Building an Integrated Activity-Based & Dynamic Network Assignment Model

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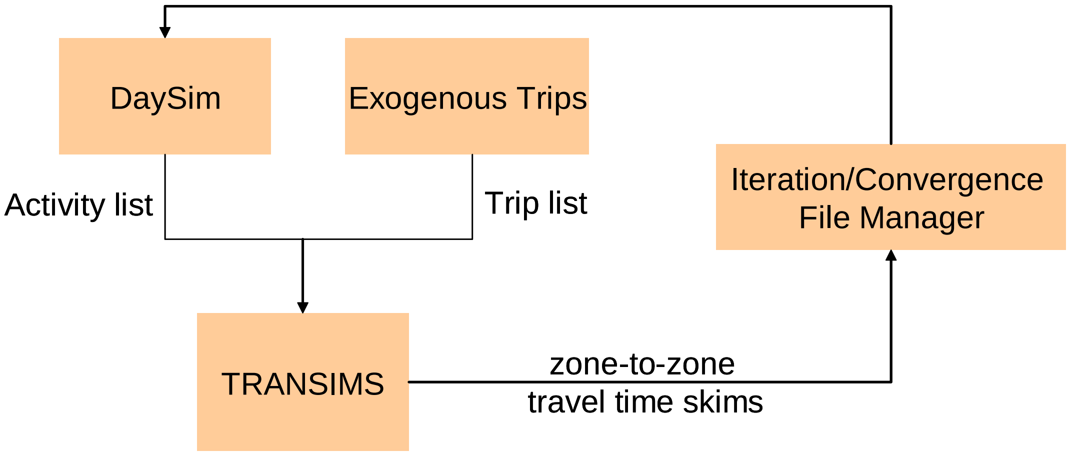
Objectives

- Project Problem Statement
  - Activity-based (AB) models limited by reliance on aggregate (spatially, temporally) static assignment model
  - Dynamic network assignment models not integrated with behaviorally-based travel demand component

- Project Solution: DaySim + TRANSIMS for Sacramento
  - DaySim
    - Provides disaggregate estimates of travel demand
    - Use individual characteristics to explain travel behavior
  - TRANSIMS
    - Spatially and temporally detailed network assignment
    - Provides detailed estimates of network performance

DaySim-TRANSIMS Integrated Model



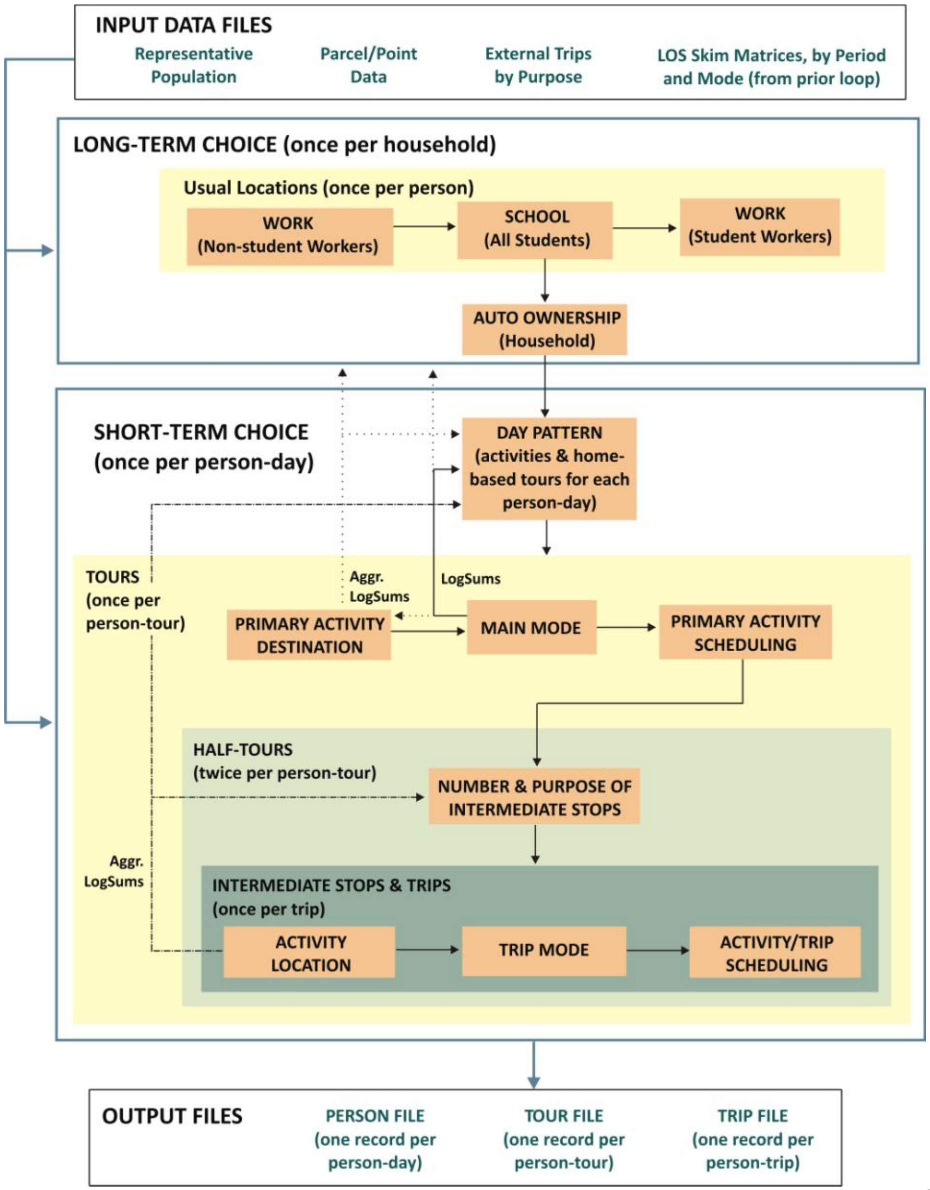
- DaySim → TRANSIMS
  - Produce TRANSIMS activity and other required files
- TRANSIMS → DaySim
  - Provide network impedance measures
- "Conservation of Demand"
  - All trips must be assigned in order to derive full benefit from integrated model system

