Incorporation of ABM-Derived Transit Demand into a DTA

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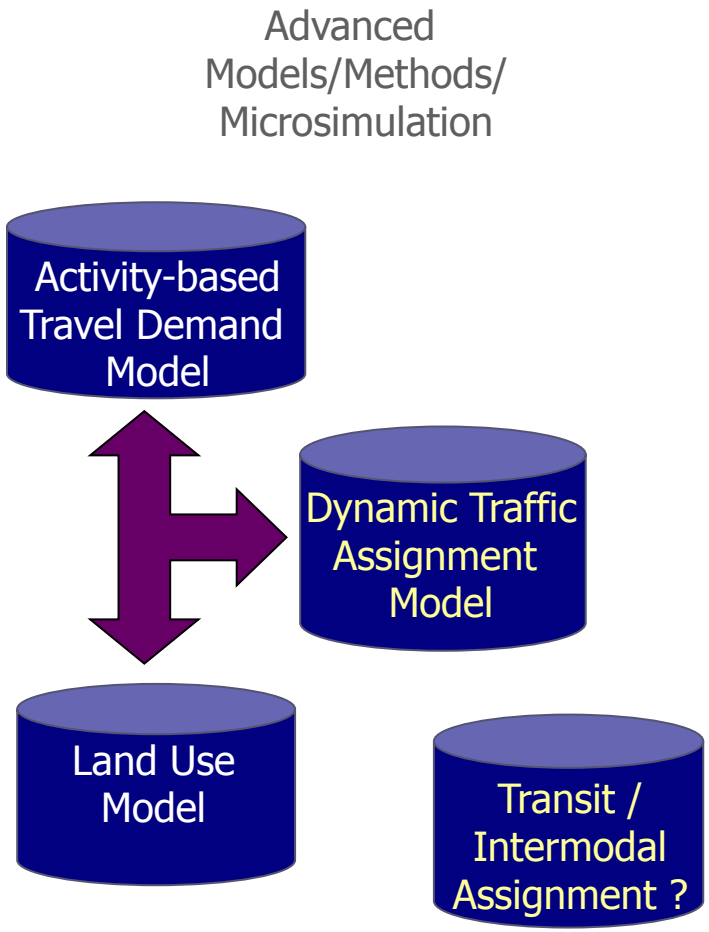
Research and Implementation

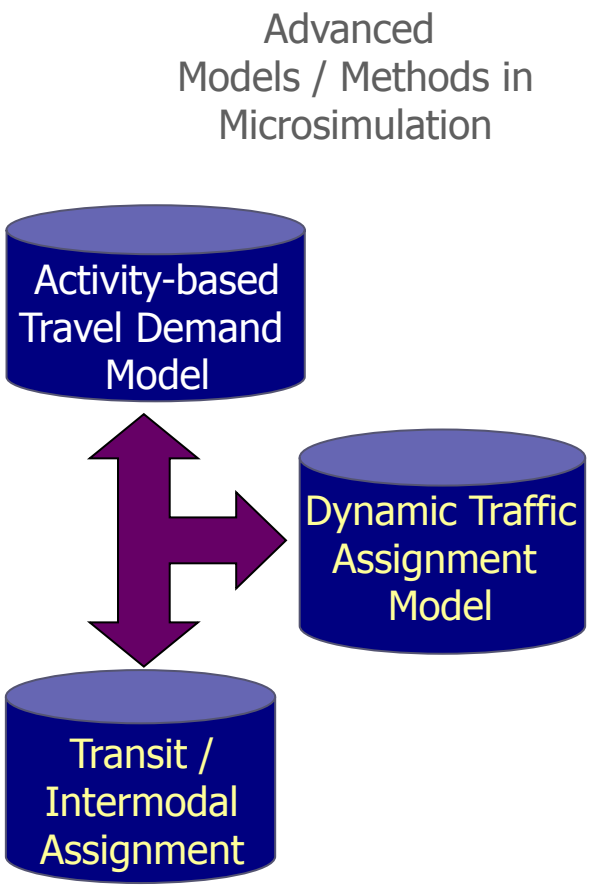
- Modeling the Urban Continuum in an Integrated Framework: Location Choice, Activity-Travel Behavior, and Dynamic Traffic Patterns
  - Sponsor: FHWA EAR Program
  - PI: Ram Pendyala, ASU



Research and Implementation

- SHRP2 C10-B: Partnership to Develop an Integrated, Advanced Travel Demand Model and a Fine-Grained, Time-Sensitive Network
  - Sponsor: SHRP2, Project C10-B
  - PI: Tom Rossi, Cambridge Systematics

- Modeling Dynamic Transit Travel for San Francisco County
  - Sponsor: SFCTA, University of Arizona
  - PI: Elizabeth Sall / Mark Hickman



