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TMIP

Using an Activity-Based Model with Dynamic Traffic Simulation to Explore Scenarios for Private and Shared Autonomous Vehicle Use in Jacksonville

TRB Innovations in Travel Modeling

Atlanta, June 25, 2018

Acknowledgements

This study was completed through the collaborative efforts of:

- **Mark Bradley** (RSG)
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Overview of the Study Approach

Defining Exploratory Modeling and Analysis (EMA)

EMA is a systematic approach to perform sensitivity analysis using models when many of the model inputs cannot be asserted with confidence, so that a wide range of different input assumptions can be tested simultaneously, looking for patterns in the results to guide **robust decision-making** (RDM).

CV/AV Application:
Develop an Approach for Modeling the System

Adapted Existing Models for the Jacksonville, Florida Region:

- ***DaySim*** activity-based travel demand simulation
- ***TransModeler*** dynamic traffic simulation
- Feedback between the simulation models

Assumptions

- Detailed simulation models will facilitate a realistic representation of new aspects of AV/CV demand and supply for exploratory analysis.
- Relevant findings from these detailed models can be adapted for use with simpler (trip-based and static) models.

DaySim: Activity-based model

- Simulates a day's travel tours and activities for each person in a synthetic population
- Schedules travel and activities to be non-overlapping
- Operates at the parcel level of spatial detail
- Already implemented in the NERPM model used by NFTPO

Enhancements Made for this Project (and Applied Elsewhere)

- Auto ownership model includes choice between conventional and autonomous private vehicles
- The "paid rideshare" (TNC) mode added to mode choice
- TNCs can be specified to use AVs
- AV passengers can have lower disutility of travel time
- Can use separate auto skim matrices for AVs