Sacramento Region

- 6 counties in north-central California
- 2 million residents
- 1 million jobs
- 1500 TAZs
- 22,000 activity locations
- 600,000 parcels
- 6.25 million daily vehicle trips

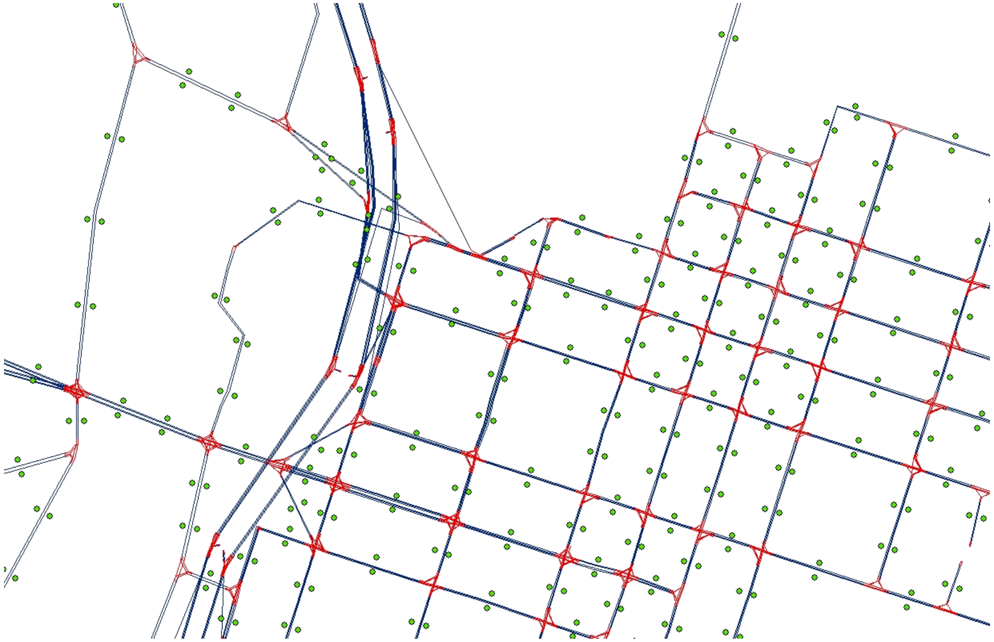
DaySim

- Detailed travel demand forecasting microsimulation
- Implemented in multiple regions
  - Sacramento (SACOG)
  - Seattle (PSRC)
- Extensively tested and peer reviewed
- Open source
- Features
  - Simulates 24-hour itineraries
  - Parcel-level spatial resolution
  - 30 Minute temporal resolution distributed to minute-by-minute
  - Tour-based / trip-chaining
  - Captures effects of time and cost on all travel choices



TRANSIMS

- Advanced traffic assignment and simulation capabilities
- Implemented in multiple regions
  - Chicago
  - Portland
  - Sacramento
  - Burlington
  - Washington DC
- Extensively tested and peer reviewed
- Open source
- Features
  - Simulate 24-hour travel plans reflecting controls, restrictions, geometries
  - Second-by-second temporal resolution



TRANSIMS activity locations & network

TRANSIMS: Features

- A suite of tools, but this project used Router only:
  - Population synthesizer
  - Activity Generator
  - *Router – develops routing "plans" to satisfy activity participation*
  - Microsimulator – uses Router plans to perform a regional microsimulation of traffic on a second-by-second basis
- Disaggregate simulation tracks:
  - Individuals
  - Households
  - Vehicles
- "DTA-like"
  - Consistent: Experienced travel time, Assignment at fine-grained temporal resolution
  - Inconsistent: Use of VDF, No queuing, fixed intersection delay

Implementation

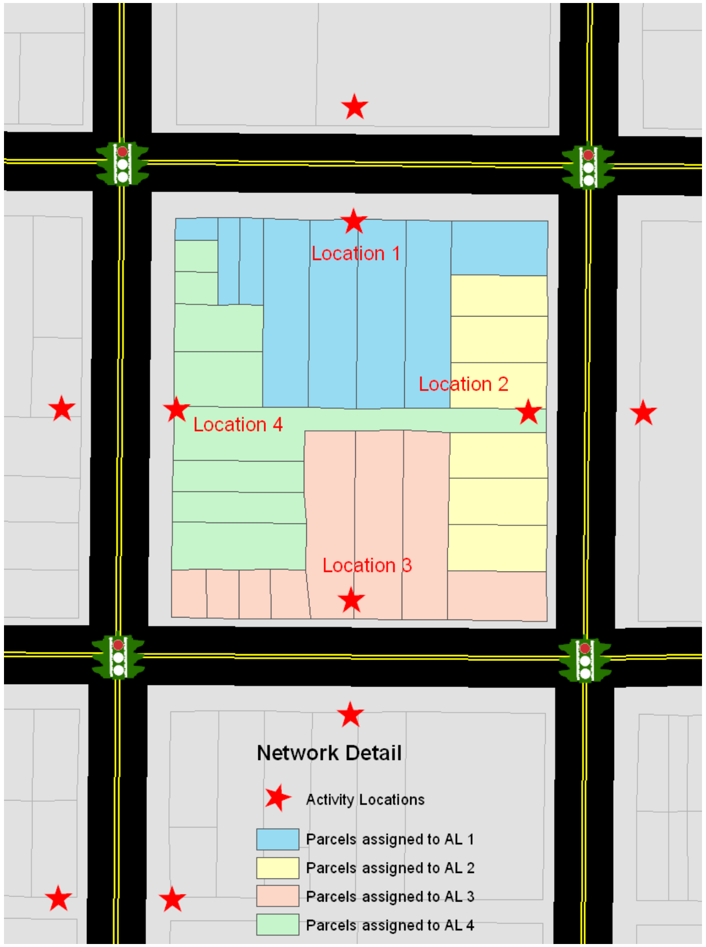
- DaySim modifications
- TRANSIMS network build
- Exogenous demand process
- Assignment strategies & convergence
- Network impedance process
- System convergence
- Runtime optimization