Research Contributors

- U of A Transit Research Unit http://transit.arizona.edu/
  - Hyunsoo Noh
  - Alireza Khani
  - Sang Gu Lee
  - Neema Nassir
- Sacramento Area Council of Governments (SHRP2 C10-B)
- San Francisco County Transportation Authority

Dynamic Transit Demand Modeling

Motivating Questions:

- How do we model transit use on tours, not just trips?
  - Constraint on mode choice throughout tour
  - Restrictions on time-of-travel from transit schedule
  - Realistic transit path choice modeling
  - Intermodal path choice / station choice
  - Agent-based simulation

- How do we capture realistic passenger level of service?
  - Schedule-based transit services, by time-of-day
  - Operational dynamics of transit service
  - Allowing for delays, missed transfers, crowding

Software Requirements

Need for a versatile simulation and assignment tool that:

- Captures operational dynamics for transit vehicles
- Connects with Dynamic Traffic Assignment (DTA) software
- Captures individual traveler assignment and network loading in a multi-modal context
- Becomes and remains open-source

F*lexible*
A*ssignment and*
S*imulation*
T*ool for*
Tr*ansit and*
I*ntermodal*
P*assenger****s***

High-level Design Approach

- Let the DTA models do what they do best
  - Assign paths to individual vehicles
    - Fixed-route transit vehicles have a pre-specified path, at a given time
  - Simulate traffic operations for millions of vehicles
  - Simulate transit vehicle movements
    - Vehicles follow traffic flow rules
    - Individual vehicle trips can have modest controls

- Create a separate tool that integrates with DTA
  - Assigns individual passengers to routes, by time-of-day
  - Simulates transit passenger movements based on DTA output
  - Provides skim information for feedback to travel demand models
  - Manages full assignment, transit simulation for intermodal trips

Transit Vehicle Movements in DTA

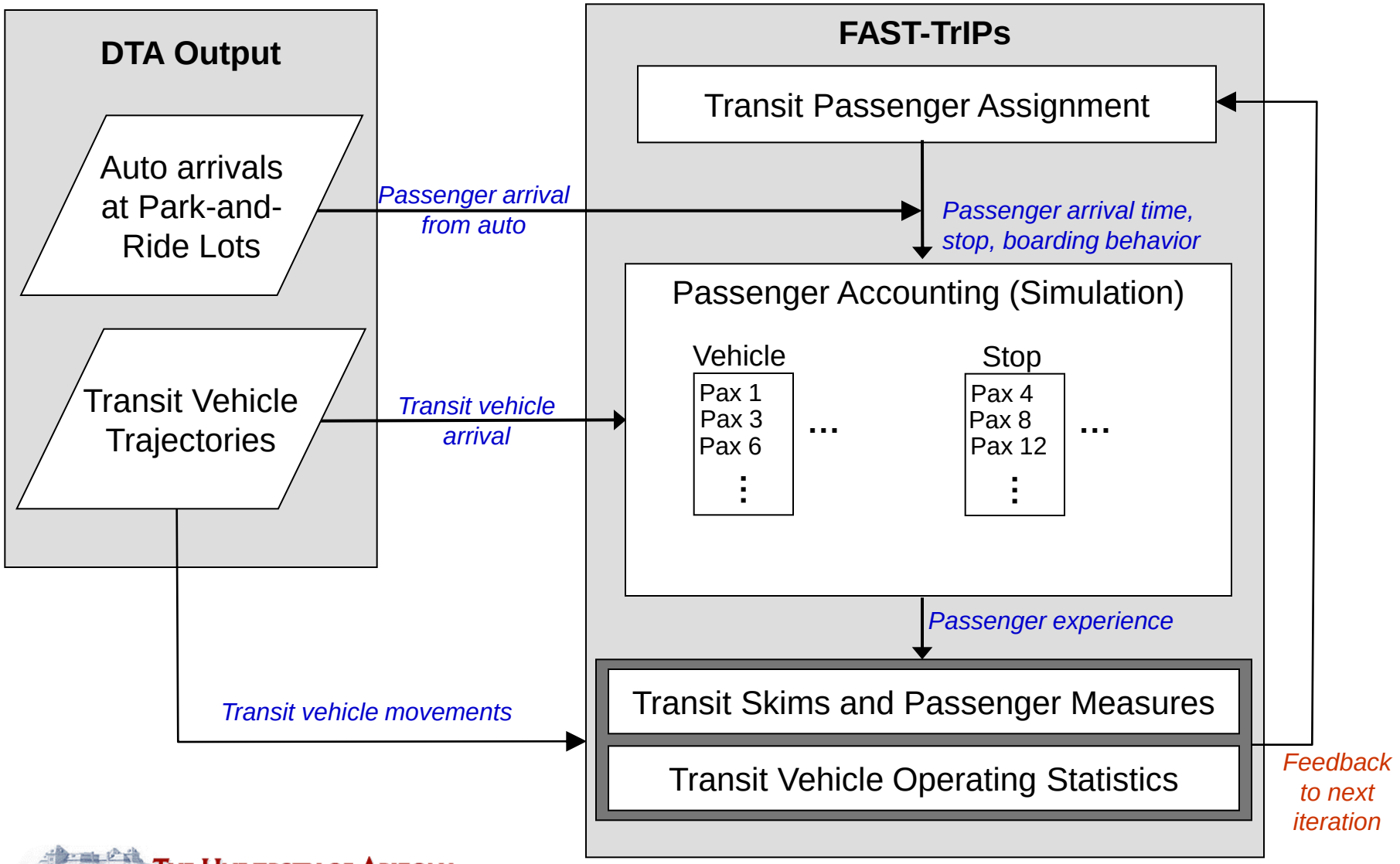
- Routes are designated by specific paths for transit vehicles
- Transit vehicles leave terminals at designated scheduled times or at specific headways
- Transit vehicles move through the network
  - Mesoscopic flow characteristics while in the traffic stream
  - Pull-outs and/or curbside traffic behavior
  - Specific modeling of hail stops, dwell times:
    - Track number of passengers at or desiring specific stops
    - Use incremental boarding and alighting time model