TransModeler: Microscopic DTA

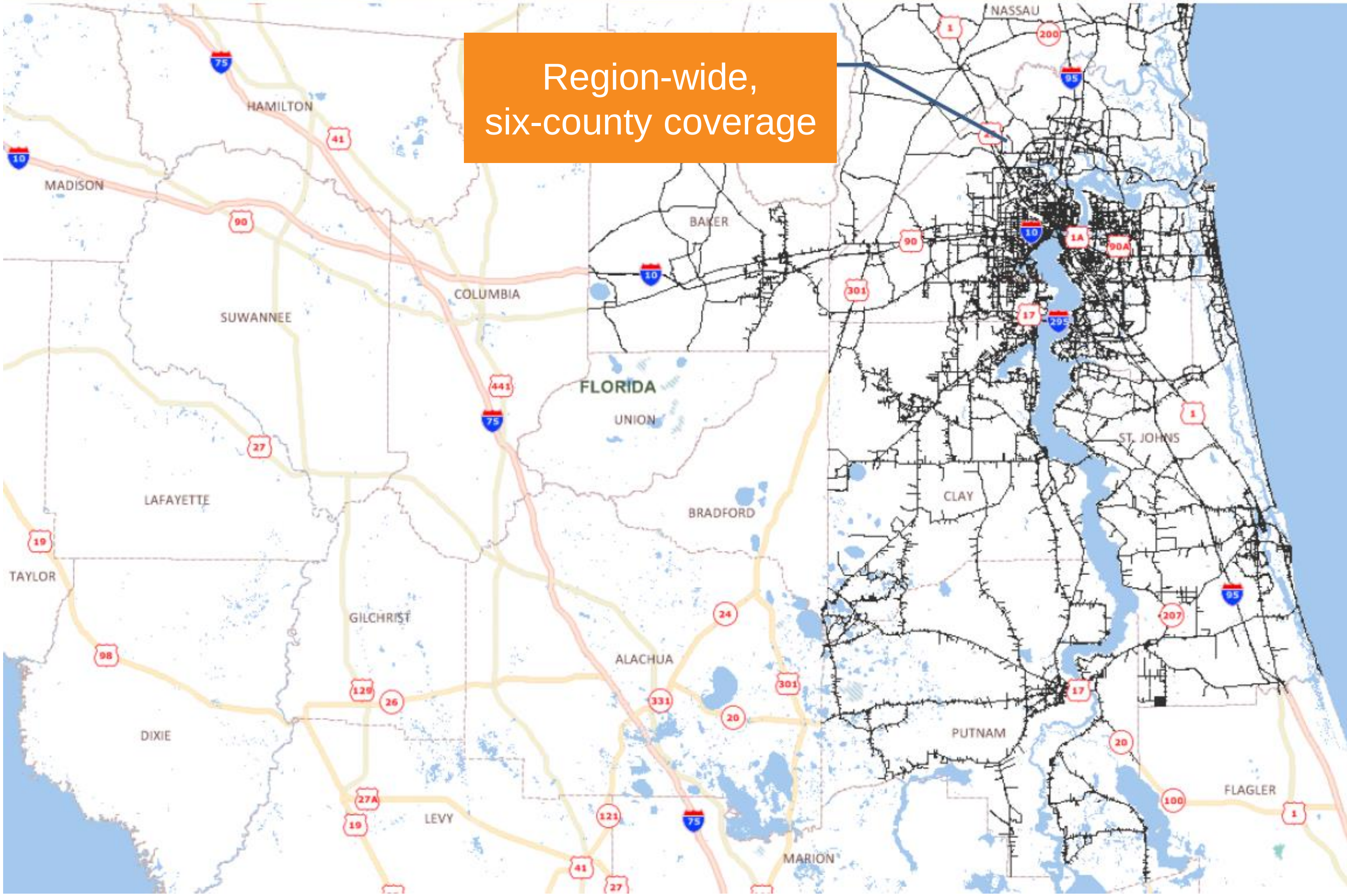
Microscopic in Level of Detail

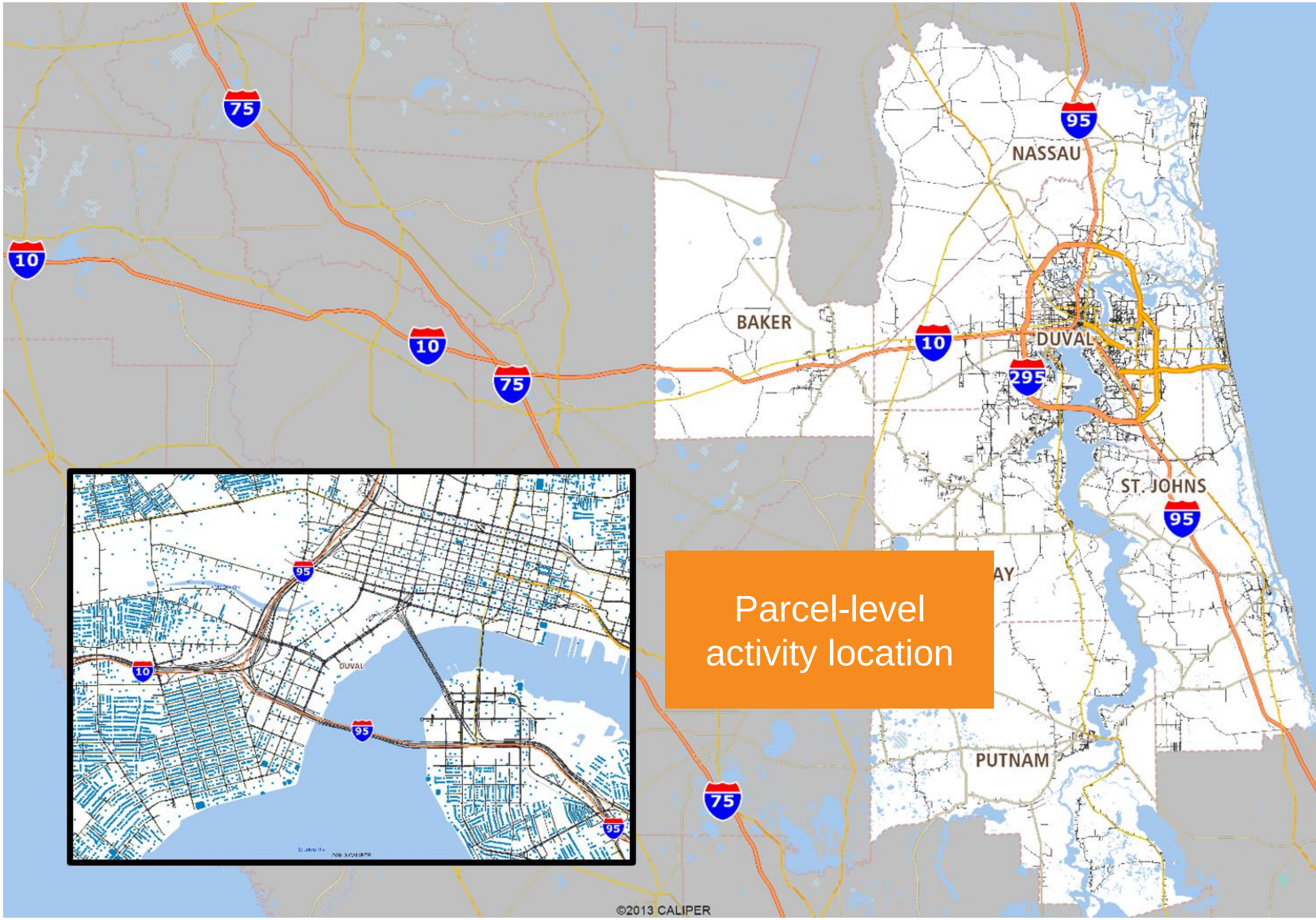
- Referenced to ground truth with accurate geometry
- Lane level and intersection area representation
- Temporal dynamics (as low as 0.1-sec)
- 2-d and 3-d dynamic visualization

Microscopic in Modeling Accuracy

- Microscopic (car following, lane changing)
- Employs realistic route choice models
- Handles complex network infrastructure (signals, variable message signs, sensors, etc.)
- Simulates multiple modes, user classes, vehicle types