DaySim Modifications

- Few modifications necessary due to structure and detail of AB model and outputs
- Activity files rather than trip files
- Identification of shared ride passengers and drivers
- Aggregation to activity locations rather than TAZs
- Increased temporal detail
    - Revised to use 22 time period skims rather than original 4
    - Some simplifications necessary in order to hold all skims in memory

TRANSIMS Network Build

- Converted traditional 4-step model networks.
- Roadway network conversion only
- Network debugging during calibration/validation



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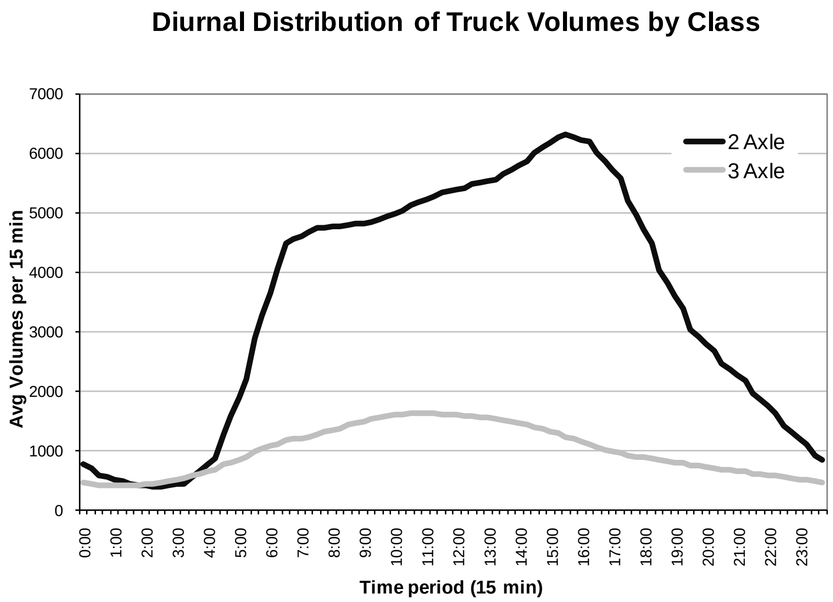
Exogenous Demand Process



- 20% of demand
- Types
  - Airports
  - Trucks
  - Externals
- Exogenous demand is travel demand not represented by core DaySim components
- Exogenous demand “fixed” in initial implementation
- TRANSIMS ConvertTrips program disaggregates spatially and temporally

Convergence

- Convergence necessary in order to ensure behavioral integrity of model system
- Iterative feedback
  - Assignment iterations
  - System iterations
- System convergence when inputs are consistent with outputs
- 3 phase implementation
  - Achieve assignment convergence using the Router
  - Achieve system convergence
  - Optimize/coordinate to reduce runtimes

Trip Gap

- Dynamic User Equilibrium (DUE)
  - Requires that the equilibrium condition be established for each departure time rather than over a broad time period.
  - Integrated model performs assignments at very detailed spatial (22,000 ALs) and temporal (minutes) levels
- Trip Gap
  - Calculated at the trip level with flexible temporal resolution
  - Gap measure of user equilibrium that exploits the disaggregate nature of the TRANSIMS Router
  - Similar to network-based