      Dwell time = max $\{b_1 * B , b_2 * A \}$
- Trajectory output includes transit vehicle departure times at all stops, travel times along route

Transit Assignment

- Transit assignment: Passenger path choice
  - Deterministic model: Shortest or least-cost, time-dependent path
  - Stochastic model: Discrete choice among all paths serving origin and destination at a given time
- Solution method
  - Direct calculation of stop and path choice in uncongested conditions
  - Iterative convergence of an assignment to a user equilibrium, if capacity constraints apply (heavily congested routes)
- Time-dependent path calculations can exploit GTFS data, transfer stop / station heirarchy

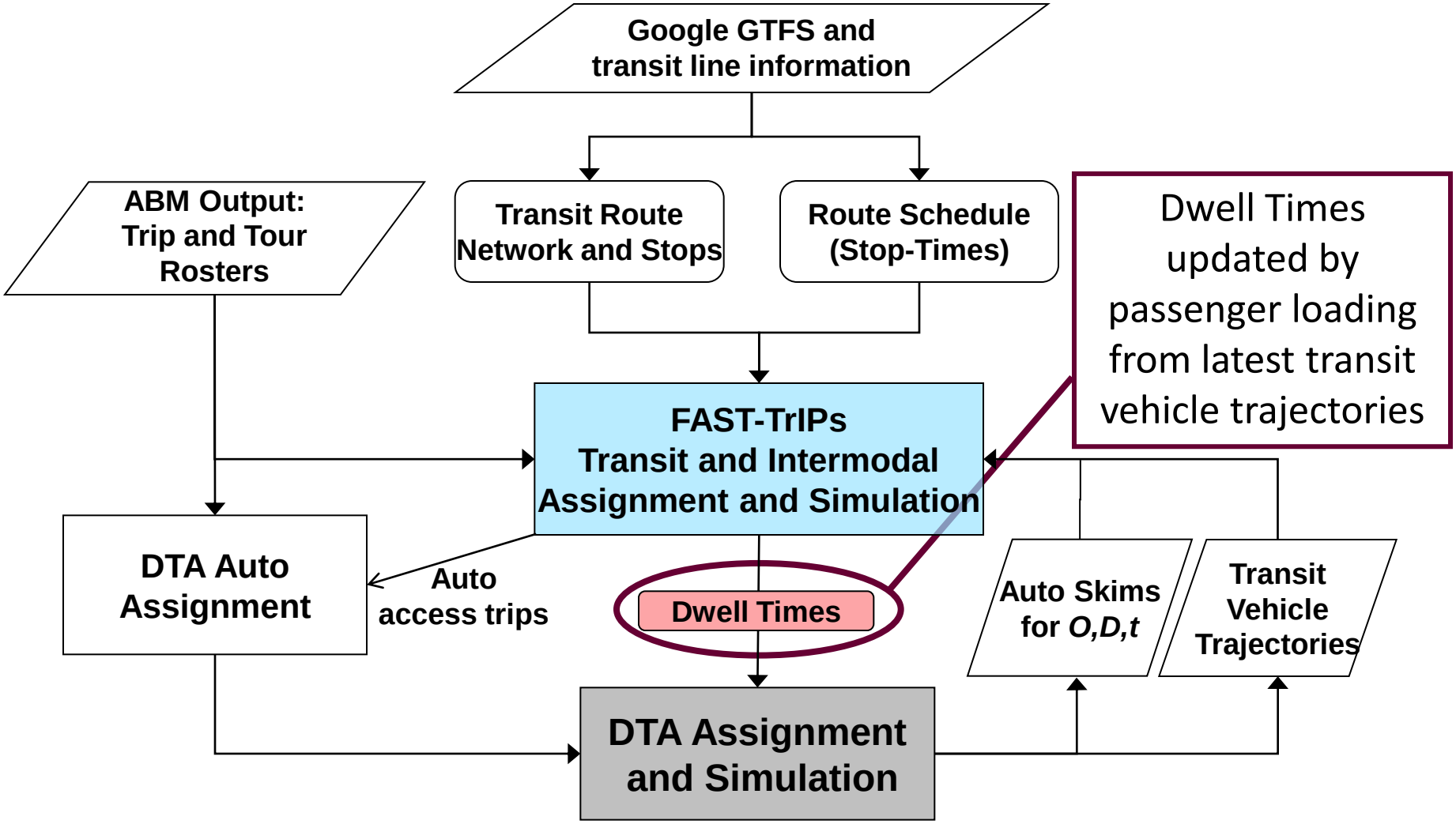
Transit and Intermodal Loading



Transit Simulation / Passenger Loading

- Passenger “loading” to queue at stops
  - Origin departure time + bike or walk access time
  - Arrival time at stop for auto access, transit transfers
  - Priority treatment based on arrival time
- Vehicle “loading” at stops
  - “Hail stop” operations
  - Passengers “alight” from vehicle: transfer to another stop queue, or egress (bike, walk, auto) to destination
