Atlanta TRANSIMS Project

Using TRANSIMS to Quantify the Impacts of Planned Transportation Projects on Congestion and Air Quality

Argonne National Laboratories

April 8-9, 2010

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Problem Statement

- Increasing traffic congestion and unhealthy air quality are key challenges in Atlanta
  - Nonattainment area for ozone and $PM_{2.5}$
  - Half of ozone precursors from on-road mobile sources
  - $5 billion shortfall in transportation funding over next 20 years
- 2005 Governor's Congestion Mitigation Task Force recommendations:
  - 70% congestion weighting in project selection process
  - Technically consistent and transparent methodology for benefit/cost analysis

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Current Methodology

- Utilizes traditional 4-step travel demand model
- Compares vehicle hours of travel for build and no-build scenarios
- TRANSIMS may be better suited to task
  - Bottlenecks
  - Peak spreading
  - Assignment algorithm
  - Speed/acceleration profile and emissions
  - Diurnal population distribution

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Purpose of the Study

- FHWA TRANSIMS Research Grant
  - Quantify the congestion impacts of planned transportation projects
  - Use MOVES to quantify the emissions impacts
  - Include Peer Review meetings

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ARC's Conflated Network

- ARC recently merged NAVTEQ network shapes and street names with TP+ links
  - The spatial accuracy of the network was improved or "conflated"
- Improves TRANSIMS conversion
  - Intersection configuration and connectivity
  - Activity locations / parking / transit stops
- Improves TRANSIMS visualization
  - Better maps and traffic displays

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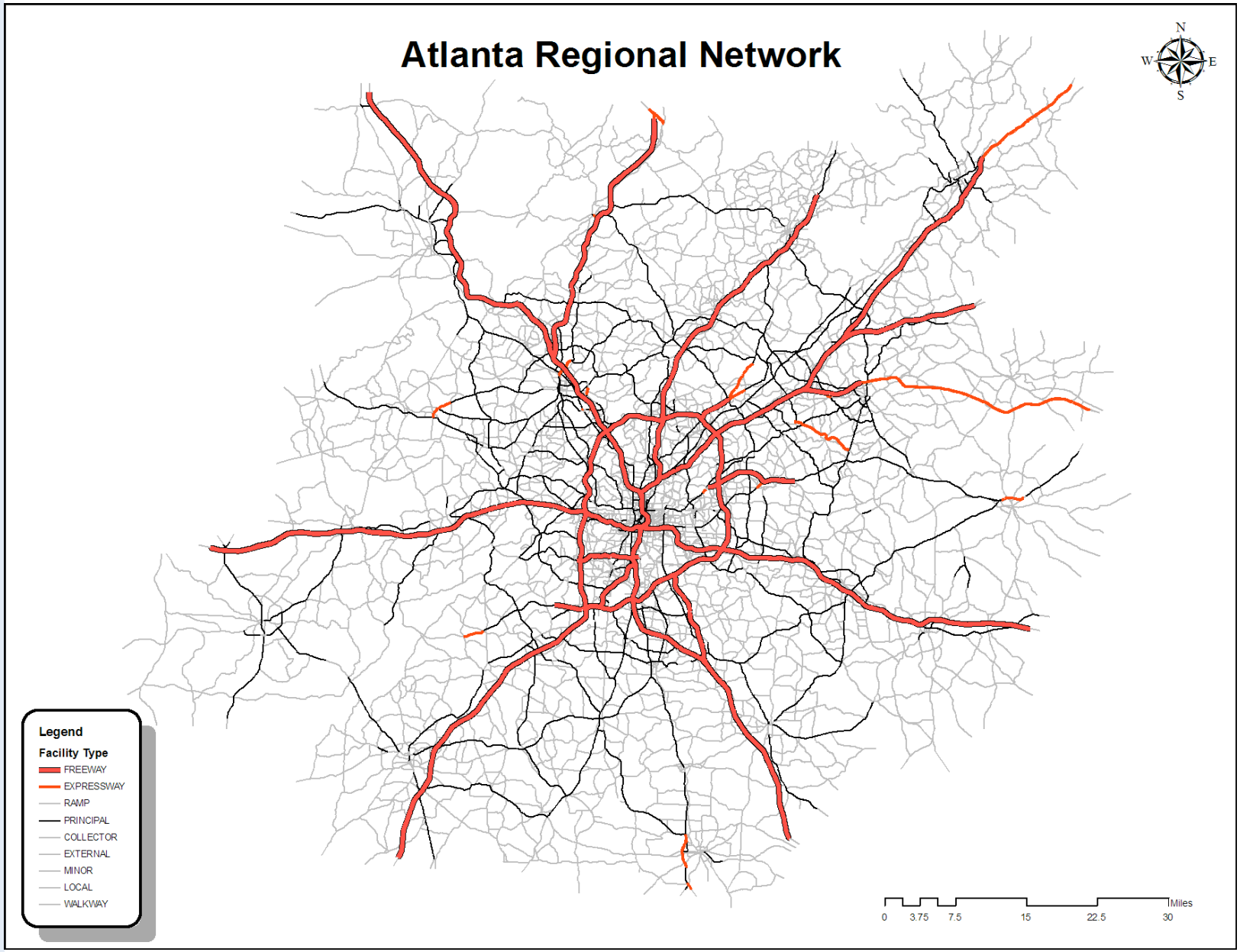

