ABM-DTA Deep Integration: Results from the Columbus and Atlanta SHRP C10 Implementations

presented by
Matt Stratton, WSP USA

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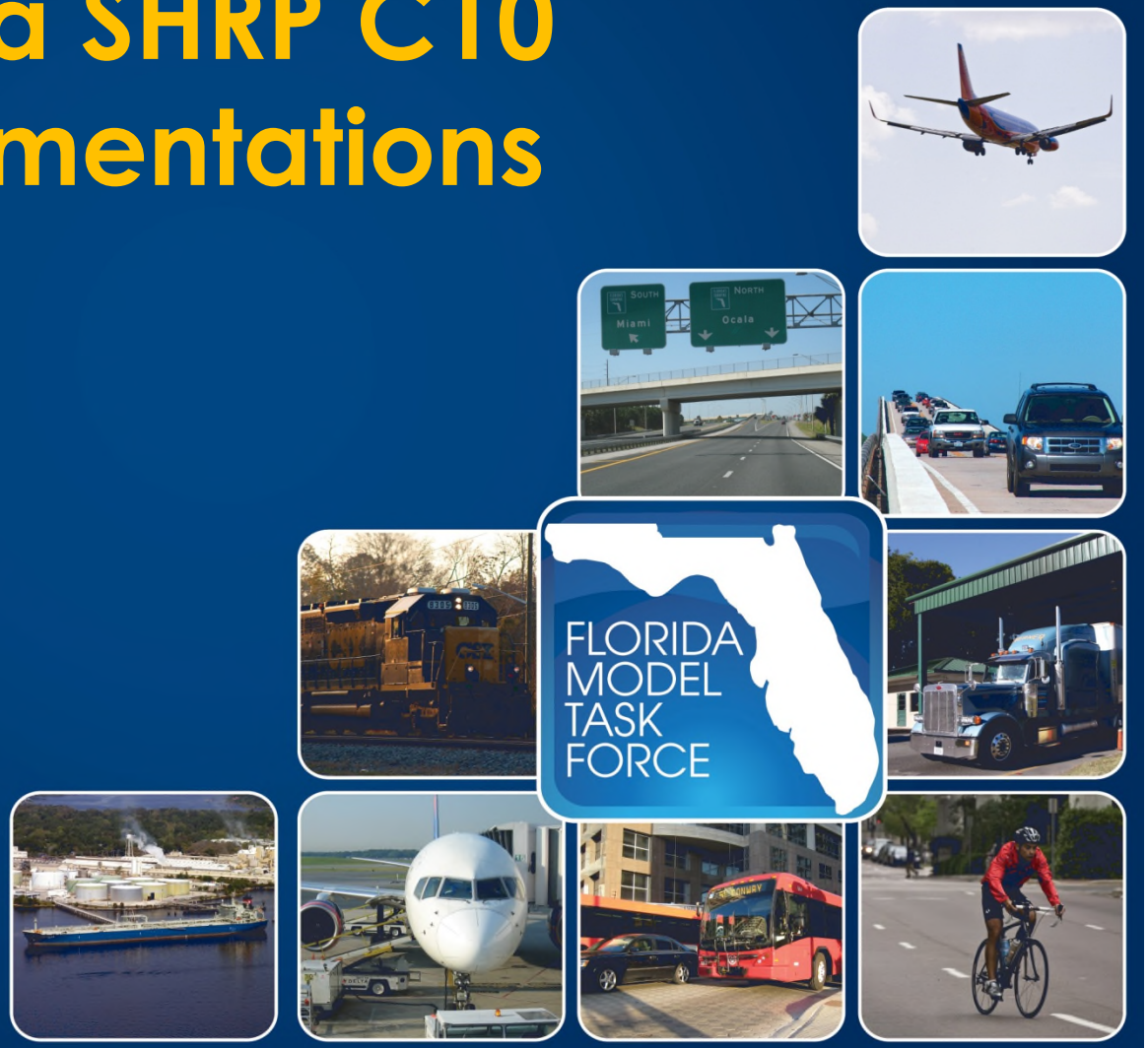