  - Passengers “board” from stop to vehicle, according to individual assignment (in priority order)
  - Transit vehicle held until max of { dwell time, holding time }
- Passengers denied boarding / missing a vehicle are re-assigned

Iterative Process through Dwell Times



Transit Skims and Operating Statistics

- Transit operating characteristics
  - Transit vehicle trip travel times, by route segment (DTA)
  - Transit vehicle loads, by route segment (FAST-TrIPs)

- Passenger experience
  - Passenger travel times, costs from experienced paths
  - Passengers denied boarding due to capacity constraints
  - Passengers missing connections on scheduled service

Experience with FAST-TrIPs

- FHWA EARP: Modeling the Urban Continuum
  - ABM: OpenAMOS
  - DTA: MALTA (Mesoscopic Assignment and Loading of Traffic Activities)
  - ABM and DTA simulate the day in parallel, then iterate
  - Phase I case study (Phoenix / MAG) uses auto mode only

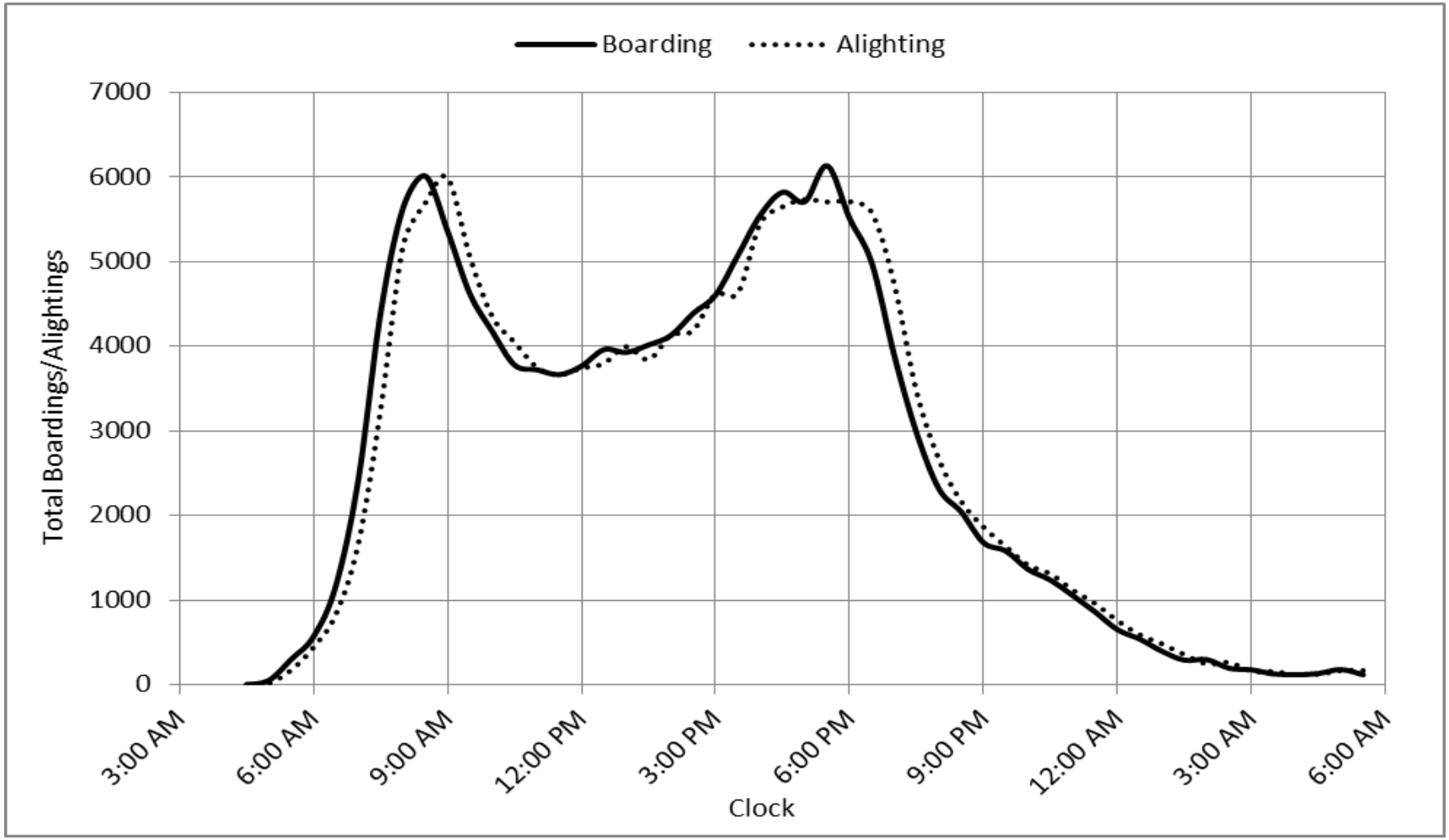
- SHRP2 C10-B
  - ABM: DaySim
  - DTA Model: DynusT (Dynamic Urban Systems in Transportation)
  - ABM and DTA simulate the day in series, then iterate
  - Entering transit model calibration and scenario modeling with SACOG