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

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 $\{c_{at}\}$

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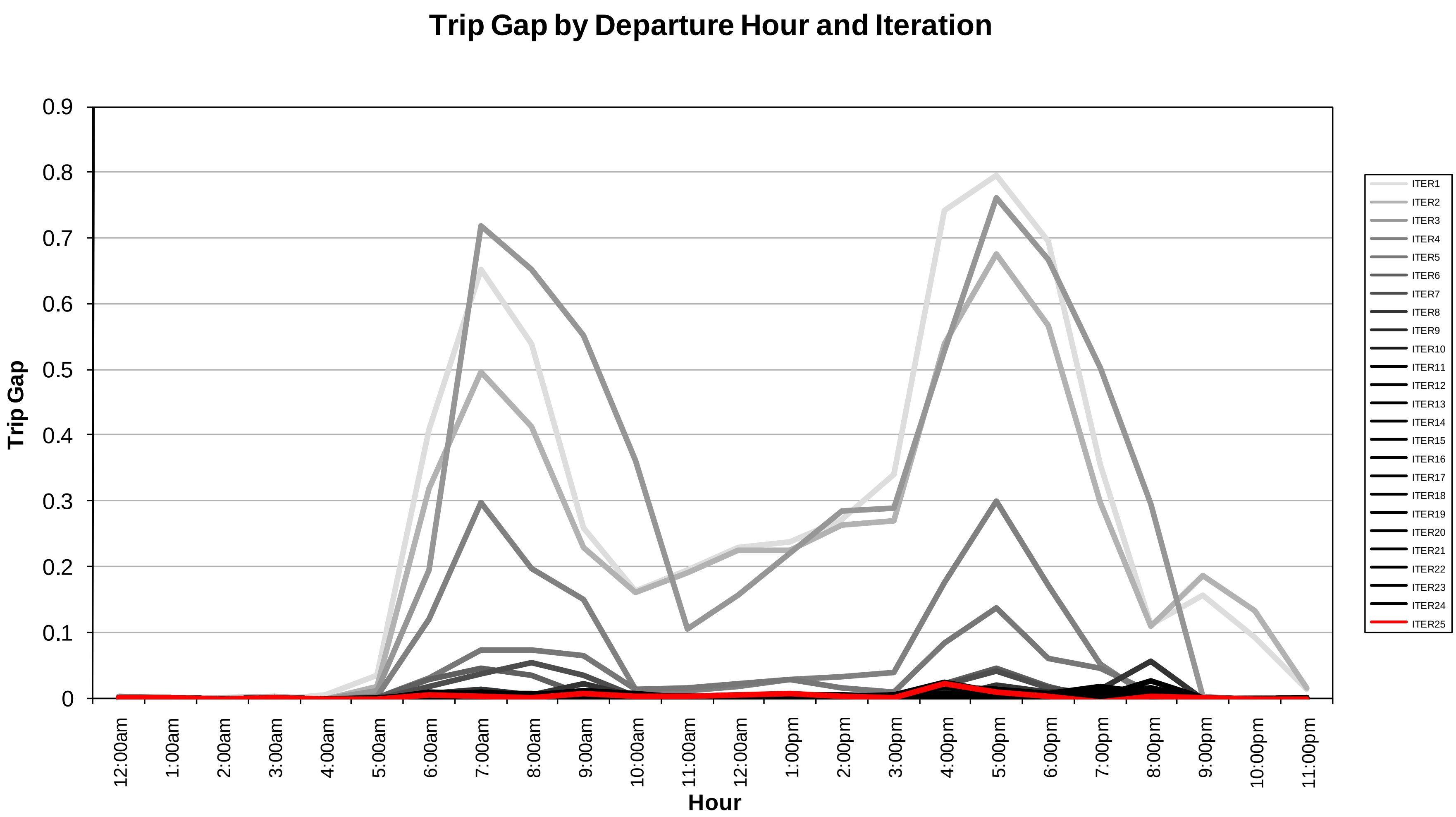
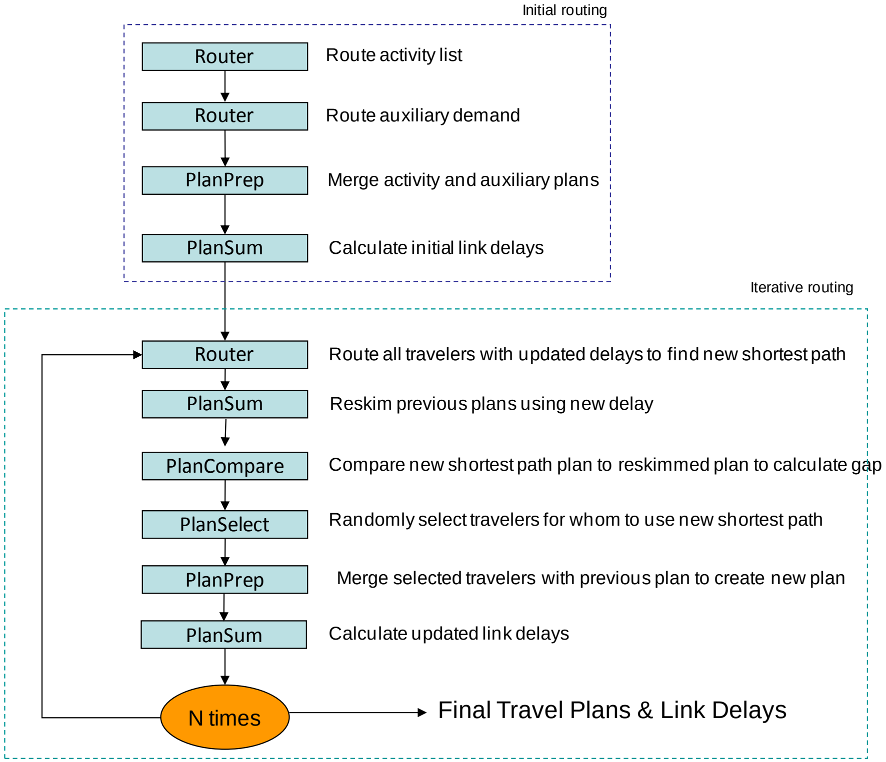
Trip Gap by Time Period



Router Stabilizer

- Multiple methods tested
- Original method
  - Route all travelers at every iteration
  - V/C heuristics in early iterations
  - Employ link volume averaging
- Revised Subselection method
  - Eliminated explicit link averaging
  - Eliminated use of heuristics
  - Consistent with current DTA practice
  - Doesn’t converge as well or as quickly