New CT-RAMP "Integrable" w/DTA

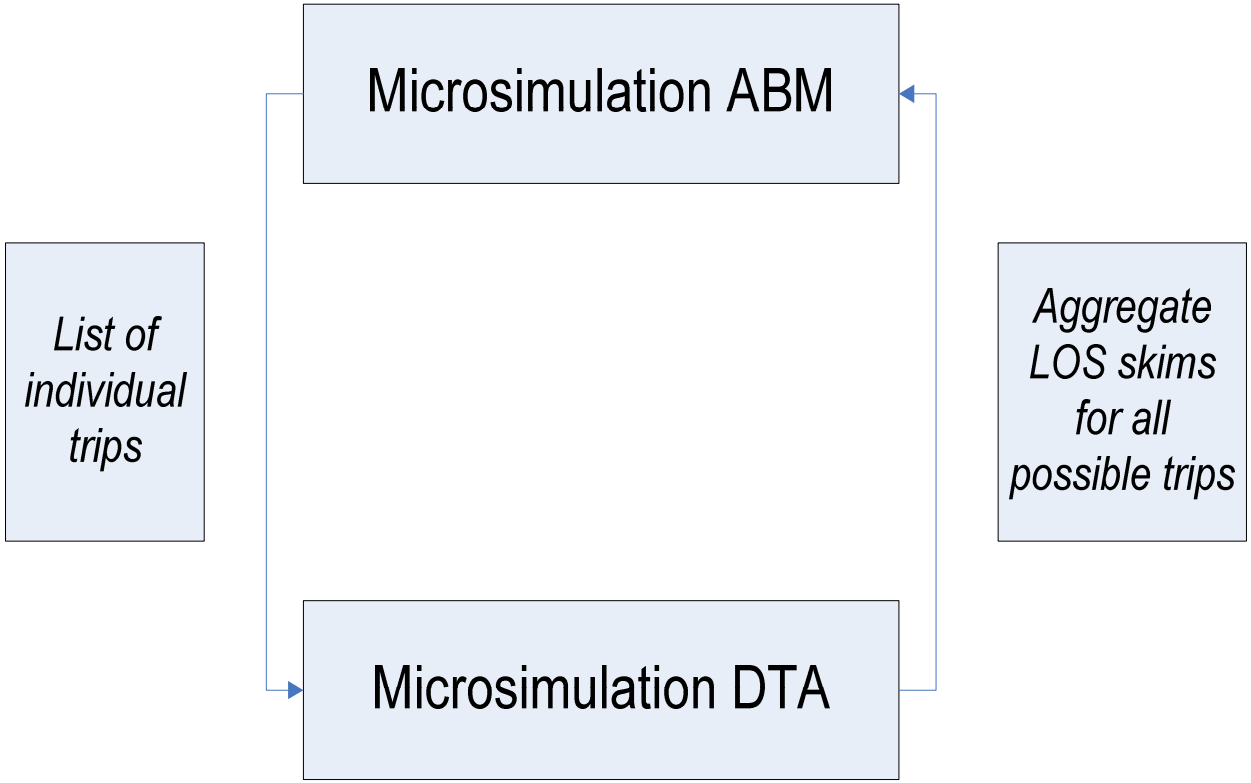

- Enhanced temporal resolution:
  - Continuous trip departure time choice
- Individual schedule consistency:
  - Trip departure time and activity duration generated by ABM consistent with travel time generated by DTA
  - Additional important constraint on the state of the system
- Dynamically updated destination choice sets:
  - Individual learning and adaptation instead of random sampling
  - Moving towards AgBM
- Explicit driver and passenger roles in carpools:
  - Translation of person trips and tours into vehicle trip and tours

New DTA "Integrable" w/ABM


- Meso-level DTA for regional planning models:
  - More detail for route choice (occupancy, VOT)
  - Less detail for vehicle simulation
- Individual route choice (VOT):
  - VOT distribution essential for pricing studies
  - Consistency between mode choice in ABM and route choice in DTA
- Database of individual trajectories:
  - Mining individual trajectories and sub-trajectories (experienced individual LOS)
- Selective TDSP:
  - API for selective TDSP call (expected individual LOS)

ABM-DTA INTEGRATION PRINCIPLES

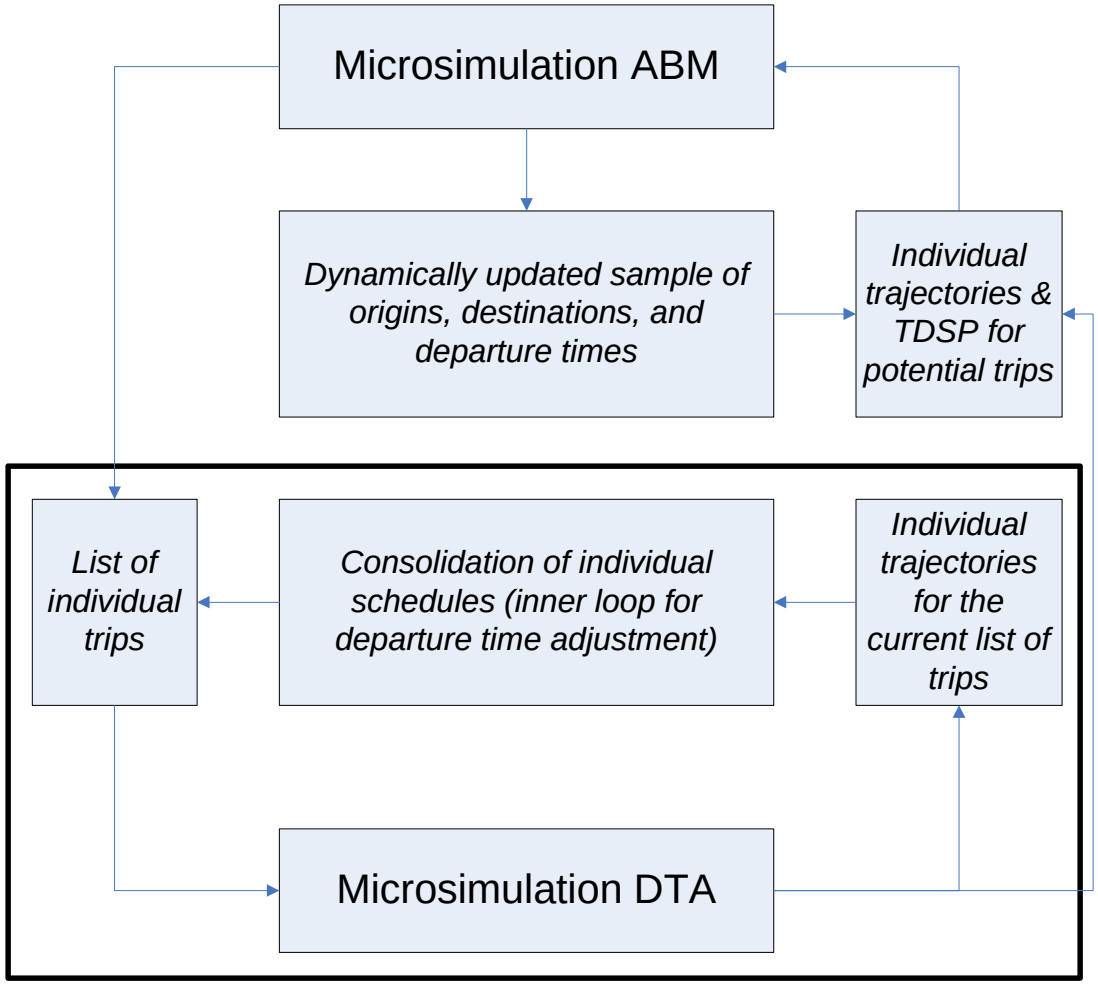
Conventional integration

Limitations of feeding back aggregate LOS OD skims


- Skims is only a surrogate for consistent individual path LOS:
  - Back to 4-step resolution and aggregation biases
- Infeasible to support segmentation pertinent to ABM ("curse of dimensionality"):
  - VOT categories (7-8 at least)
  - Occupancy categories (3 at least)
  - Departure time bins (15 min at least)
  - All this for $(\#TAZs)^2$
- Behaviorally non-appealing:
  - No relation to individual experience, learning, or adaptation