Experience with FAST-TrIPs

- SFCTA: Modeling Dynamic Transit Travel for San Francisco County
  - ABM: SF-CHAMP
  - DTA: Dynameq
  - ABM and DTA simulate the day in series, then iterate
  - SFCTA has a stochastic transit path choice model

- Case study:
  - Develop network interface with Dynameq
  - Generate transit network and schedule using GTFS
  - Estimate time-of-day use from automated passenger count data
  - Apply deterministic and stochastic path choice models
  - Validate using passenger boarding, alighting, loading

Travel by Time of Day from APC data



SFCTA Stochastic Path Choice Model Weights

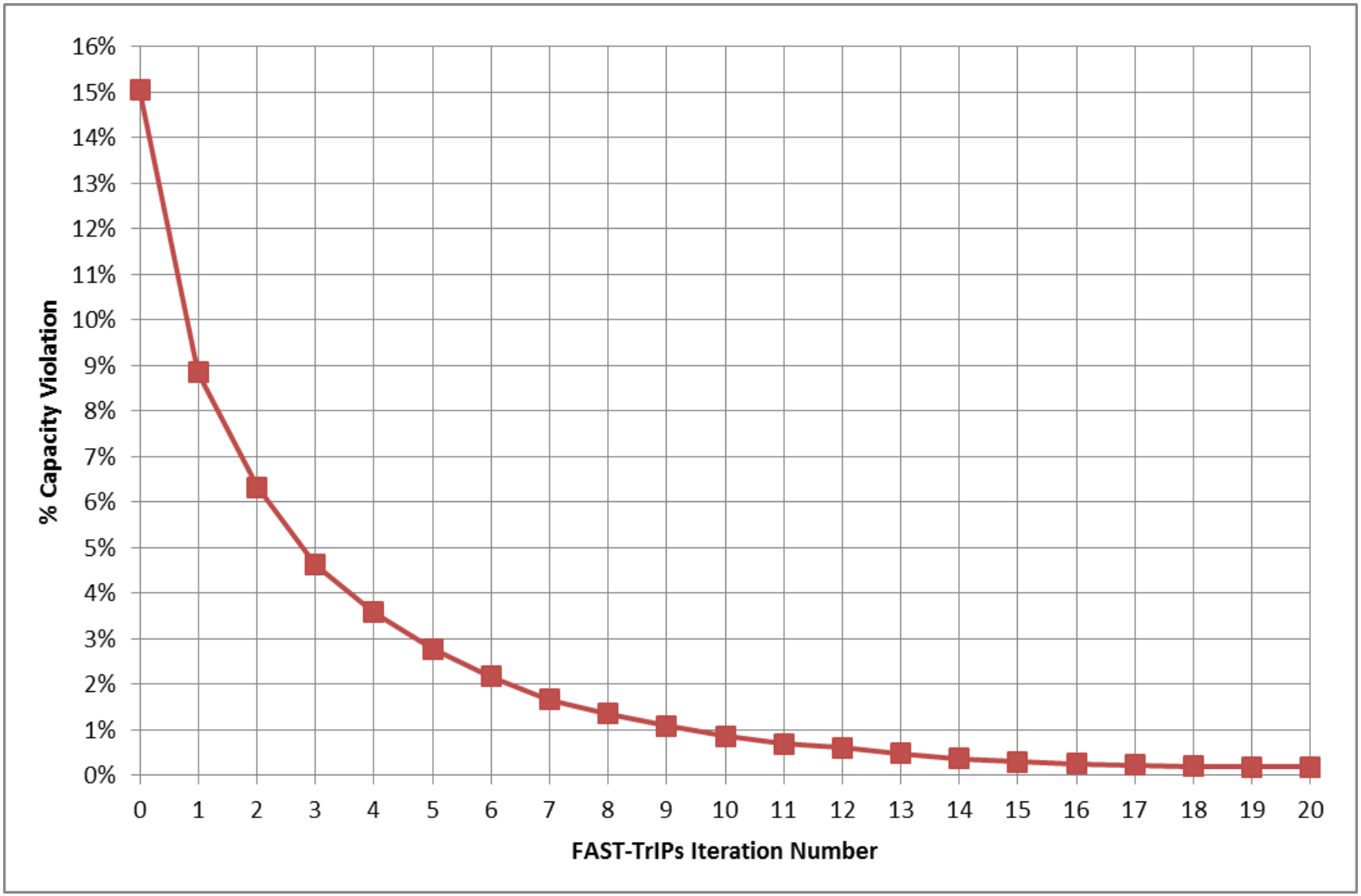
Coefficient values relative to in-vehicle time = 1.0