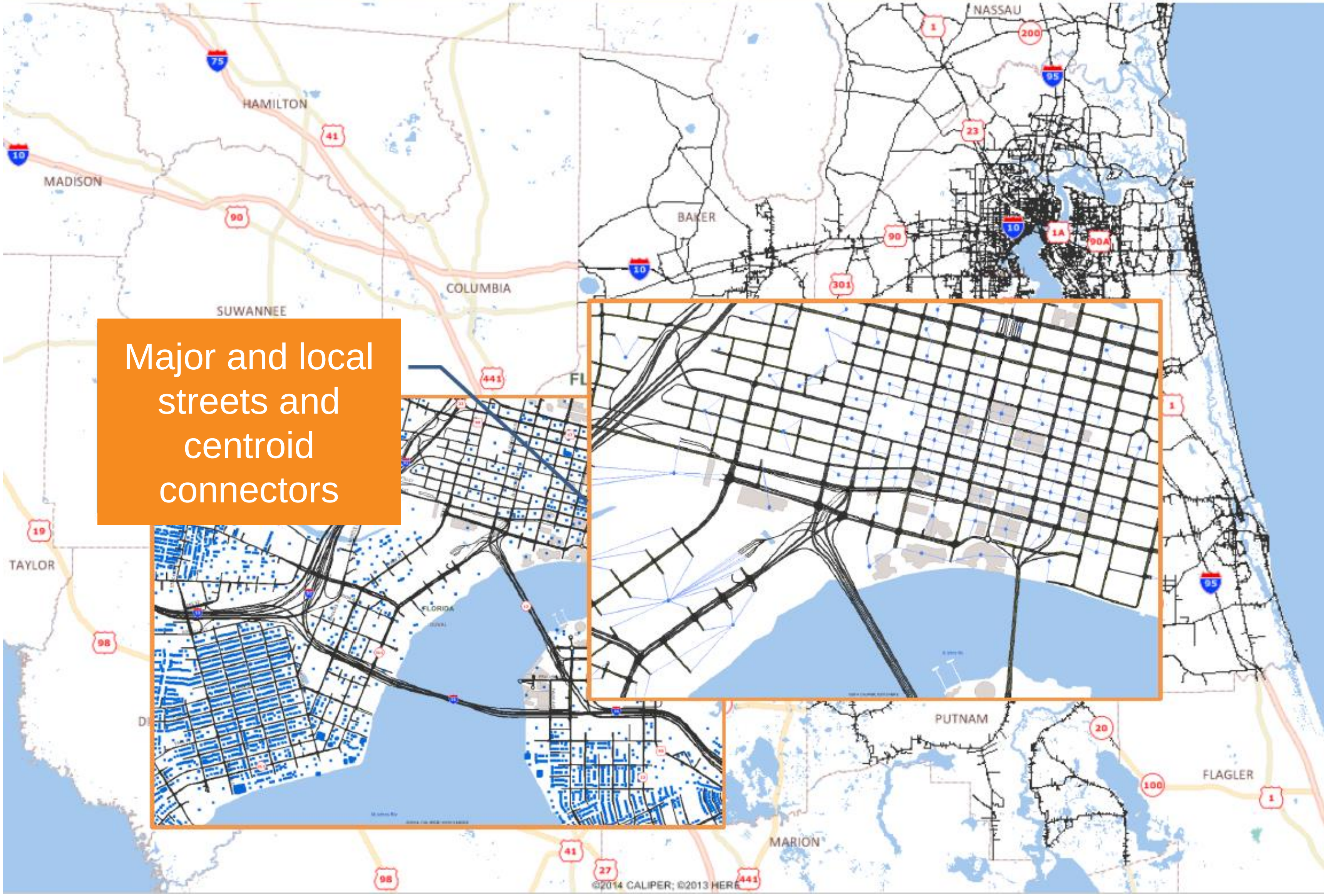
Implementation: Jacksonville, FL



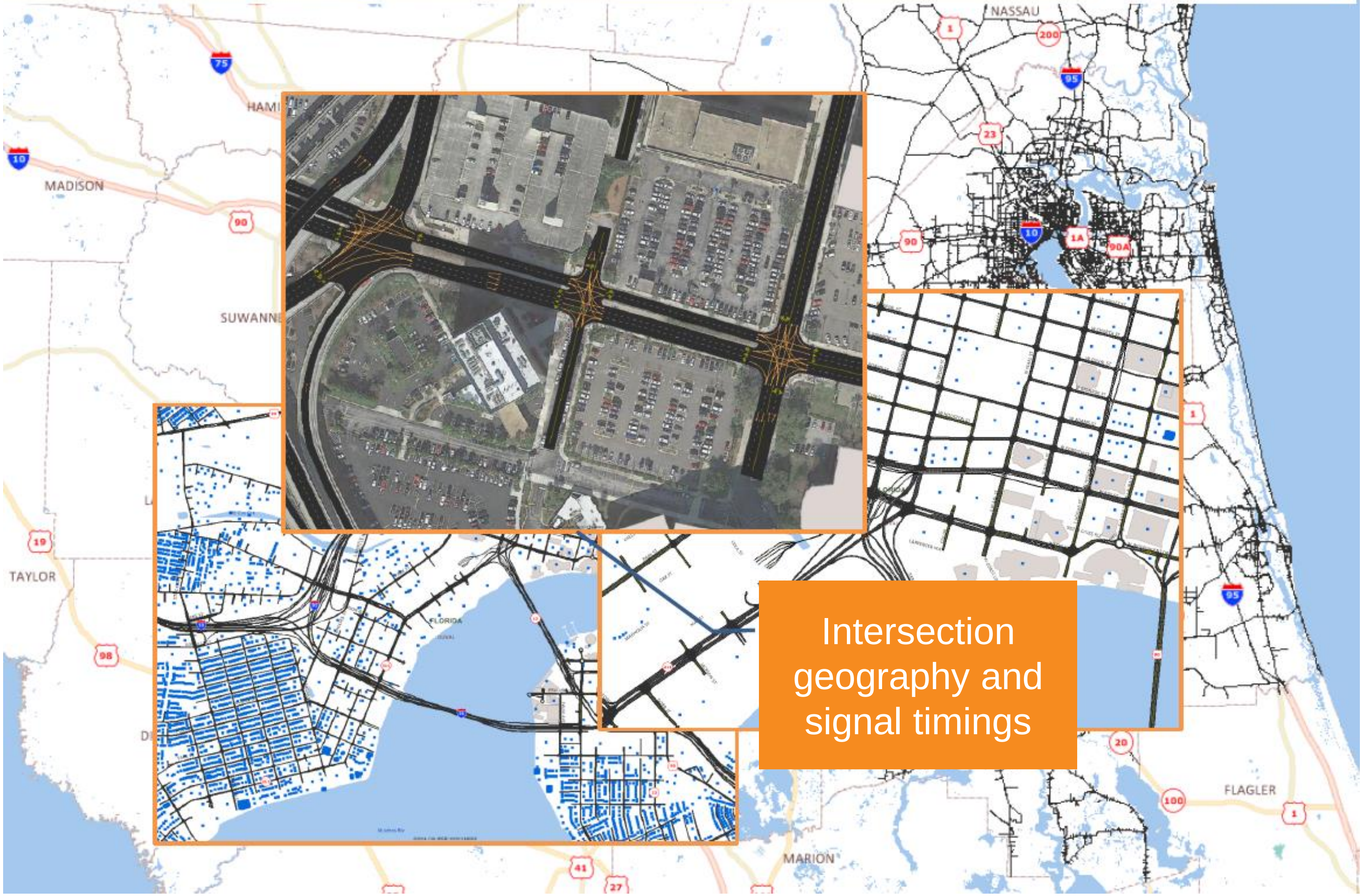


Parcel-level activity location

Implementation: Jacksonville, FL



Implementation: Jacksonville, FL



Information Flows at Model Interfaces

DaySim to TransModeler >>>>
A trip list (over 6 million daily trips), parcel-to-parcel, minute-to-minute.
Trip matrices for freight, externals, etc. Processed into compatible trip lists with more detailed times and locations.

TransModeler to DaySim >>>>
Dynamic travel time skims, TAZ-TAZ, 30 minute periods, by user class (SOV, HOV, Conventional vehicles, Autonomous vehicles)

Performing the ABM + DTA Runs

- Windows machines with 12 cores
  - TransModeler DTA – 5 to 9 AM, 25 iterations → 24 hours
  - DaySim ABM → 45 min
  - DaySim using AM dynamic skims + transpose for PM peak and static assignment for midday and night periods
  - Ran 3 to 5 feedback loops
  - Transit skims held constant
- Runtimes limited the number of EMA runs that could be done

Illustrative Results

Experimental Design for 16 Scenario Runs (Plus Base Scenario)

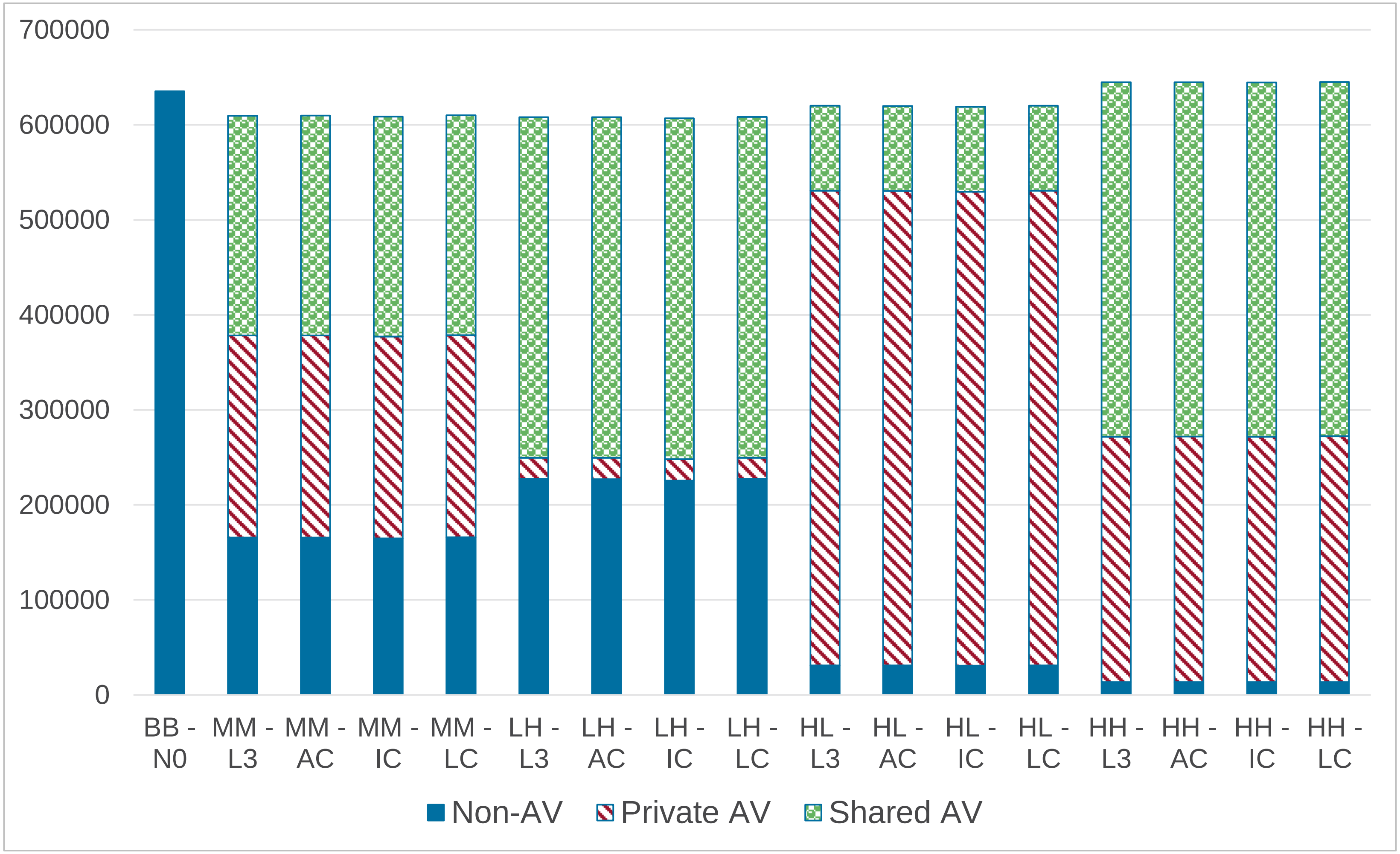
SCENARIO	PRIVATE AV ADOPTION	SHARED AV ADOPTION	RESERVED AV CAPACITY	AUTOMATION LEVEL
BB–N0	None	None	None	None
MM–L3	Medium	Medium	Interstate left lanes	Level 3
MM–AC	Medium	Medium	None	Level 3 + ACC
MM–LC	Medium	Medium	Interstate left lanes	Level 3 + ACC
MM–IC	Medium	Medium	Interstate all lanes (only inside the I 295 ring road)	Level 3 + ACC
LH–L3	Low	High	Interstate left lanes	Level 3
LH–AC	Low	High	None	Level 3 + ACC
LH–LC	Low	High	Interstate left lanes	Level 3 + ACC
LH–IC	Low	High	Interstate all lanes (only inside the I 295 ring road)	Level 3 + ACC
HL–L3	High	Low	Interstate left lanes	Level 3
HL–AC	High	Low	None	Level 3 + ACC
HL–LC	High	Low	Interstate left lanes	Level 3 + ACC
HL–IC	High	Low	Interstate all lanes (only inside the I 295 ring road)	Level 3 + ACC
HH–L3	High	High	Interstate left lanes	Level 3
HH–AC	High	High	None	Level 3 + ACC
HH–LC	High	High	Interstate left lanes	Level 3 + ACC
HH–IC	High	High	Interstate all lanes (only inside the I 295 ring road)	Level 3 + ACC