Approach for Day-Level Integration

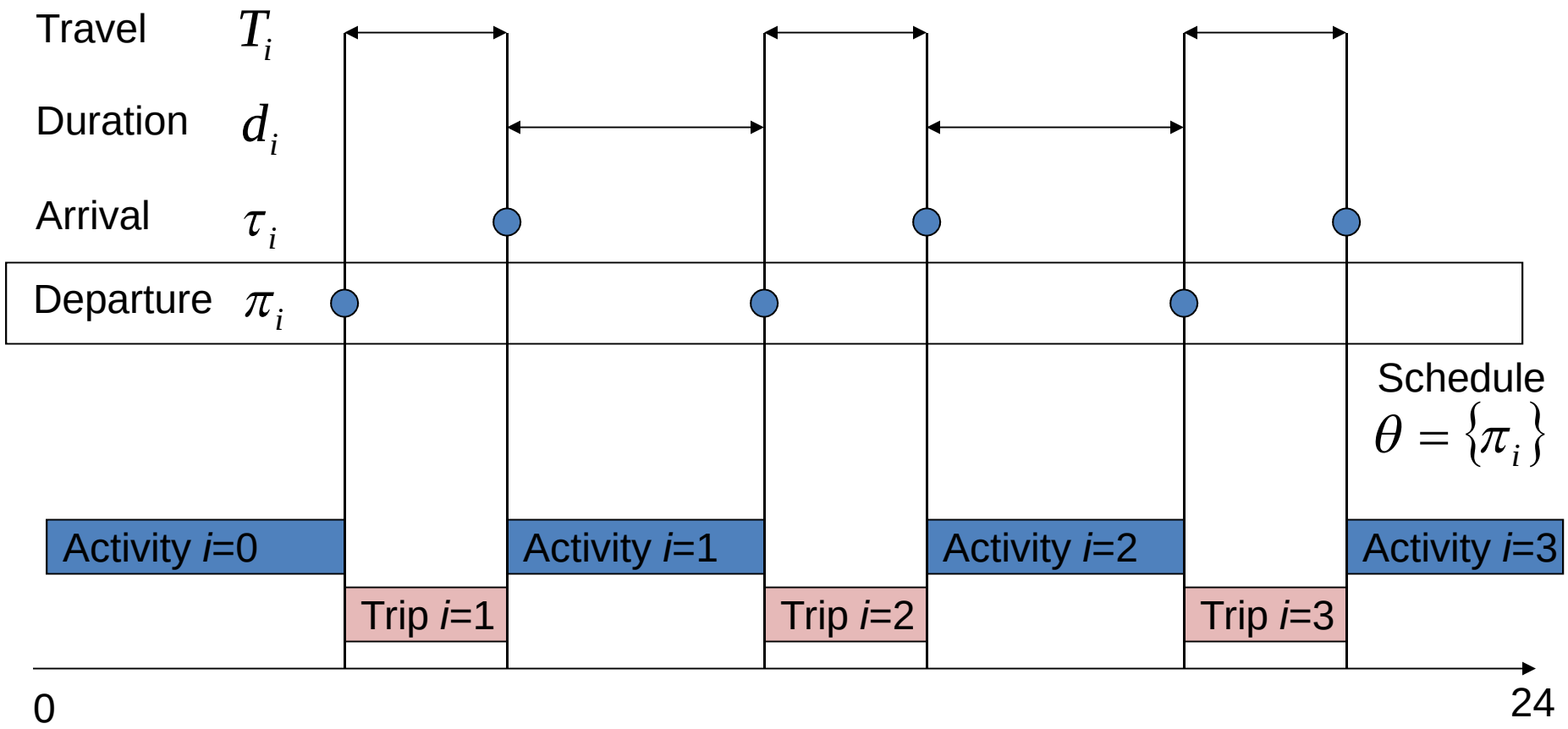


Temporal equilibrium to achieve individual schedule consistency

INTERNAL LOOP OF INDIVIDUAL SCHEDULE ADJUSTMENTS

Taking advantage of individual trajectories

Individual Schedule Consistency

Individual Schedule Adjustment


- Schedule deviation minimization approach:
  - Generalization of schedule delay approach developed by K. Small for a single trip
  - Objective function terms with importance weights summed over all trips/activities:
    - **α × Max(PlanActDur-AdjActDur,0)** // shorter
    - **β × Max(AdjActDur-PlanActDur,0)** // longer
    - **λ × Max(PlanTripDep-AdjTripDep,0)** // depart earlier
    - **γ × Max(PlanTripDep-AdjTripDep,0)** // depart later
    - **μ × Max(PlanTripArr-AdjTripArr,0)** // arrive earlier
    - **ν × Max(PlanTripArr-AdjTripArr,0)** // arrive later