Transit Wait	2.23
Transit Access Walk	1.83
Transit Egress Walk	5.39
Transfer Walk	7.45
Bike (mode)	2.56
Walk (mode)	2.70

FAST-TrIPs and DTA Results: *PM Peak Period*

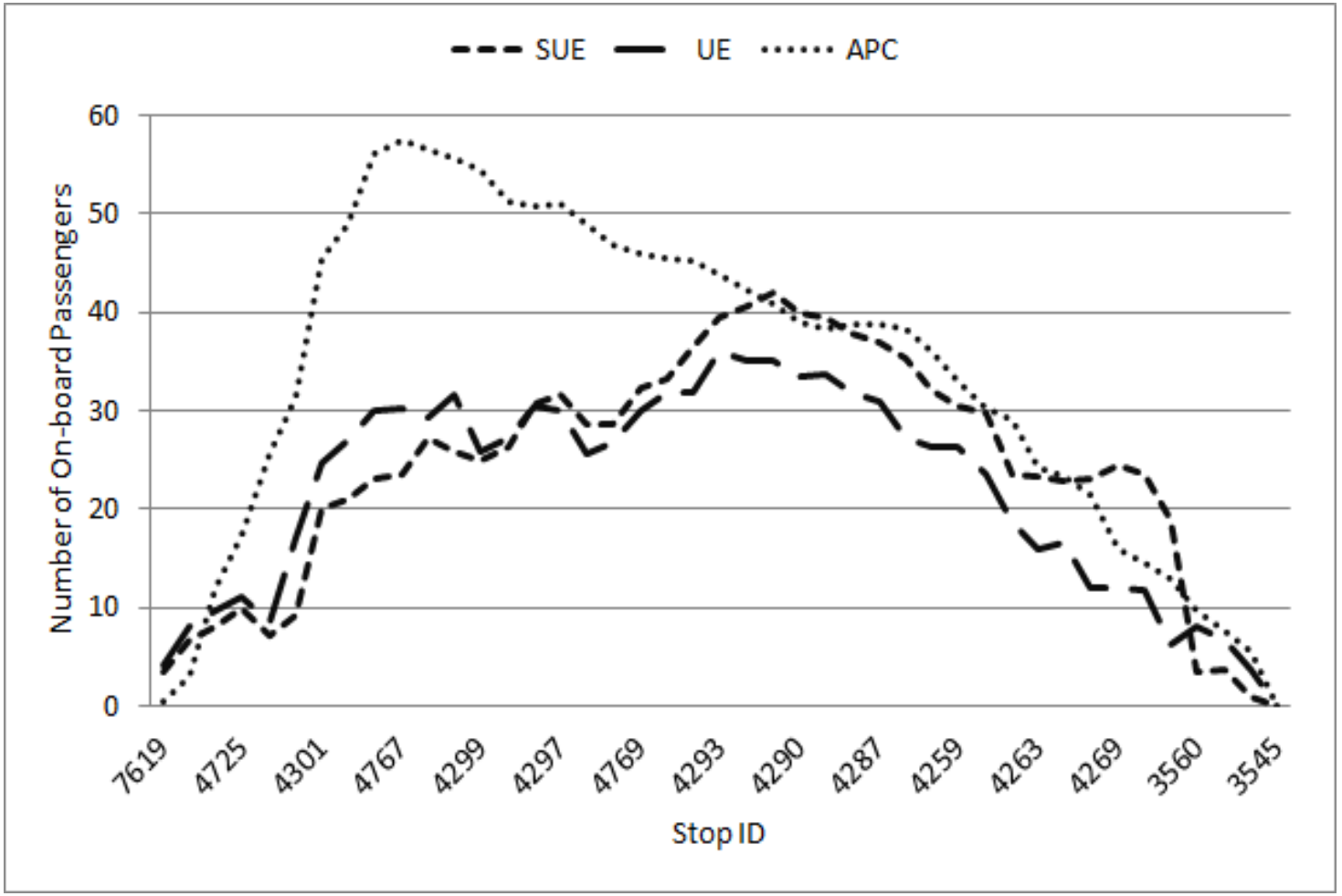
	Deterministic	Stochastic
# of Global Iterations	2	2
Dwell Time Gap (%)	61	64
# of FAST-TrIPs Iterations	7	7
CPU Time (min)	92	203
Transit Demand (trips)	85,665	85,665
Capacity Violation (%)	1.67	1.72
Avg Travel Time (min)	25.31	25.94
Avg # of Transfers	0.71	0.72
Avg Dwell Time (sec)	8.1	8.8