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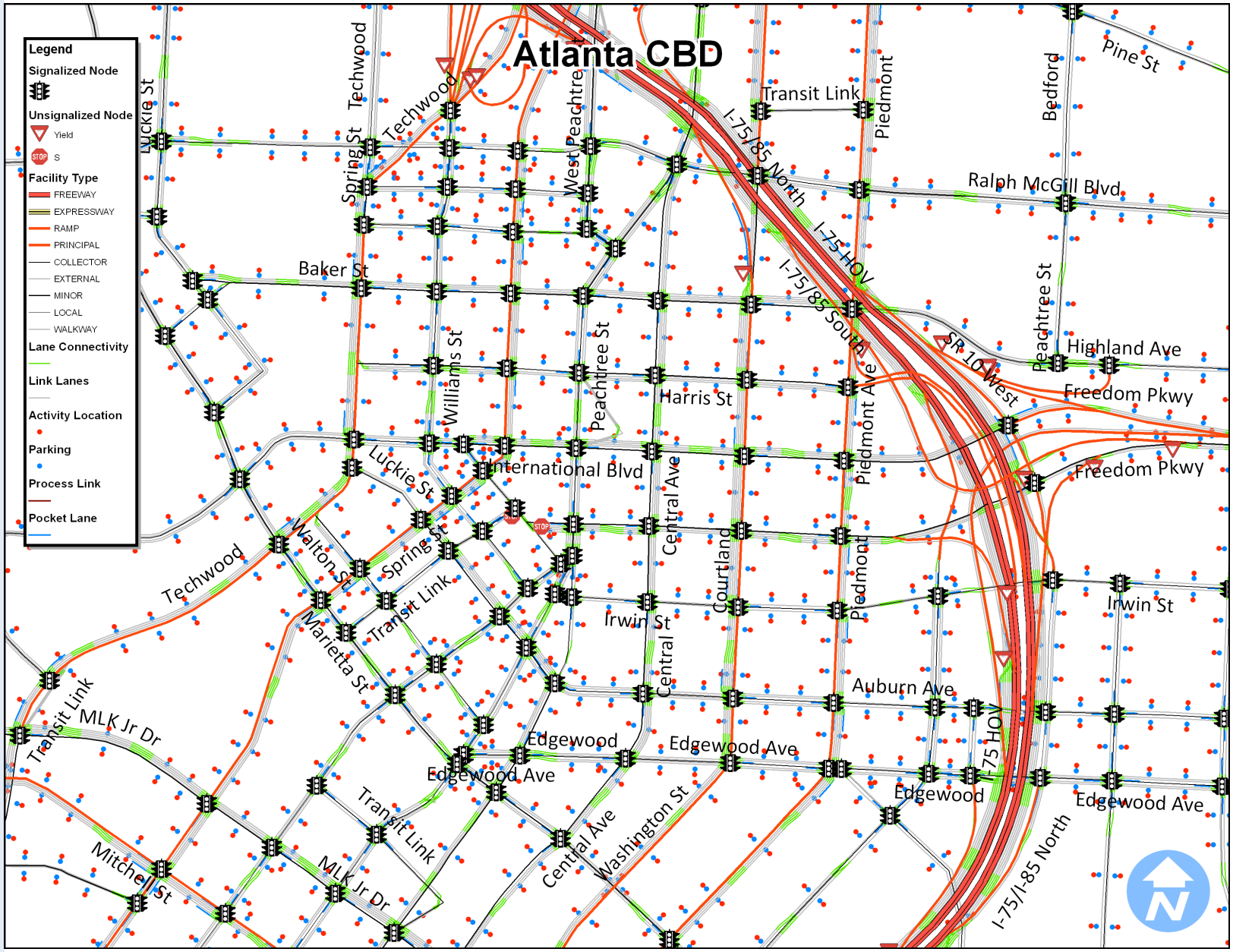