Ran 3 Global Iterations to Reasonable Convergence

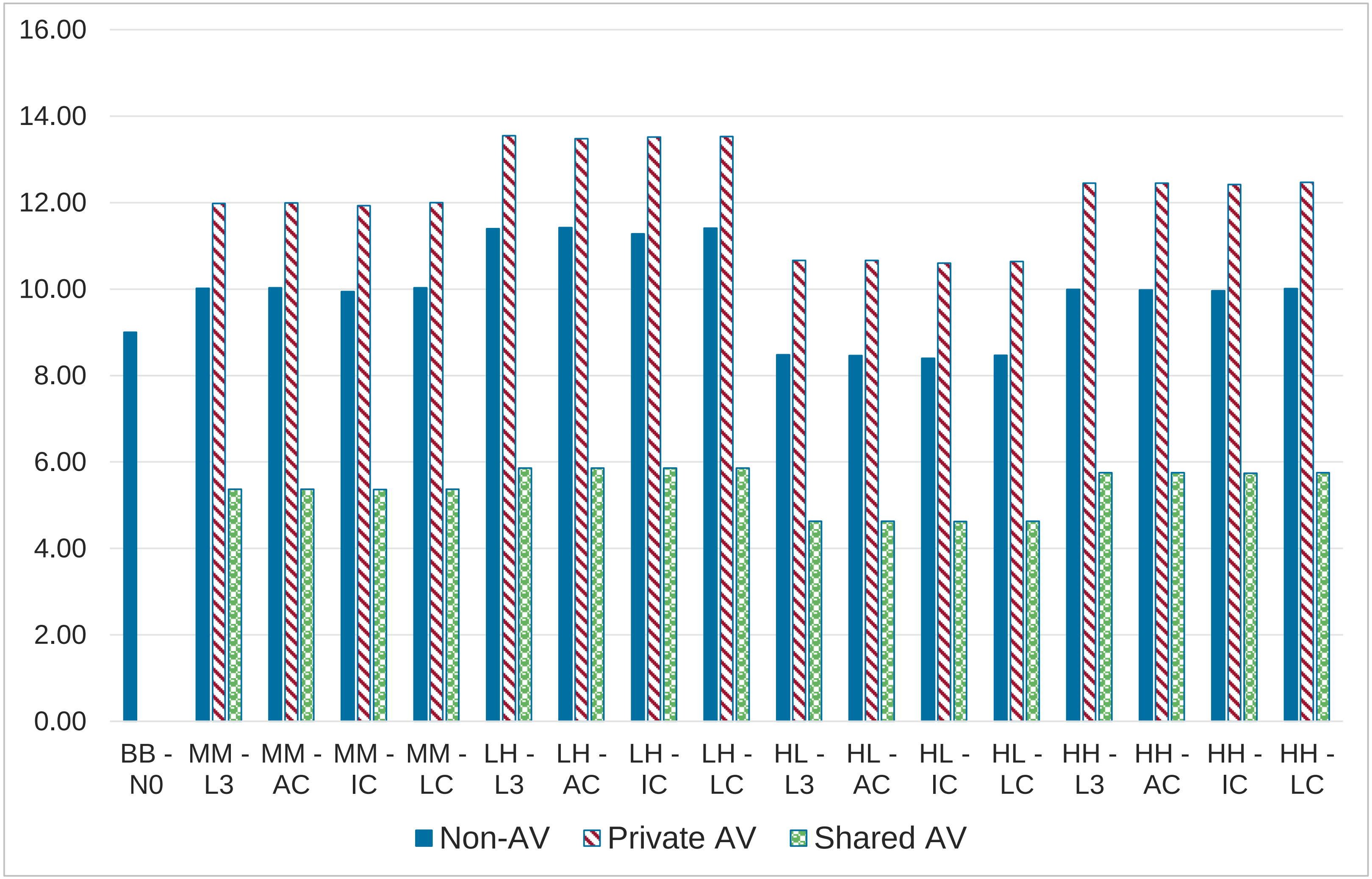
Change in overall predicted average trip speeds from iteration 2 to iteration 3