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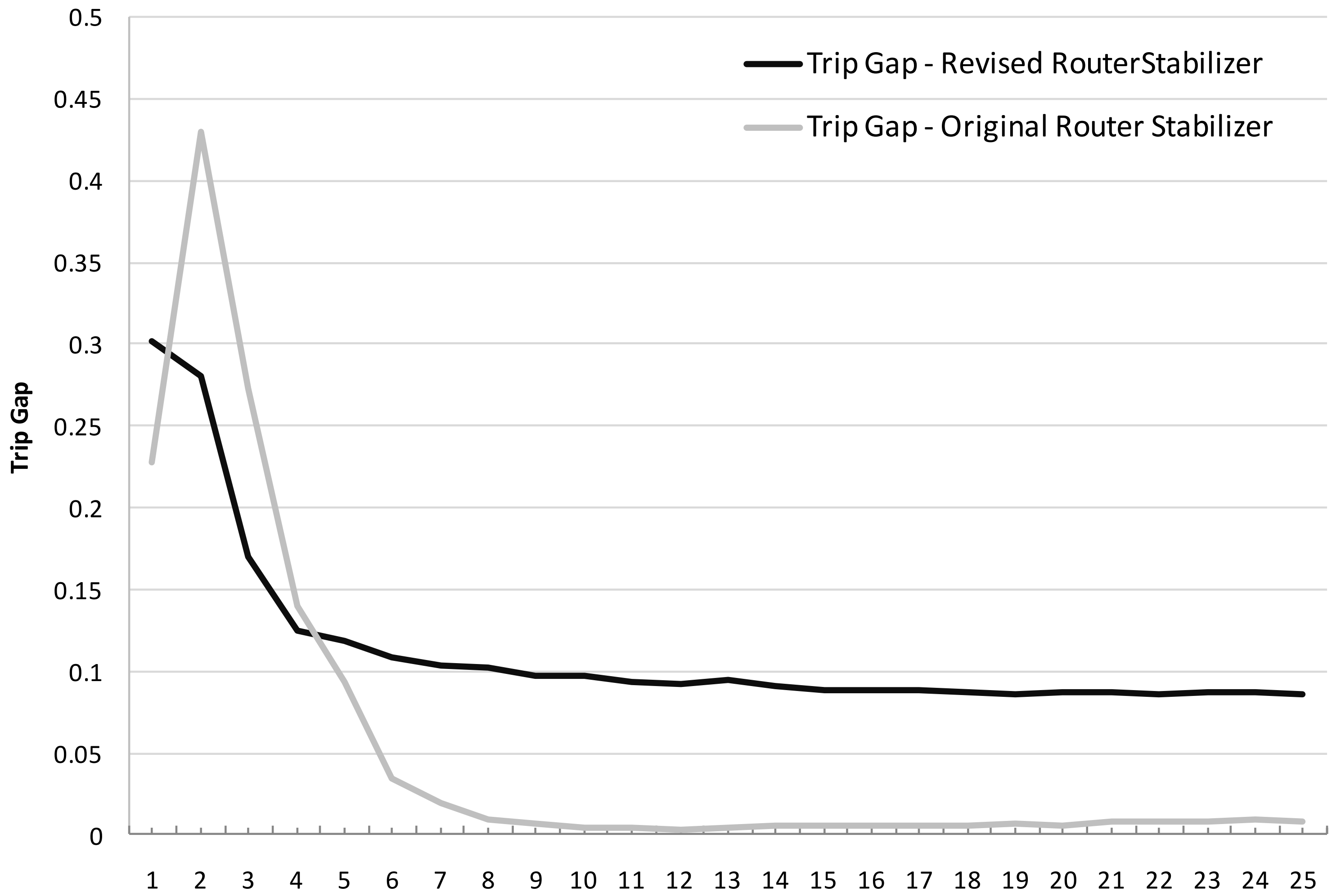
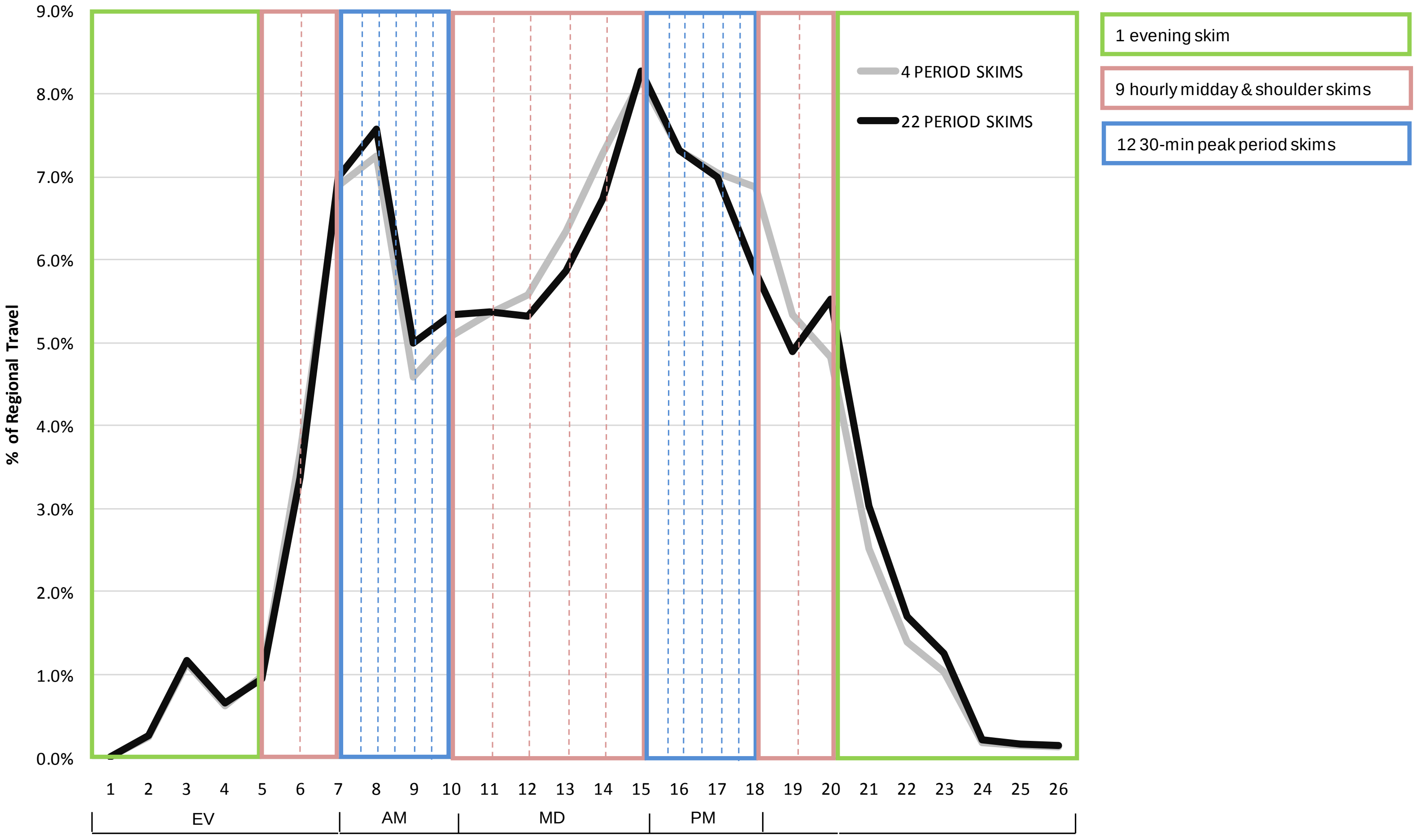
Router Stabilizer: Original vsRevised