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Network Improvements

- Router-Microsimulator identifies coding problems and desirables enhancements
  - Link connections and traffic conflicts
  - One-way / two-way street conflicts
  - Literal versus conceptual coding conventions
    - HOV lanes and other lane-use-related traffic restrictions

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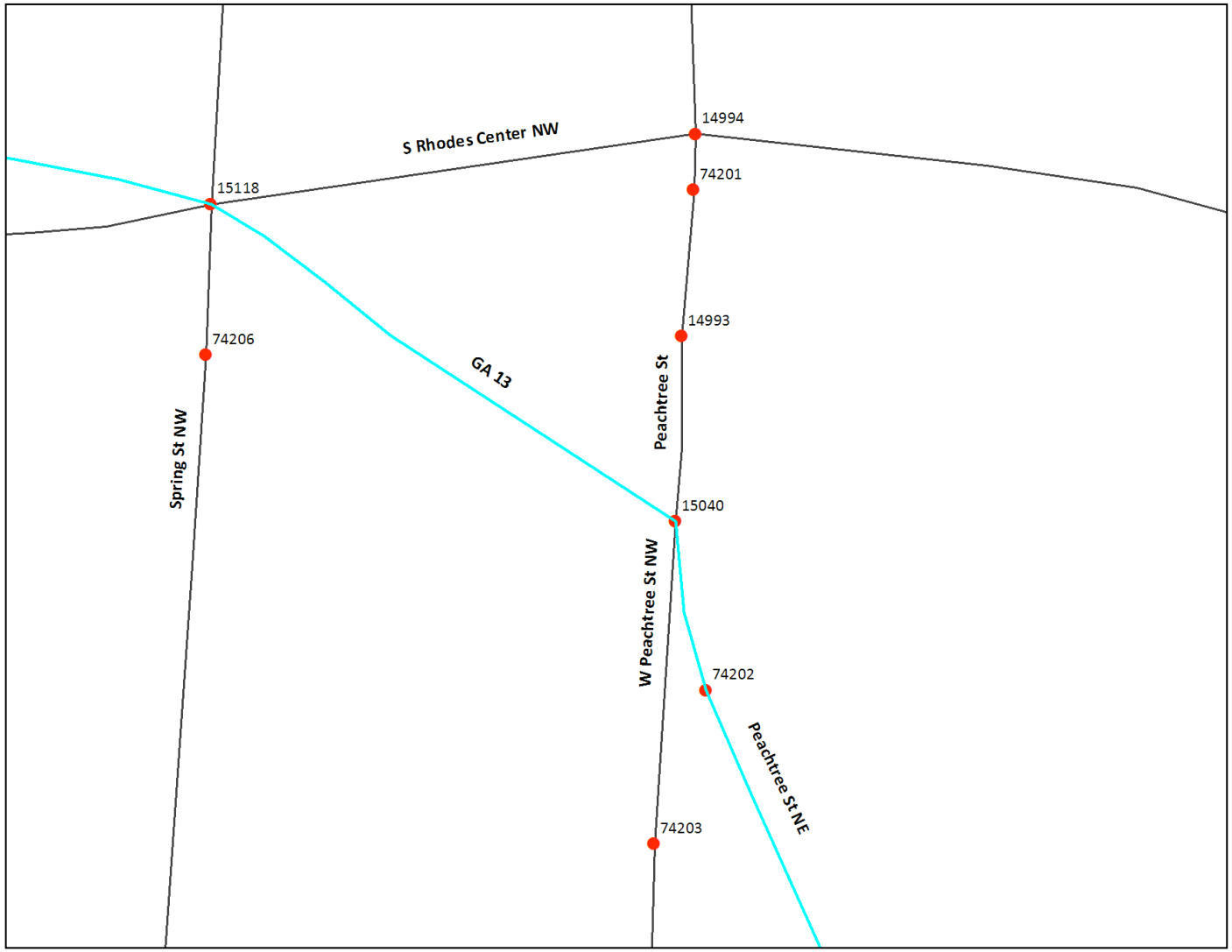
Peachtree St. and GA13