Transit Capacity Violations



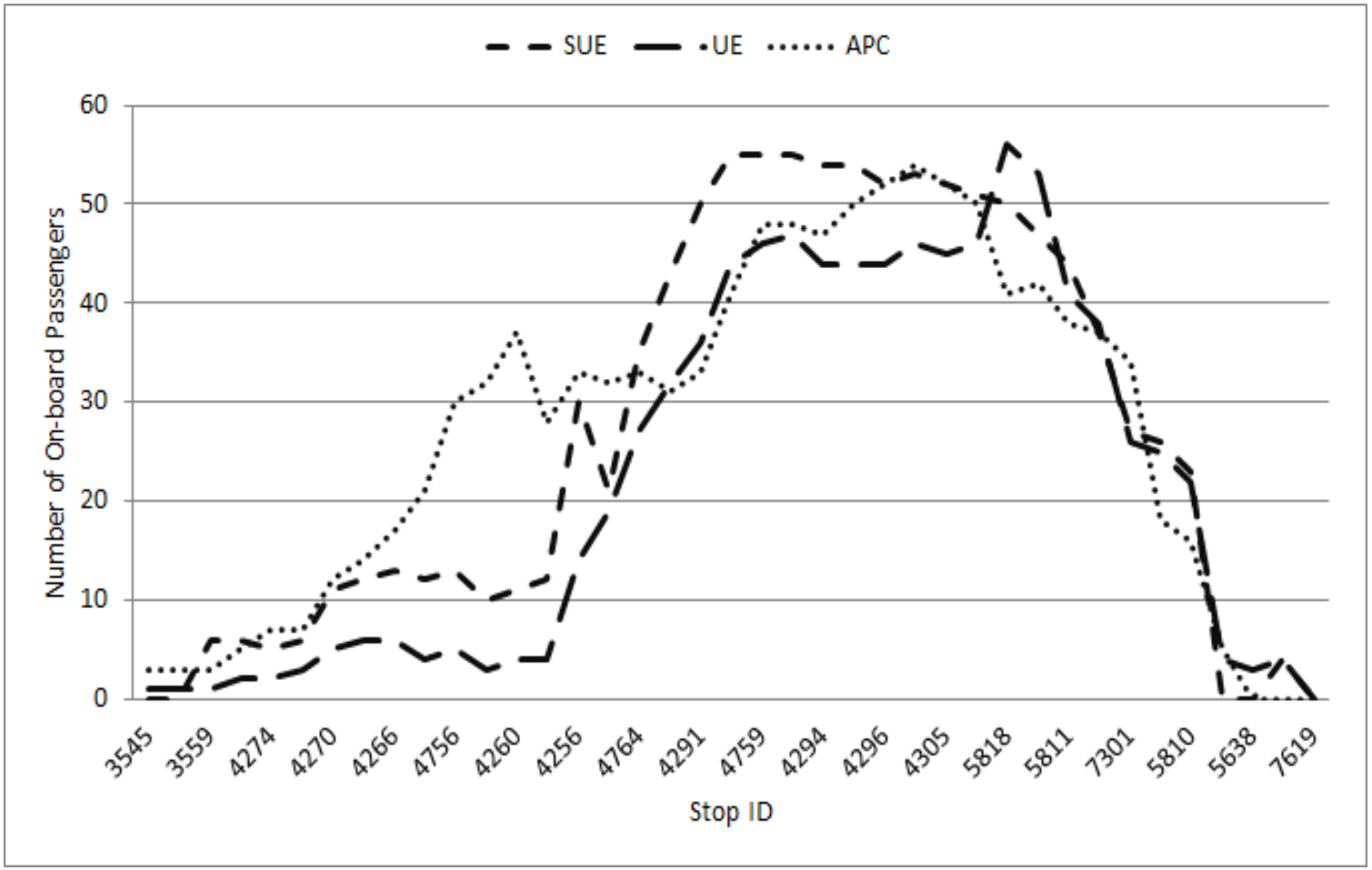
FAST-TrIPs Load Profile Results

- Route 38 outbound, PM peak average load

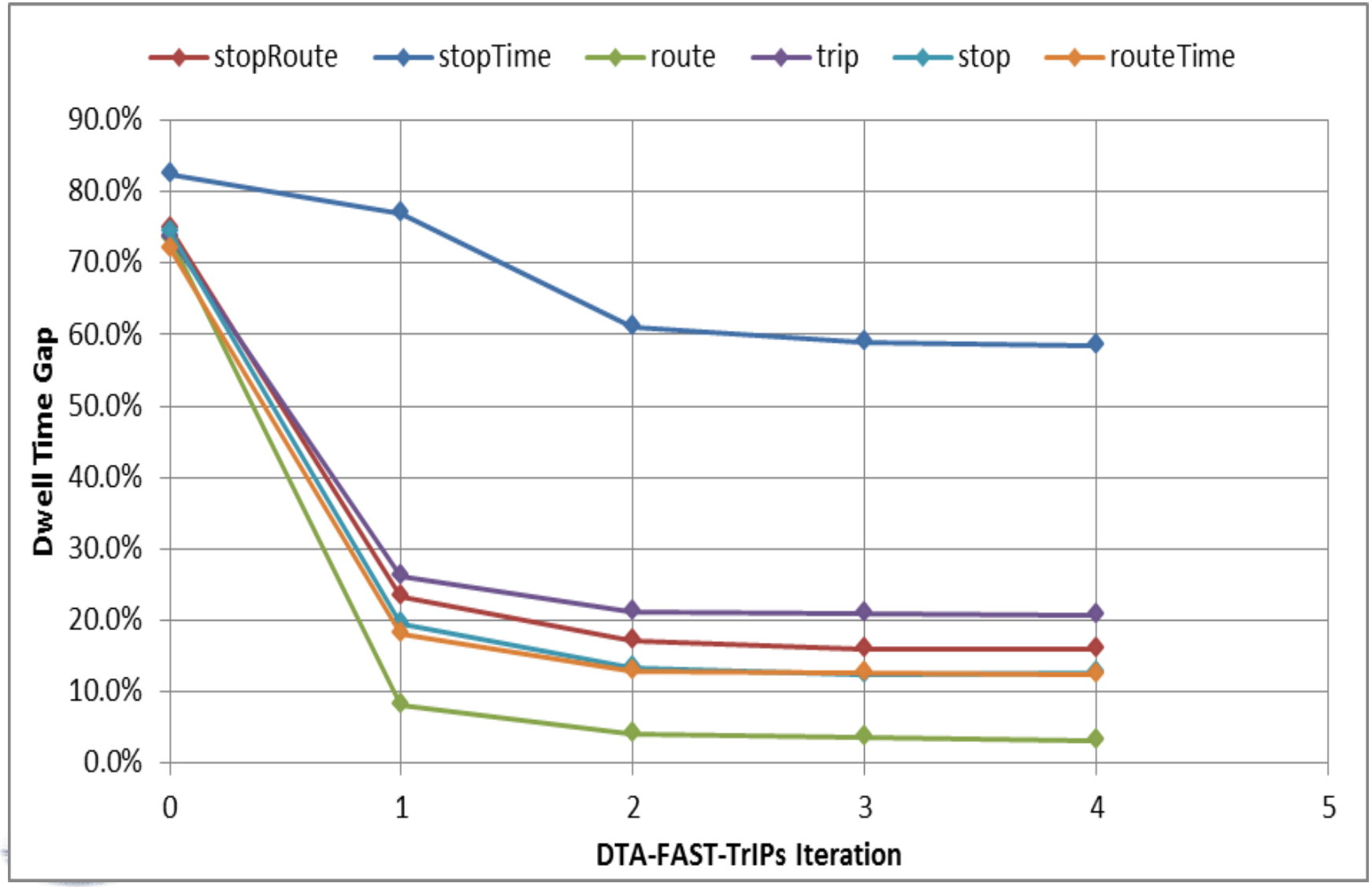


Load Profile Results

- Route 38 outbound, 17:47 vehicle trip



Convergence Measures (Dwell Time Gap)



On-going Research

- SHRP2 C10-B
  - Model calibration for SACOG
  - Scenario development using Line files -> GTFS
  - Formal open-source release
- SFCTA
  - Further model validation
  - Feedback with DTA (Dynameq) and with ABM (SF-CHAMP)
  - Experiment with service reliability
- EAR Program
  - Possible Phase II application with transit