Network Impedance Skims

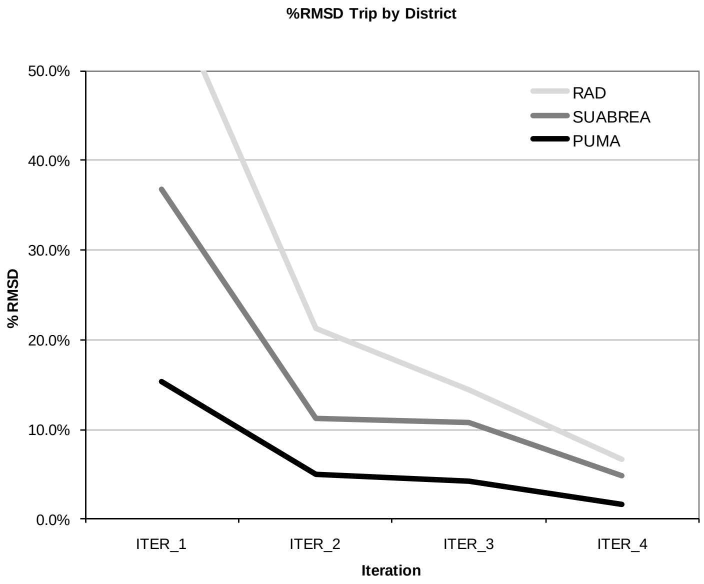
- Router tool creates traveler “plans”
- Plans summed to produce link volumes and delays
  - Flexible temporal resolution
  - 15 minute resolution for this project
- PlanSum tool creates skims of times, distances and costs
  - Initially, 4 broad time periods
  - Refined to include 22 time periods (1/2 hour in peaks, 1 hour in midday and peak shoulders, multi-hour overnight)
  - TAZ level

Network Impedance Skims Revised



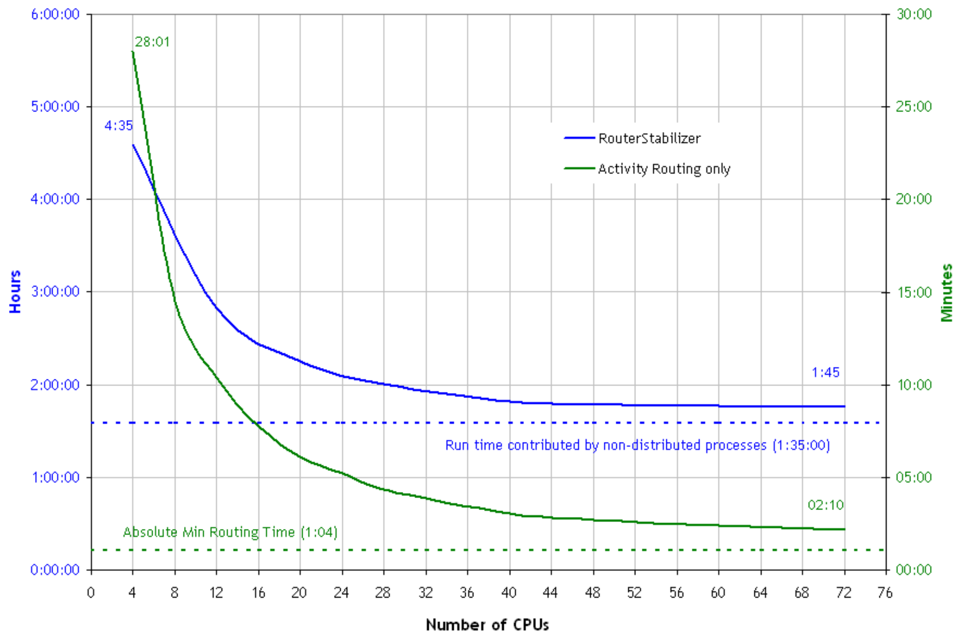
System Convergence

- Common strategies for achieving system convergence not applicable
  - Averaging travel demand doesn't work in disaggregate framework
  - Averaging skims doesn't work as we move towards "on the fly"
- Strategy for system convergence: averaged link volumes across system iterations and recalculated of link delays
- Measure of system convergence: Root mean square difference in district flows



Runtime Optimization

- Significant processing times
- Distributed / parallelized processing
- Windows or LINUX-based



Testing on TRACC cluster at Argonne National Lab identified that max runtime gains achieved with ~40 processors