Individual Schedule Adjustment

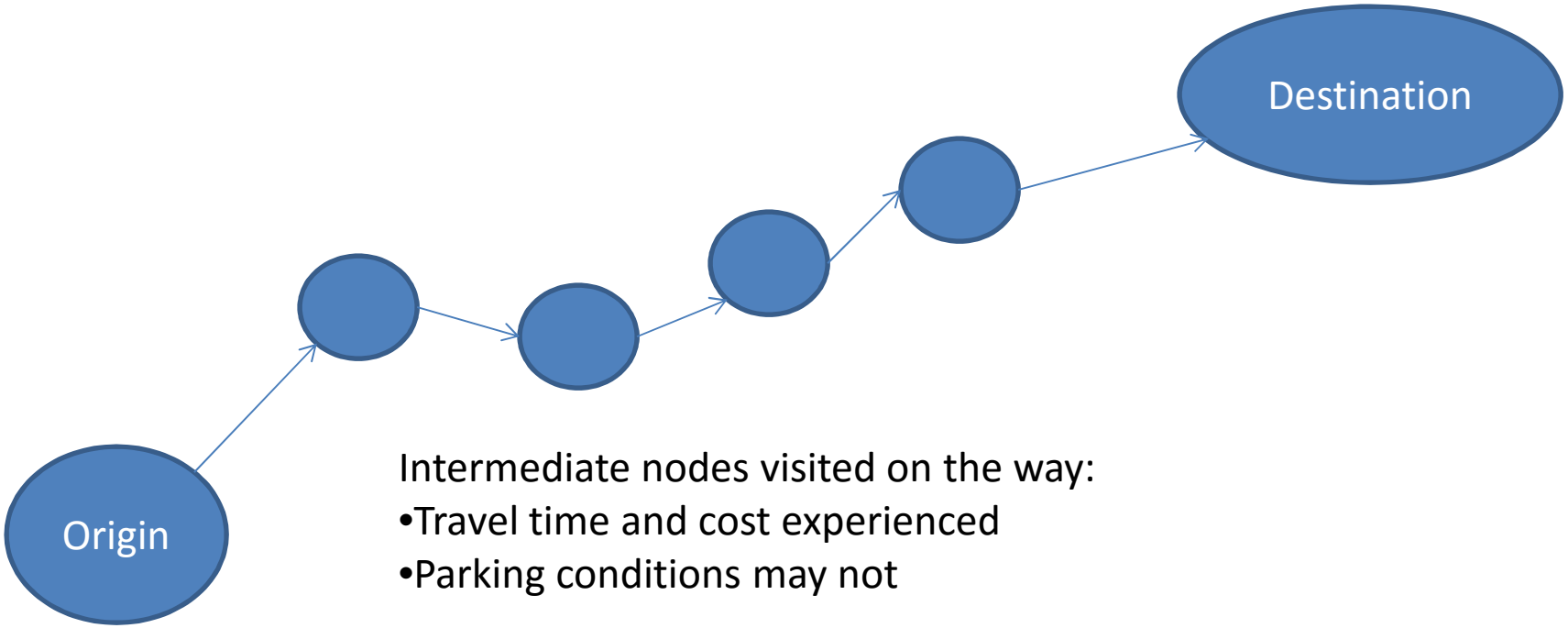

- Results in LP problem with entire-day schedule consistency constraints
- Fully consistent with schedule delay models and TOD choice
- Applied for entire HH and accounts for joint trips
- Works as a natural “randomizer” for trip departure time

MINING AND DISSECTING INDIVIDUAL TRAJECTORIES

Taking advantage of simulated individual trajectories as the best measure of actual LOS

Learning about Space from Individual Trajectories (Dynamic Choice Set)

- One implemented trip provides individual learning experience w.r.t. multiple destinations [*Tian & Chiu, 2014*]



Bank of Trajectories and Mining


Quick mining:

- Filter user(s):
  - Filter trajectories that span departure time bin (TOD)
    - Filter sub-trajectories that start from OTAZ and TOD
    - Filter sub-trajectories that include DTAZ

Aggregation if more than one found:

- Give precedence to the modeled individual
- Give precedence to later iterations
- Averaging rules (max, min, mean, STD)

EQUILIBRATION

How the external and internal loops can be combined

Travel "Stress"

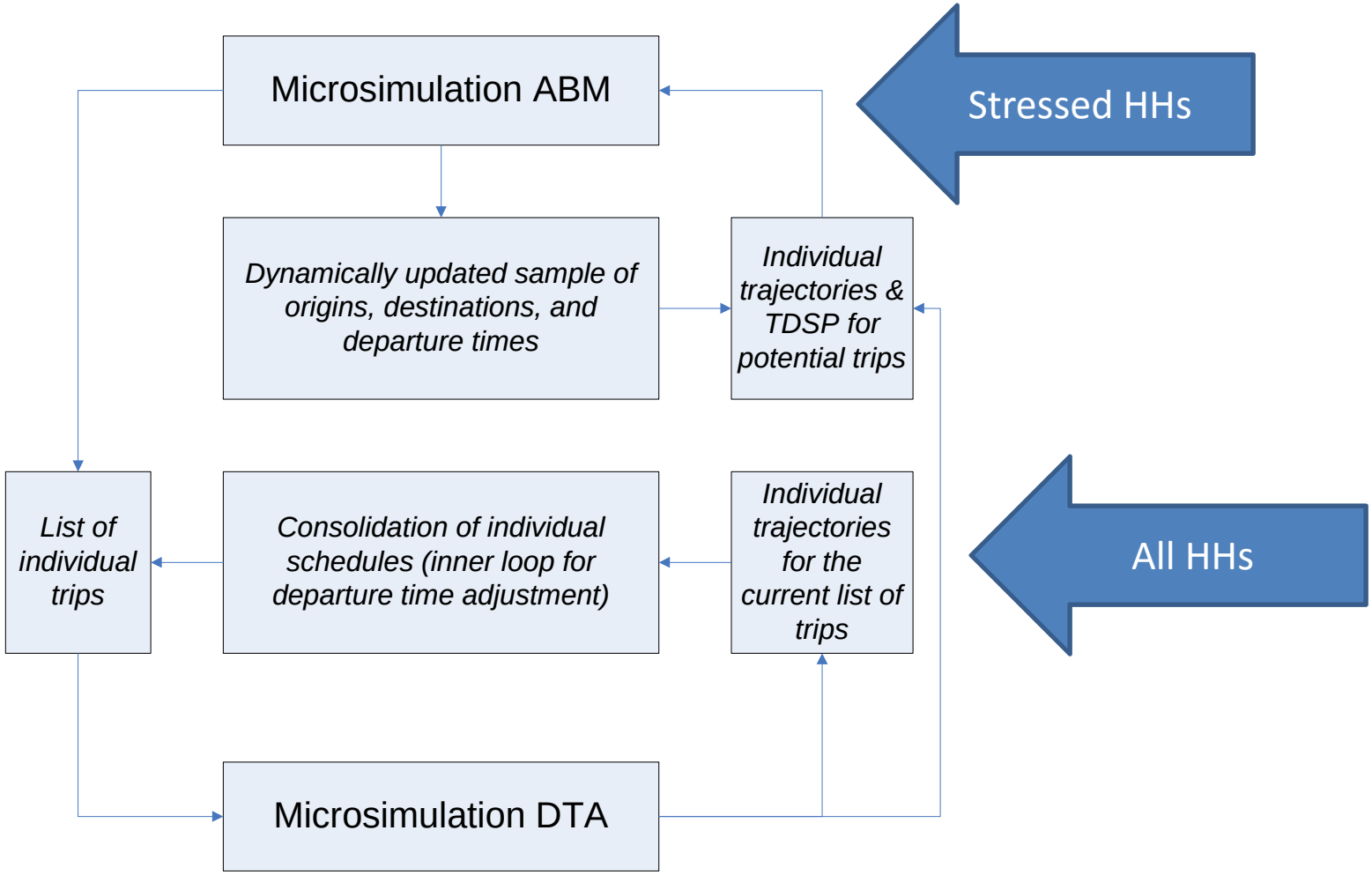

- Behavioral meaning:
  - Experienced travel times unreasonable and/or very different from the expected travel times
  - Individual will seek other travel choices
- Formal meaning for ABM-DTA equilibration:
  - Empirical "gap" measure
  - Generated individual activity-travel pattern does not belong to stationary solution
  - Entire daily pattern has to be re-generated
- Practical daily measures of travel "stress":
  - Total daily travel time
  - Travel overhead (travel time / out-of-home activity time)
  - More elaborate measures explored