Run	5:00 am–5:29 am	5:30 am–5:59 am	6:00 am–6:29 am	6:30 am–6:59 am	7:00 am–7:29 am	7:30 am–7:59 am	8:00 am–8:29 am	8:30 am–8:59 am
BB–N0	0.13%	-0.13%	0.09%	0.23%	0.16%	0.00%	0.24%	0.29%
MM–L3	-0.07%	0.17%	-0.31%	-0.16%	-0.25%	-0.11%	-0.70%	-1.17%
MM–AC	0.04%	-0.04%	0.27%	0.44%	0.39%	0.15%	-0.07%	-0.13%
MM–IC	0.26%	0.04%	-0.26%	0.02%	0.34%	-0.07%	-0.32%	-0.45%
MM–LC	0.15%	-0.11%	0.33%	0.33%	0.45%	0.49%	0.47%	0.67%
LH–L3	-0.11%	-0.11%	0.12%	0.16%	0.06%	0.73%	0.34%	0.13%
LH–AC	-0.22%	0.04%	-0.19%	-0.04%	-0.18%	-0.09%	-0.13%	0.22%
LH–IC	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
LH–LC	-0.17%	0.07%	0.27%	0.14%	0.10%	0.64%	0.70%	0.58%
HL–L3	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
HL–AC	-0.17%	0.06%	0.35%	0.16%	0.46%	0.22%	0.37%	-0.09%
HL–IC	0.17%	0.04%	-0.28%	-0.08%	0.13%	0.18%	-0.23%	-0.46%
HL–LC	-0.22%	-0.11%	-0.17%	-0.31%	-0.04%	-0.51%	-0.69%	-1.34%
HH–L3	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
HH–AC	-0.28%	0.00%	0.14%	-0.14%	0.19%	0.18%	0.59%	0.21%
HH–IC	0.15%	0.00%	-0.12%	-0.08%	0.04%	0.04%	0.09%	-0.26%
HH–LC	0.00%	-0.04%	-0.12%	0.12%	0.38%	0.28%	0.51%	0.44%

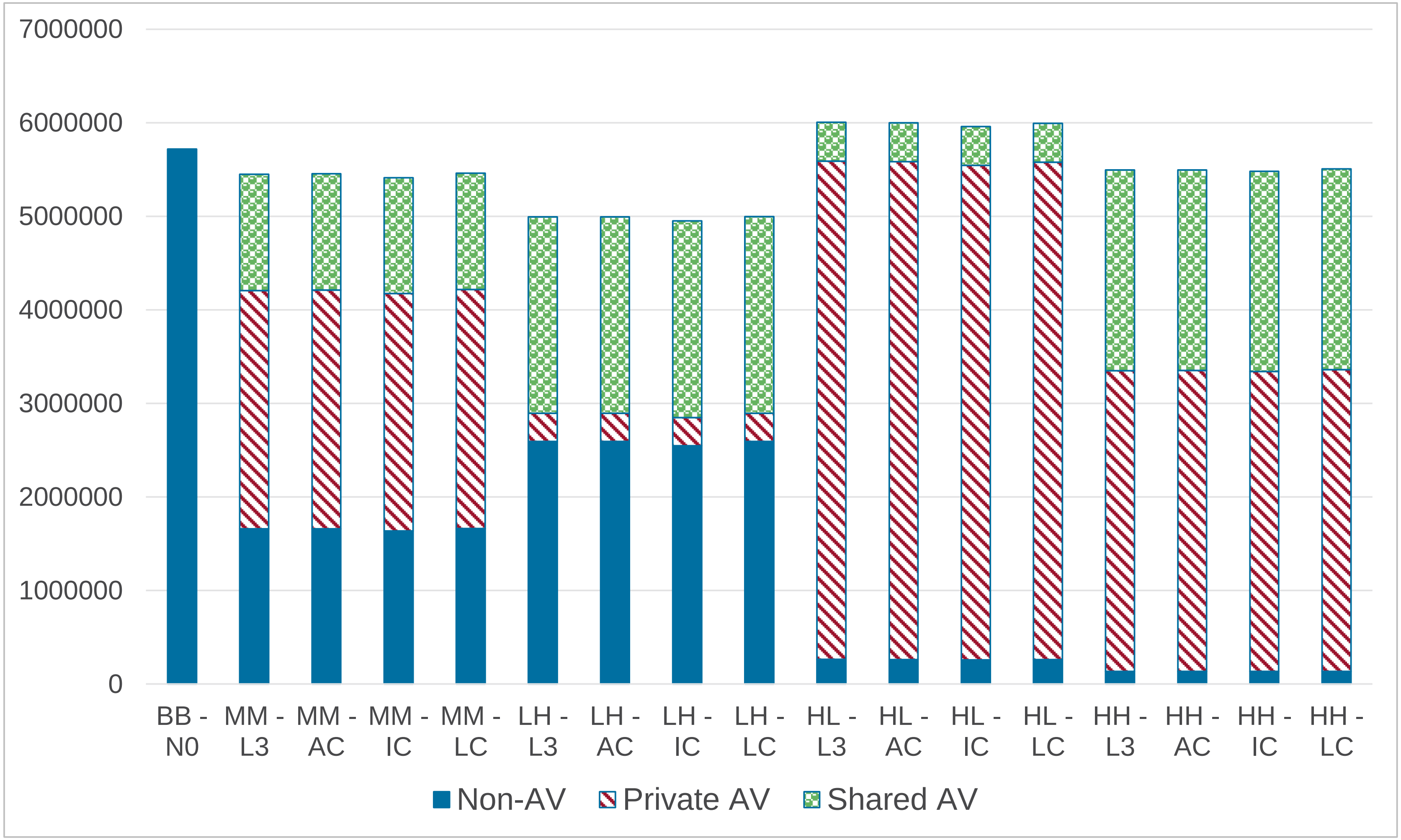
AM Vehicle-Trips, by Vehicle Type and Scenario