Validation: SACSIM vs Integrated Model

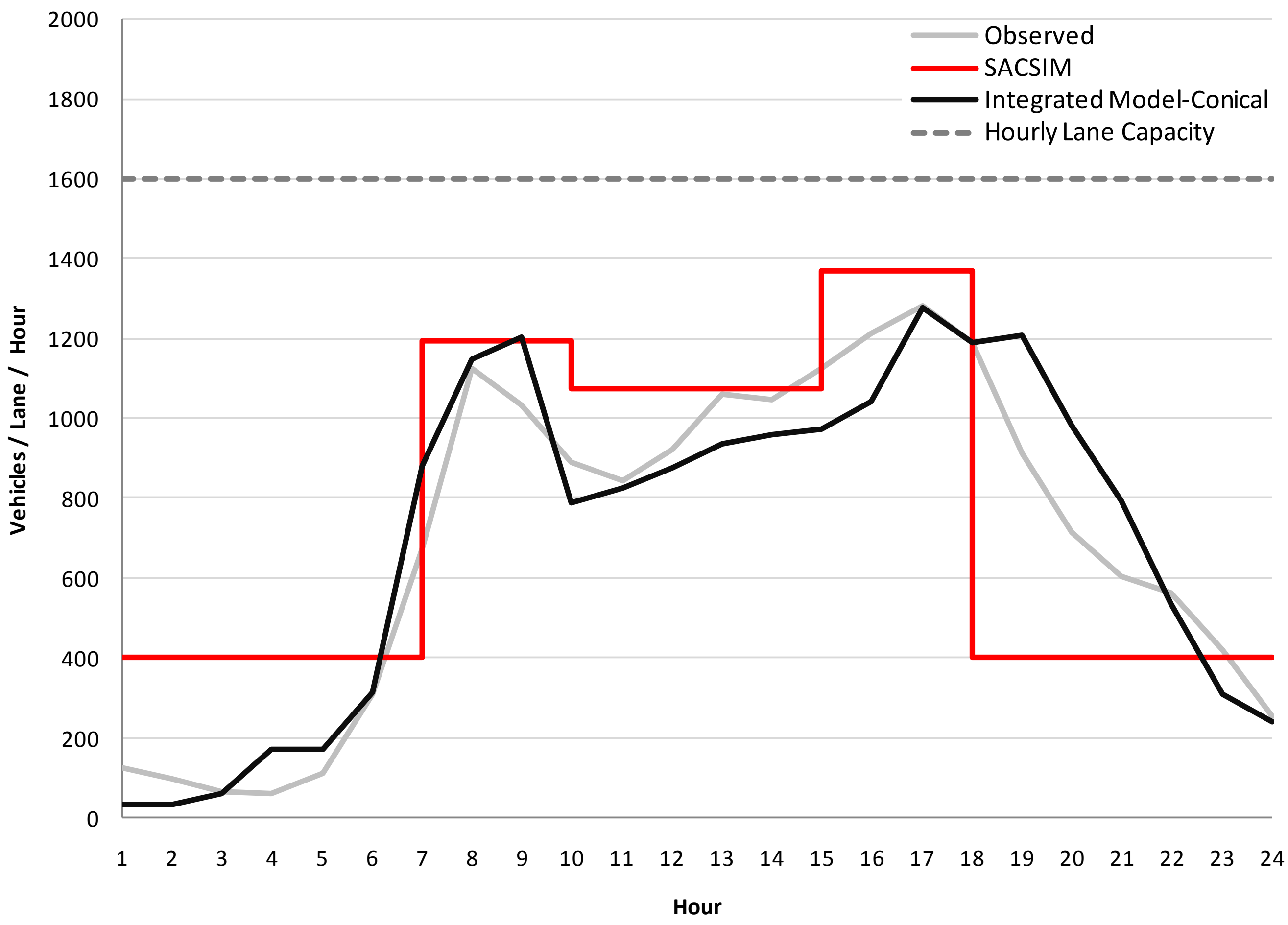
Daily

	SACSIM Model	Integrated Model
Facility Type	Validation Ratio	Validation Ratio
Freeway	1.04	1.01
Expressway	1.02	0.98
Major Arterial	1.00	1.14
Minor Arterial	0.82	1.01
Collector	0.81	1.04
Ramp	0.96	1.01
TOTAL	0.99	1.05
R-squared	0.97	0.91
Ave Link Error	21%	25%
RMSE	35%	41%

PM Peak

	SACSIM Model	Integrated Model
Facility Type	Validation Ratio	Validation Ratio
Freeway	1.05	1.06
Expressway	1.06	0.90
Major Arterial	0.95	1.04
Minor Arterial	0.81	0.93
Collector	0.77	0.94
Ramp	-	-
TOTAL	0.97	1.03
Ave Link Error	21%	25%
RMSE	35%	40%

