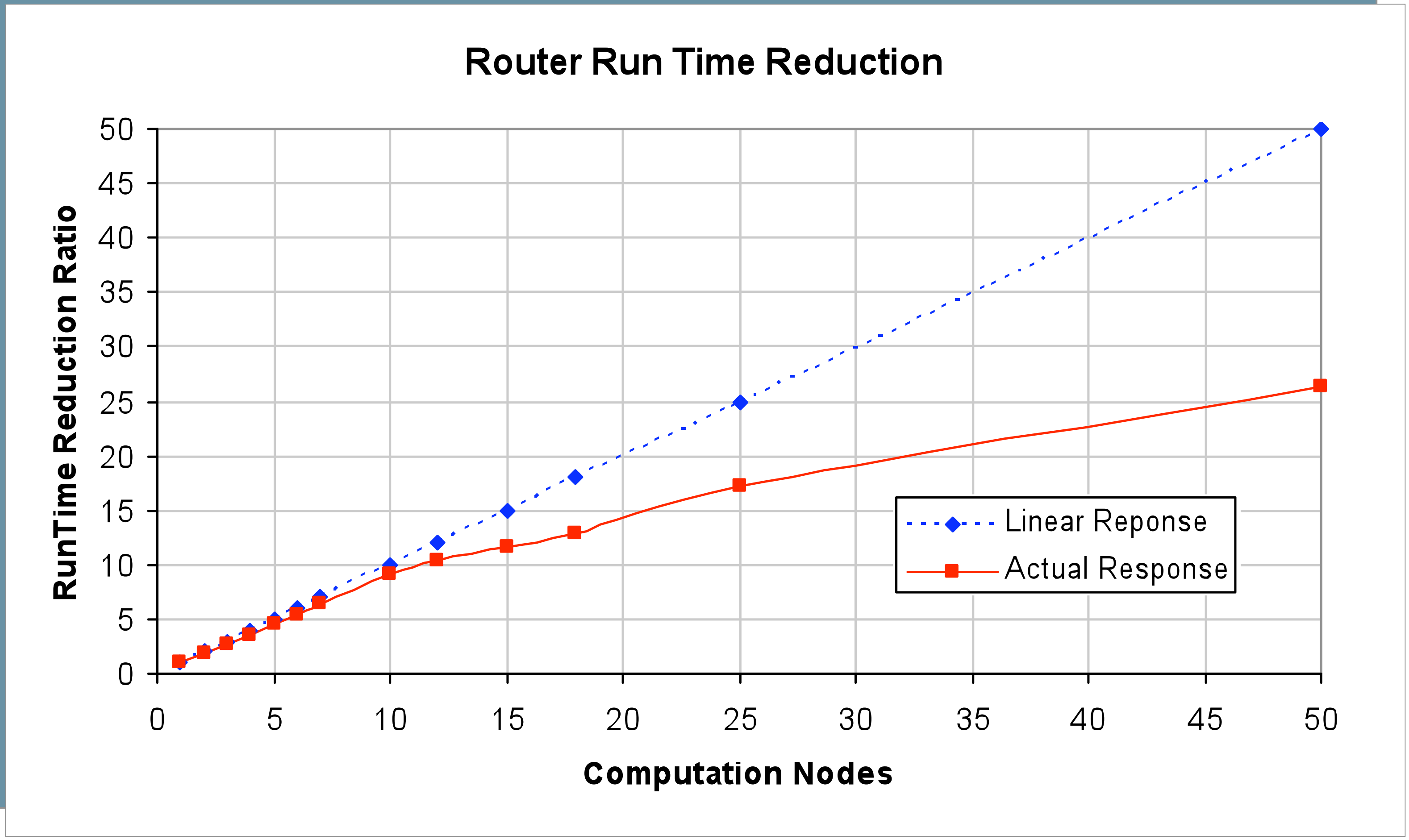
Run Times & Distributed Processes

- 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



TRACC Sensitivity Testing



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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?

Appendix

AM & MD Period Validation by Facility Type

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

Facility	# of counts	Estimated	Observed	Difference	% Difference	Avg Error	% Avg Error	% RMSE	R-Squared
Freeway	167	2,129,422	2,032,987	96,435	4.7	2,705	22.2	30.3	0.82
Expressway	53	142,421	149,460	-7,039	-4.7	564	20	29.4	0.941
Major Arterial	312	1,349,234	1,307,701	41,533	3.2	1,127	26.9	35.4	0.733
Minor Arterial	128	398,568	433,498	-34,930	-8.1	1,087	32.1	41.5	0.345
Collector	67	137,515	140,242	-2,727	-1.9	710	33.9	47.5	0.565
TOTAL	727	4,157,160	4,063,888	93,272	2.3	1,403	25.1	38.2	0.877

PM & EV Period Validation by Facility Type

Facility	# of counts	Estimated	Observed	Difference	% Difference	Avg Error	% Avg Error	% RMSE	R-Squared
Freeway	167	1,631,845	1,533,517	98,328	6.4	2,111	23	31.7	0.833
Expressway	53	107,631	119,620	-11,989	-10	497	22	31	0.936
Major Arterial	312	992,725	955,080	37,645	3.9	804	26.3	37.2	0.704
Minor Arterial	128	302,061	325,803	-23,742	-7.3	856	33.6	43.9	0.372
Collector	67	98,243	104,126	-5,883	-5.6	536	34.5	47.1	0.577
TOTAL	727	3,132,505	3,038,146	94,359	3.1	1,066	25.5	40.1	0.879

Facility	# of counts	Estimated	Observed	Difference	% Difference
Freeway	151	2,536,374	2,463,133	73,241	3.0
Expressway	53	175,691	166,543	9,148	5.5
Major Arterial	312	1,612,746	1,188,636	424,110	35.7
Minor Arterial	128	464,974	369,421	95,553	25.9
Collector	67	163,217	120,415	42,802	35.5
TOTAL	711	4,953,002	4,308,148	644,854	15.0