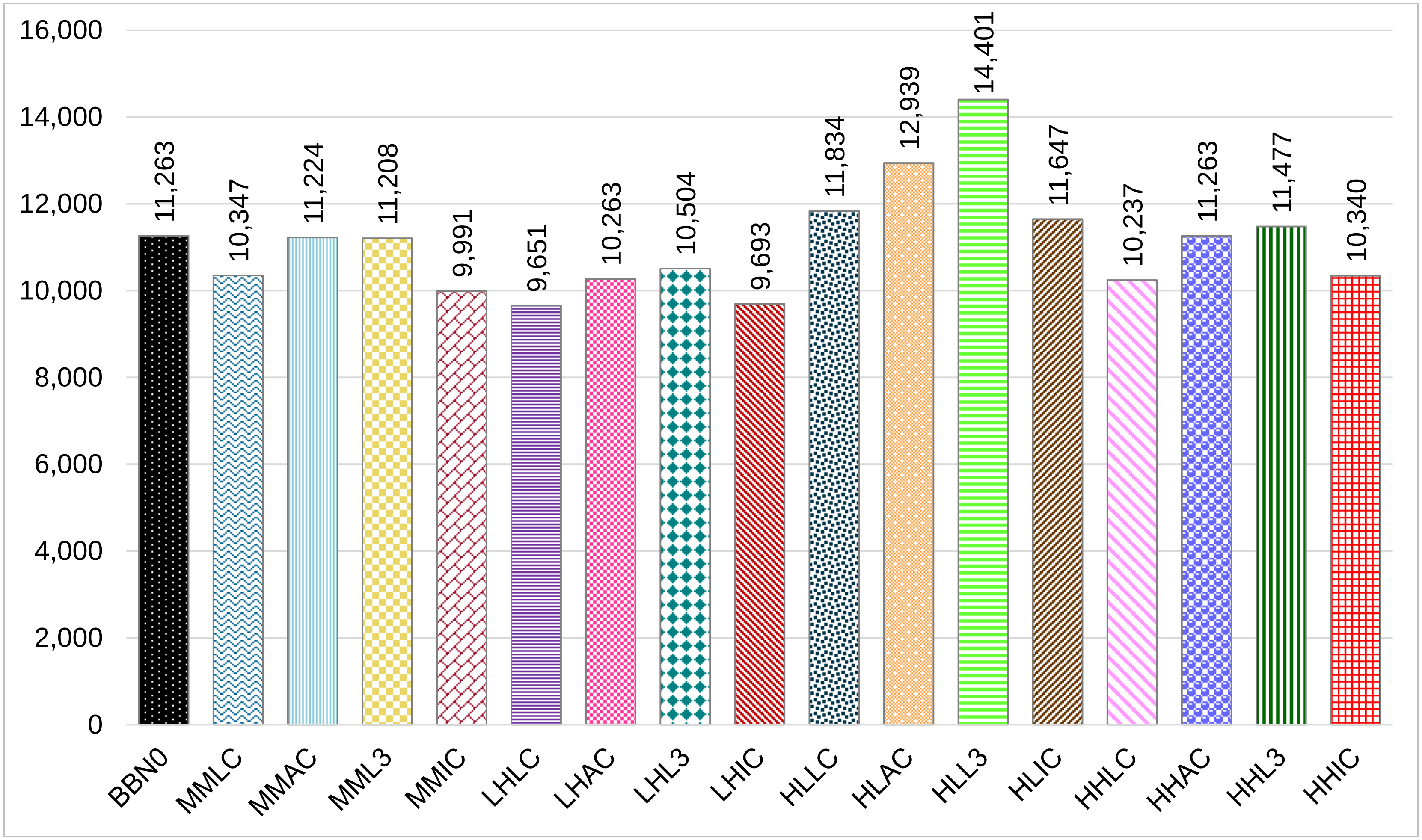
AM Average Vehicle-Trip Distances, by Vehicle Type and Scenario