Sensitivity Test: Watt Ave Bridge Base Validation



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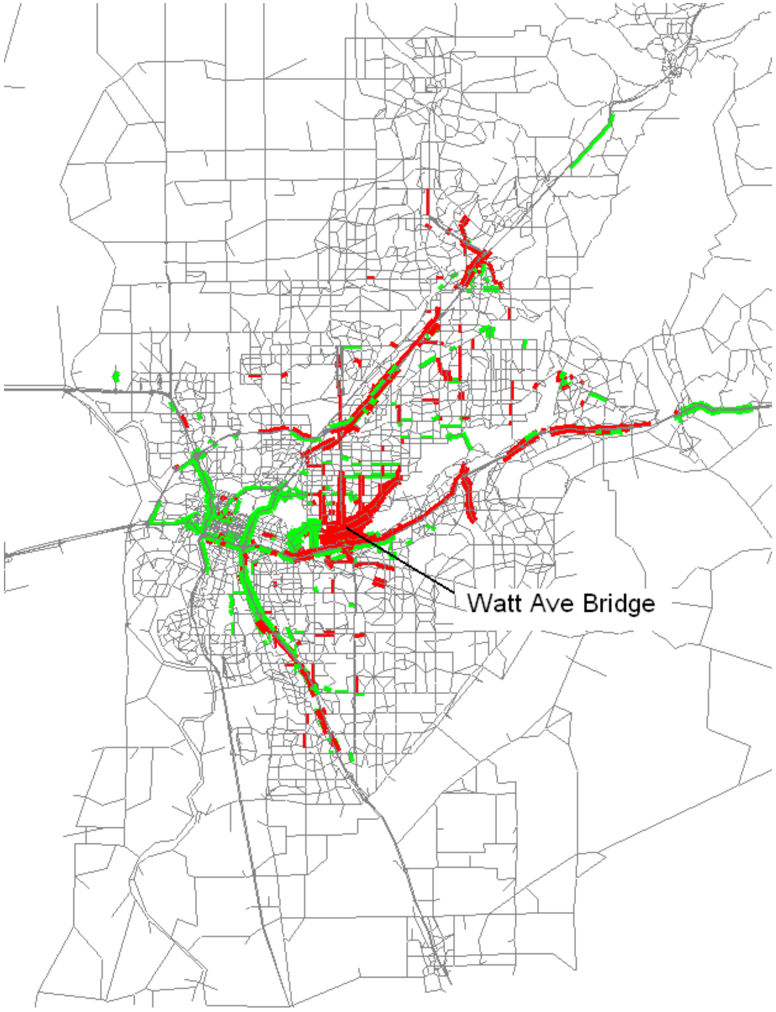
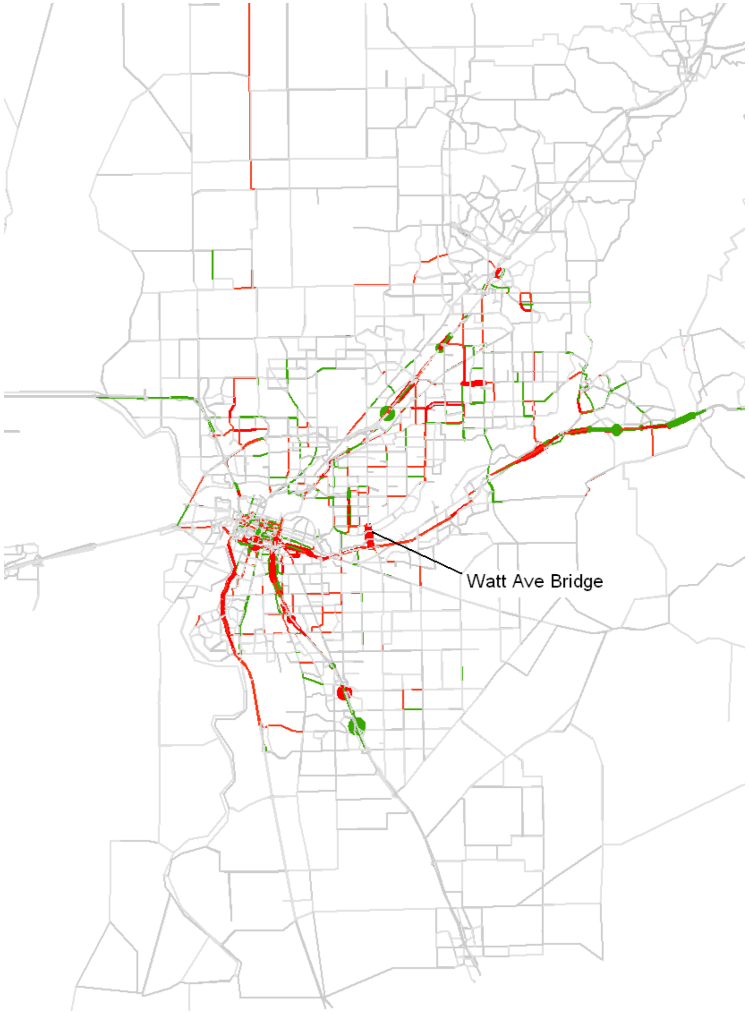
Sensitivity Test: SACSIM vs Integrated Model

SACSIM



Integrated Model



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Lessons Learned

- Integrating an AB model with a detailed network assignment model and producing reasonable validation and sensitivity results is an achievable goal.
- Development of skims for aggregate time periods involves many complexities and the skim construction process needs to be thoughtfully considered and integrated with the demand model.
- AB models and network simulation models provide more opportunities as well as more complications when addressing activity and time scheduling issues.
- Reasonable results were achieved with a “straight transfer” of all DaySim travel demand model coefficients and constants.
- Integrated model would benefit from additional calibration efforts, both on the travel demand and the network supply side.
- Network convergence measures and methodologies need to be thoughtfully considered, and need to address both theoretical and practical (i.e. runtime) concerns.

Future Development

- Spatial and temporal disaggregation of skims
  - Activity location level or flexible “skim location” level
  - “On the fly” level-of-service calculation
  - Fine-grained time periods
- Refined convergence methods
  - Rescheduling (demand side, supply side)
  - Reassigning subsamples
  - Coordinated demand resimulation and reassigning of targeted HHs, persons, trips
- Integration of Microsimulator
  - More complete representation of network characteristics and performance
  - Long runtimes
- Enhanced behavioral sensitivities
  - Distributed values of time (VOT)
  - Intra-household coordination
- TRANSIMS v5