Travel "Stress" Thresholds


Person type	Max total travel time, min	Travel time overhead	Min total activity time for overhead, min
1=Full-time worker	240	0.5	180
2=Part-time worker	180	0.8	120
3=University student	240	0.8	120
4=Non worker U65	180	1.5	60
5=Retiree	150	1.5	60
6=Driving-age school child	150	0.4	120
7=Pre-driving-age school child	120	0.4	120
8=Preschool child	120	0.8	120

- Person is "stressed" if either the max time is reached or max overhead is reached in combination with min activity time
- HH is "stressed" if at least one person is "stressed"

"Stressed" and "Un-stressed" HHs



OVERVIEW OF 2 PROJECTS

Commonality and differences between ARC and MORPC applications

2 Parallel applications


Columbus, OH (MORPC)

- 1.4M population
- 2,000 TAZs
- 18,000 MAZs
- 10,000 links
- CT-RAMP2 ABM
- DTA daily simulation of 6M vehicles

Atlanta, GA (ARC)

- 5.0M population
- 5,873 TAZs
- No MAZs currently
- 50,000 links
- CT-RAMP1 ABM
- DTA daily simulation of 20M vehicles

ARC SCENARIOS

Results, analysis, and performance of internal loop

4 Scenarios

- Base DTA with fixed demand
- Base DTA+iSAM (schedule adjustment)
- I-85 Bridge closure DTA with fixed demand
- I-85 Bridge closure DTA+iSAM (schedule adjustment)

Overall Scenario Comparison


Scenario	Average trip time	Average delay	Unfinished trips
Base DTA w/fixed demand	25.81 min	2.90 min	0
Base DTA w/iSAM	24.63 min	2.64 min	0
I-85 Bridge closure DTA w/fixed demand	33.89 min	4.24 min	38,728
I-85 Bridge closure DTA w/iSAM	30.99 min	3.73 min	26,151

MORPC SCENARIOS

Results, analysis, and performance of internal & external loops

LOS Skims Replaced w/ Indiv. Trajectories

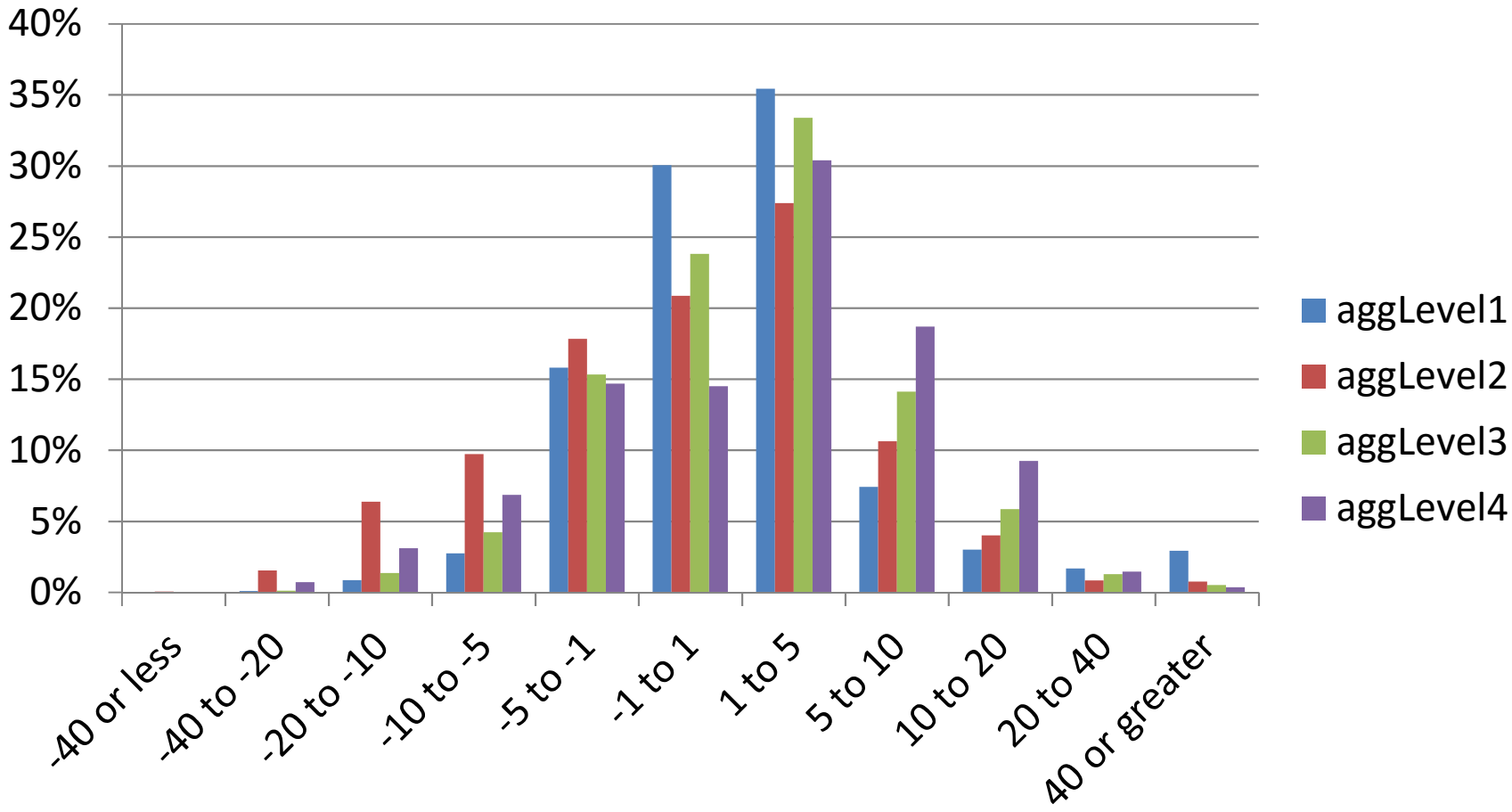

- Would the trajectories from several DTA iterations be enough to cover the need for LOS for ABM?
- How good would be the match between the individual trips and trajectories?
- Do we still need aggregate skims to fill the gaps?
- How different are travel times from DTA compared to static assignment?
- Would the ABM-DTA integrated model require a complete recalibration compared to standard ABM?