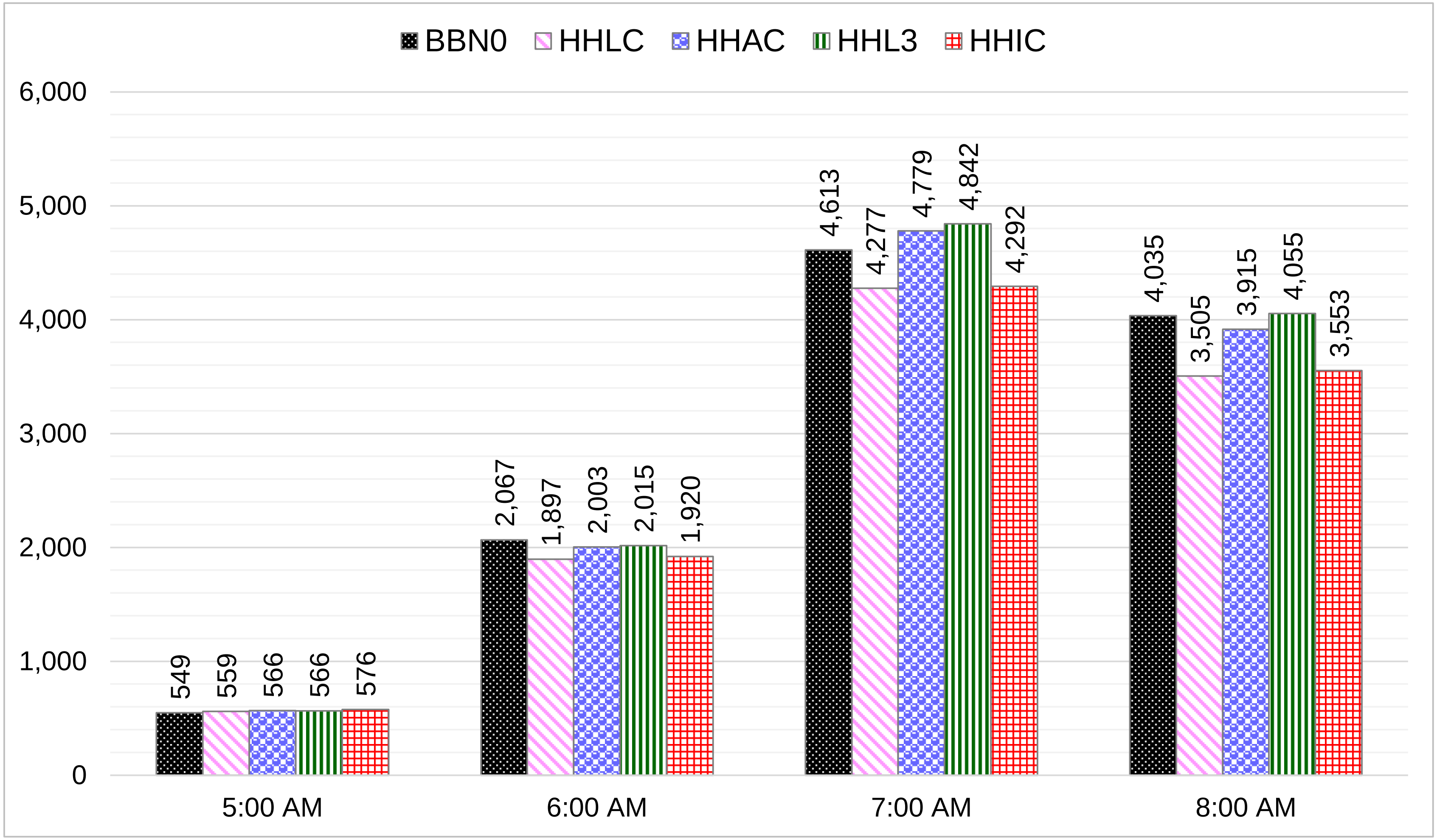
AM VMT, by Vehicle Type and Scenario



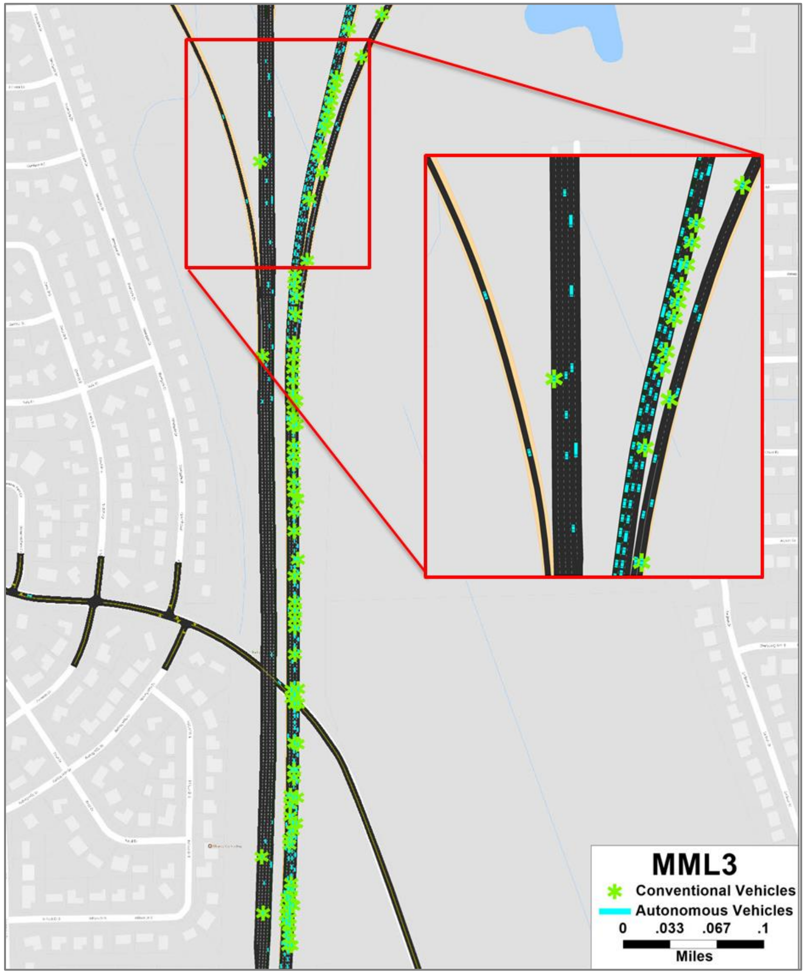
DTA Vehicle-Hours of Delay, by Scenario

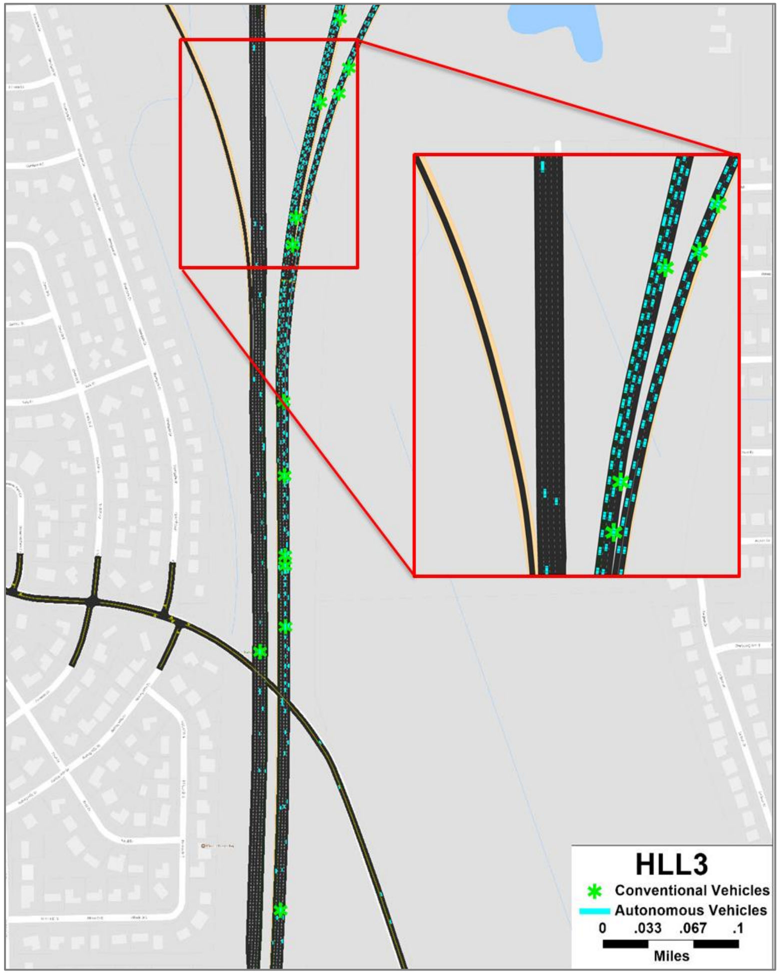


DTA Vehicle-Hours of Delay for the HH Demand Scenarios, by AM Time Period



Visualizations of Back of I-295 Northbound Queue in MM-L3 and HL-L3 Scenario





Regression Model on ABM Output: Total VMT (millions), by Scenario / Time Period / Vehicle Type

Vehicle Type	Non-AV	Non-AV	Private AV	Private AV	Shared AV	Shared AV	All types	All types
Variables	**Coeff.**	**T-stat**	**Coeff.**	**T-stat**	**Coeff.**	**T-stat**	**Coeff.**	**T-stat**
Constant	0.262	11.1	0.443	10.6	0.226	12.9	0.931	117.6
Demand - High Private, Low Shared	-0.174	-9.8	0.346	11.0	-0.103	-7.8	0.068	11.4
Demand - Low Private, High Shared	0.116	6.5	-0.281	-8.9	0.108	8.1	-0.057	-9.6
Demand - High Private, High Shared	-0.190	-10.6	0.083	2.6	0.113	8.5	0.006	1.1
Supply - Network scenario AC	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0
Supply - Network scenario IC	-0.002	-0.1	-0.002	-0.1	0.000	0.0	-0.004	-0.7
Supply - Network scenario LC	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.1
Arrive Period - 5:00 to 5:29	-0.182	-7.2	-0.434	-9.7	-0.237	-12.7	-0.853	-100.7
Arrive Period - 5:30 to 5:59	-0.177	-7.0	-0.422	-9.5	-0.231	-12.3	-0.830	-98.1
Arrive Period - 6:00 to 6:29	-0.051	-2.0	-0.109	-2.5	-0.075	-4.0	-0.235	-27.8
Arrive Period - 6:30 to 6:59	-0.057	-2.3	-0.125	-2.8	-0.081	-4.3	-0.263	-31.1
Arrive Period - 7:00 to 7:29	0.035	1.4	0.107	2.4	0.051	2.7	0.192	22.7
Arrive Period - 7:30 to 7:59	0.008	0.3	0.042	0.9	0.026	1.4	0.076	9.0
Arrive Period - 8:30 to 8:59	-0.017	-0.7	-0.048	-1.1	-0.018	-1.0	-0.083	-9.8