Trajectory Coverage Stats


TOD	Aggregation level					
	1	2	3	4	9	Total
Before 6	83.0%	12.5%	0.2%	0.1%	4.2%	100.0%
6-10	61.3%	5.6%	19.5%	7.6%	5.9%	100.0%
10-15	93.4%	5.7%	0.1%	0.1%	0.7%	100.0%
15-19	66.6%	5.9%	17.2%	6.2%	4.2%	100.0%
After 19	92.0%	6.9%	0.1%	0.0%	0.9%	100.0%
Total	77.7%	6.1%	9.6%	3.6%	3.0%	100.0%

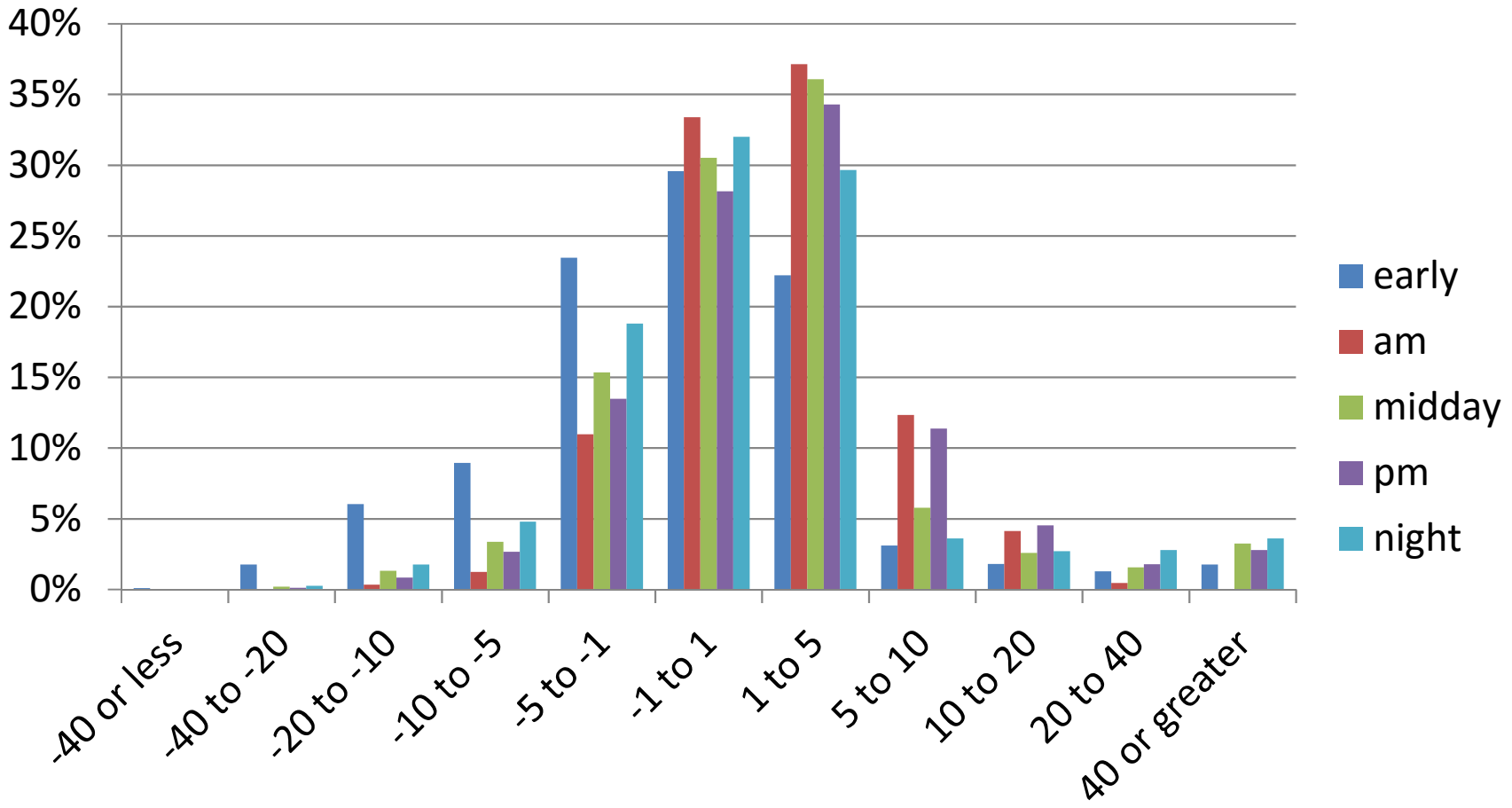
Travel Time Differences by aggLevel:

Trajectory-Skim, min



Travel Time Differences by TOD:

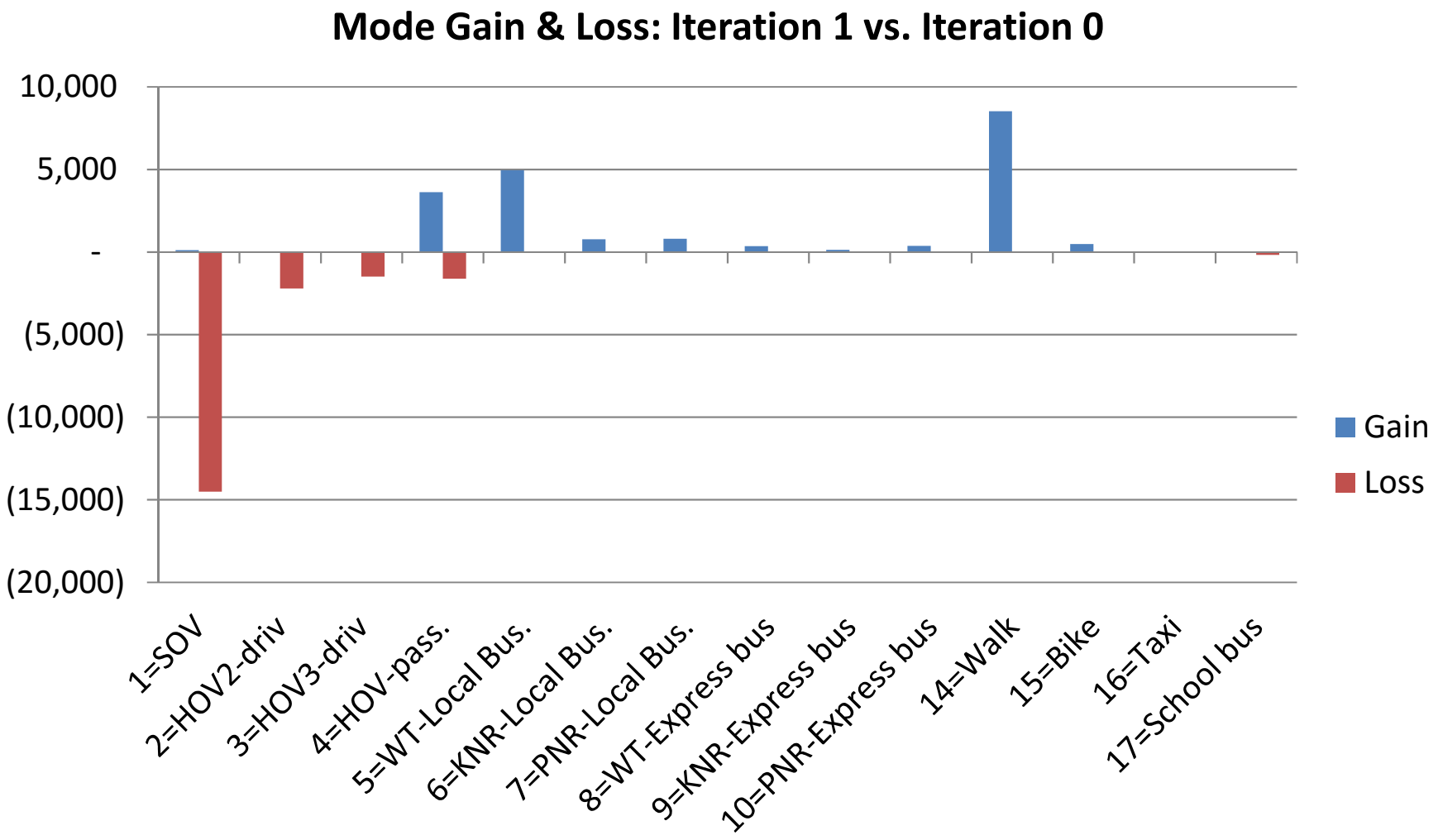
Trajectory-Skim, min



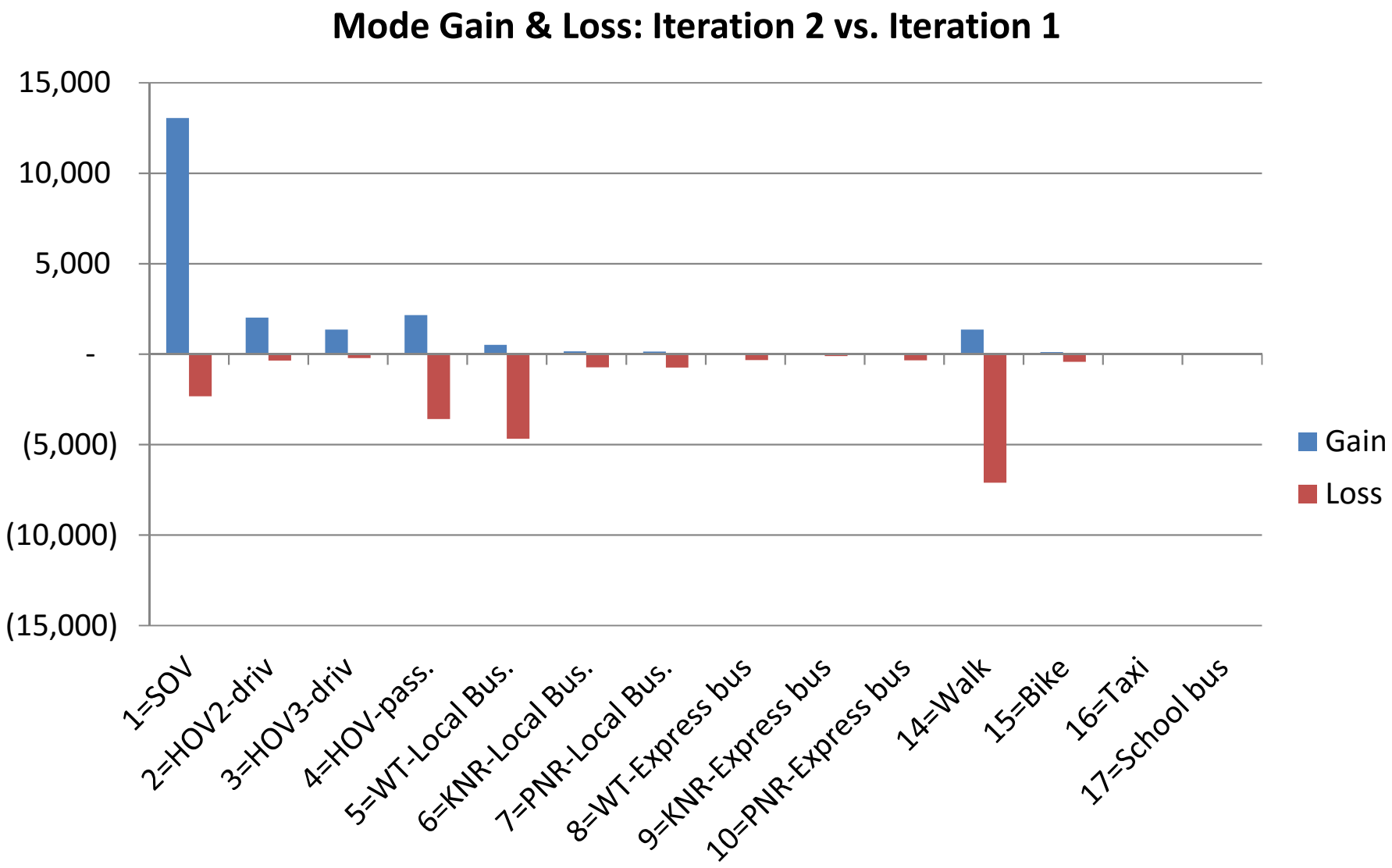
Impact of DTA on Mode Choice


- Useful constrained exercise included equilibration of the following 3 components:
  - ABM mode choice only
  - iSAM
  - DTA
- It provides a pure impact of substitution of static LOS skims with DTA trajectories:
  - Trip list by all modes stays the same
  - Mode switches can be analyzed at individual level

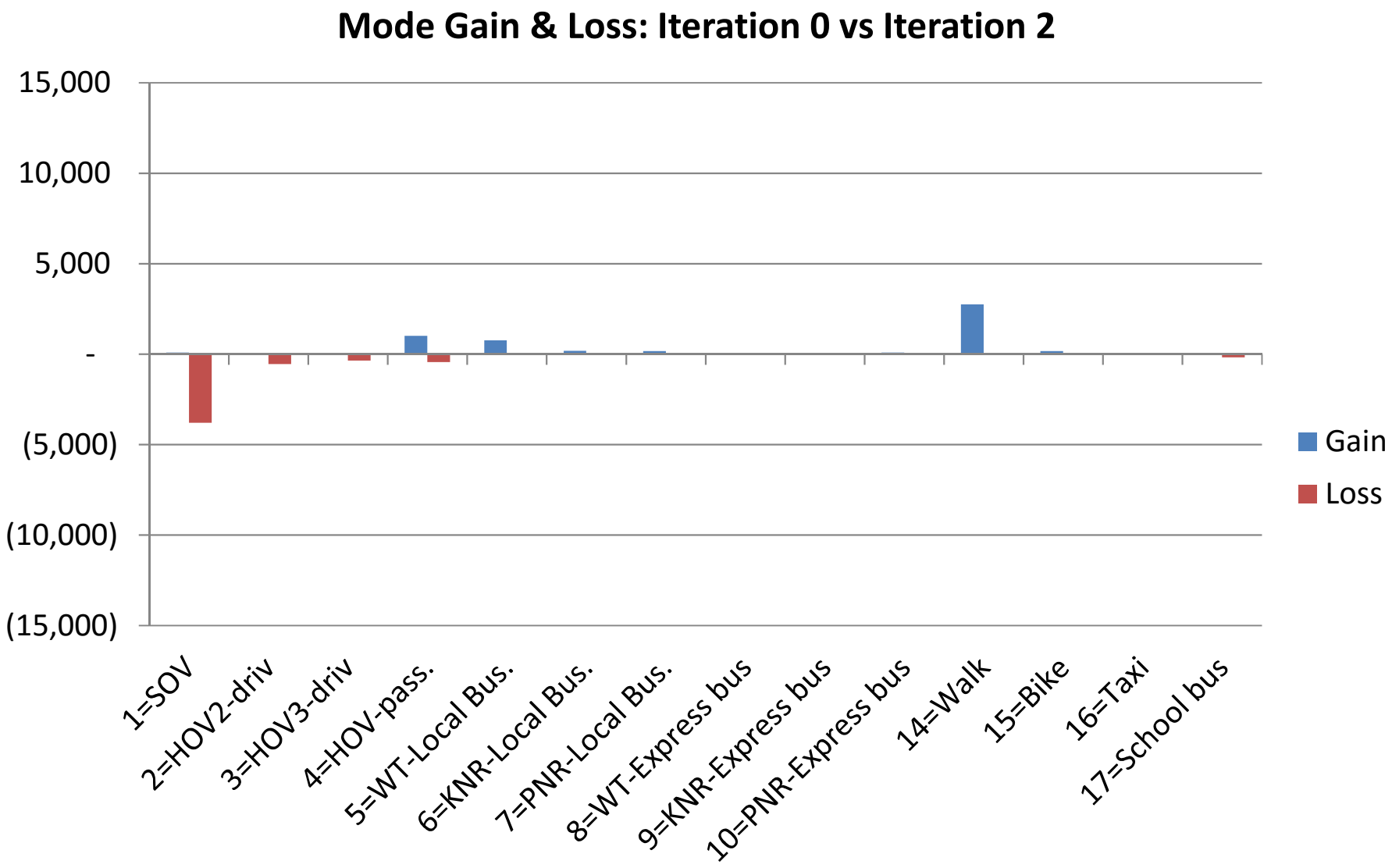
Mode Gain and Loss by Switching from Static Skims to Dynamic Trajectories



Mode Gain and Loss (Iter. 2 vs. Iter. 1)



Mode Gain and Loss



Observations on Impact of DTA on Mode Choice


- Overall a well-calibrated ABM does not suffer a stress from switching to DTA
- No substantial recalibration needed
- Most shifts are from auto modes to transit and non-motorized in the 1st iteration:
  - More extreme congestion for certain auto trips compared to static skims
- The opposite equilibration shift from transit and non-motorized modes to auto in the 2nd iteration:
  - Relative congestion relief in the second DTA application

Observations on convergence


- Schedule consistency and stability are improved over internal iterations and also between the global iterations although each global iteration (ABM) starts with a “stress” due to a new demand
- Stressed schedules are improved over internal iterations but not between the iteration 0 and 1 where the main change of LOS (trajectories vs. skims) occur
- More global iterations needed to analyze convergence

Conclusions


- Deep integration of ABM and DTA is feasible:
  - Already practical for regions under 1M
- Many additional new avenues:
  - Moving towards AgBM
- Runtime is an issue:
  - Integration layer adds only a little
  - DTA and ABM constitute major time-consuming components, especially DTA for large regions

Contacts


- Matt Stratton
  - Matt.Stratton@wsp.com
- Peter Vovsha
  - Peter.Vovsha@wsp.com
- Rosella Picado
  - Rosella.Picado@wsp.com