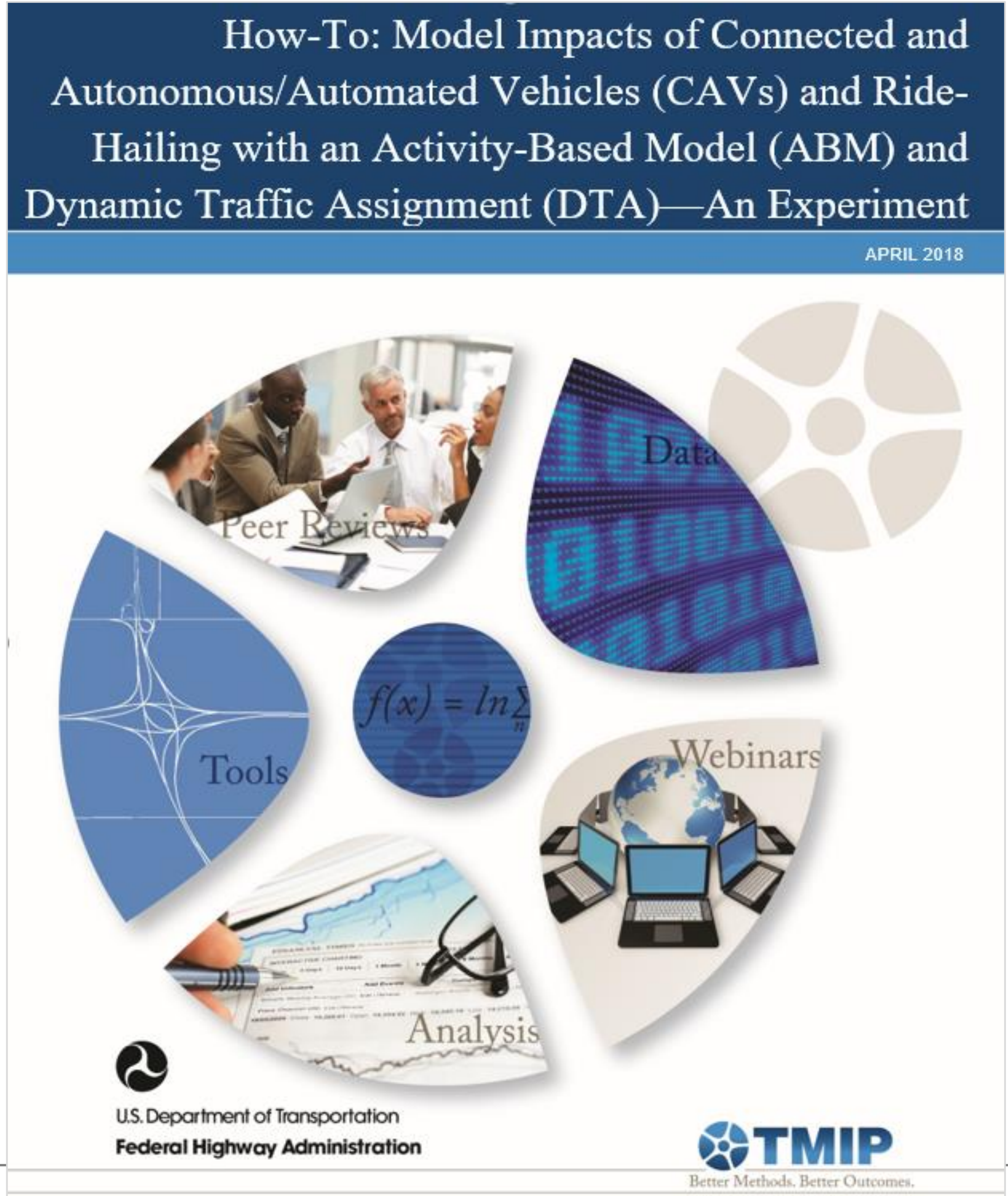
Regression Model on DTA Output: Average Trip Speed (MPH), by Scenario / Time Period / Vehicle Type

Vehicle Type	Non-AV	Non-AV	AV	AV	Both types	Both types
Variables	**Coeff.**	**T-stat**	**Coeff.**	**T-stat**	**Coeff.**	**T-stat**
Constant	31.292	111.2	31.070	136.0	31.036	136.9
Demand - High Private, Low Shared	-1.138	-5.4	-0.608	-3.5	-0.574	-3.3
Demand - Low Private, High Shared	0.618	2.9	-0.533	-3.1	-0.007	0.0
Demand - High Private, High Shared	0.455	2.1	0.135	0.8	0.206	1.2
Supply - Network scenario AC	1.064	5.0	0.004	0.0	0.328	1.9
Supply - Network scenario IC	-0.024	-0.1	1.416	8.2	1.008	5.9
Supply - Network scenario LC	0.724	3.4	0.975	5.6	0.943	5.5
Arrive Period - 5:00 to 5:29	11.496	38.2	11.898	48.7	11.829	48.8
Arrive Period - 5:30 to 5:59	13.737	45.7	14.314	58.6	14.258	58.8
Arrive Period - 6:00 to 6:29	11.052	36.7	11.193	45.8	11.306	46.7
Arrive Period - 6:30 to 6:59	8.516	28.3	8.963	36.7	8.949	36.9
Arrive Period - 7:00 to 7:29	4.976	16.5	4.779	19.6	4.888	20.2
Arrive Period - 7:30 to 7:59	1.651	5.5	1.753	7.2	1.783	7.4
Arrive Period - 8:30 to 8:59	-0.573	-1.9	0.156	0.6	0.011	0.0

Possible Extensions to the Work

- Run for a wider range of assumptions and scenarios, using regression approach to summarize
  - Differences in Value of Time
  - Remote parking locations for private Avs
  - Cost structures and levels for TNC's
  - **Occupancy (pooling) assumptions for "shared" (TNC) AVs**
  - Changes in household activity patterns to use AVs as "private taxis"
  - Lower priority for zero-occupant AVs (ZOVs) on the network
  - Additional types of network scenarios (e.g., AV-based TNCs can use HOV lanes)

- See if the network behavior simulated in the DTA can be replicated with static assignment methods
  - Would allow many more exploratory runs to be done quickly


How-To: Model Impacts of Connected and Autonomous/Automated Vehicles (CAVs) and Ride-Hailing with an Activity-Based Model (ABM) and Dynamic Traffic Assignment (DTA)—An Experiment

APRIL 2018

U.S. Department of Transportation
Federal Highway Administration

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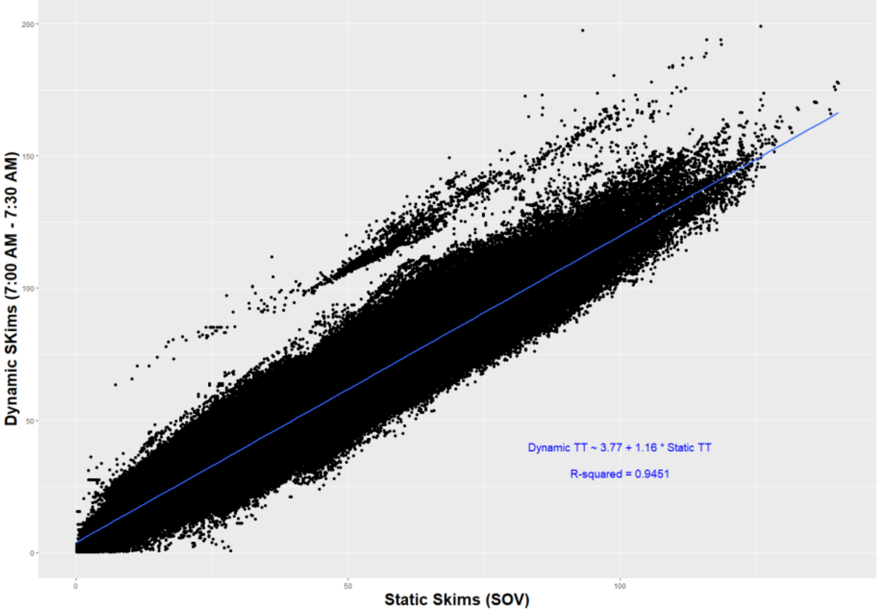
Better Methods. Better Outcomes.

Questions

Verification of Dynamic Skims

Dynamic versus static



Outlier review