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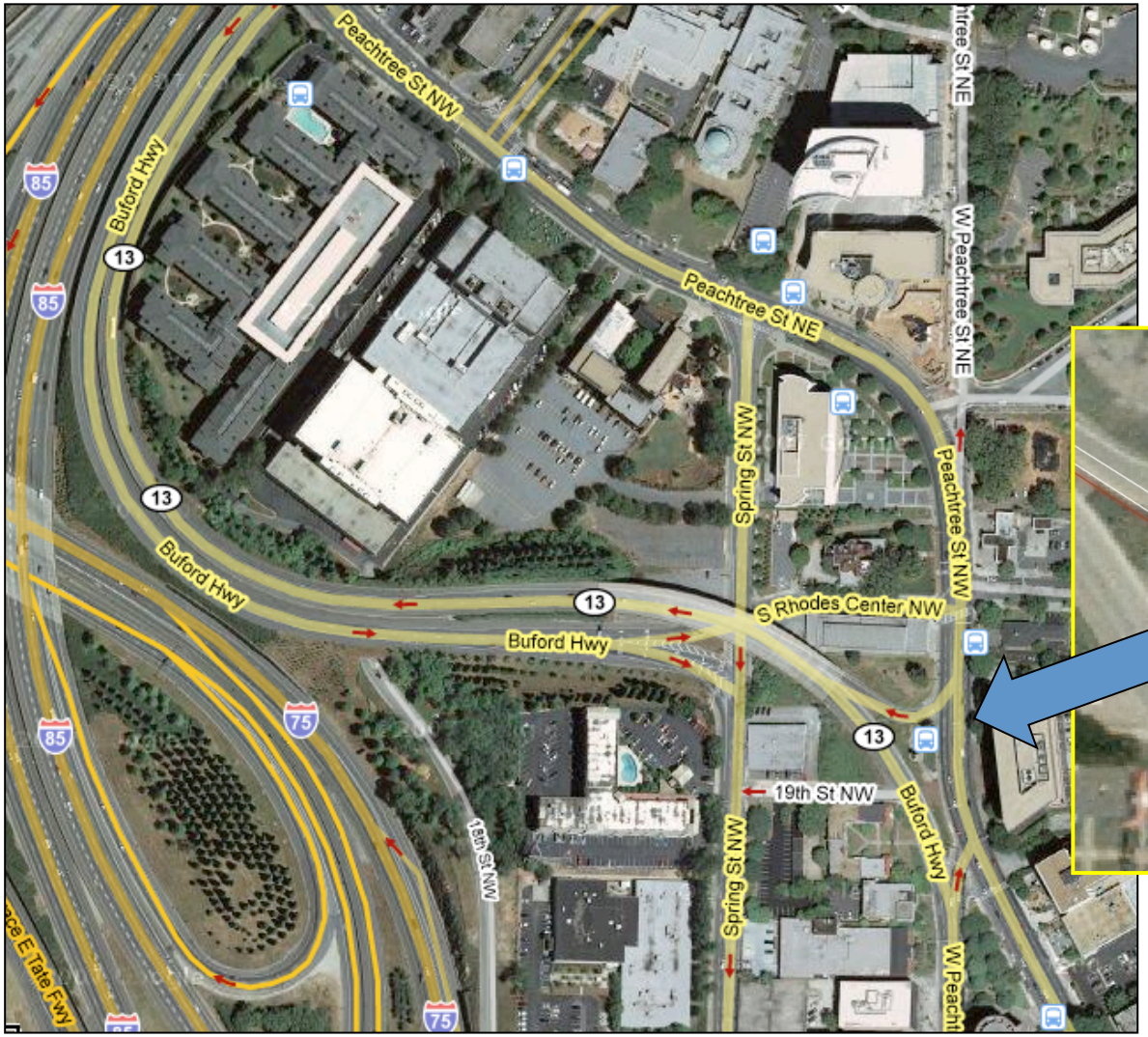
GA13 Volumes Too High



Improper Connect

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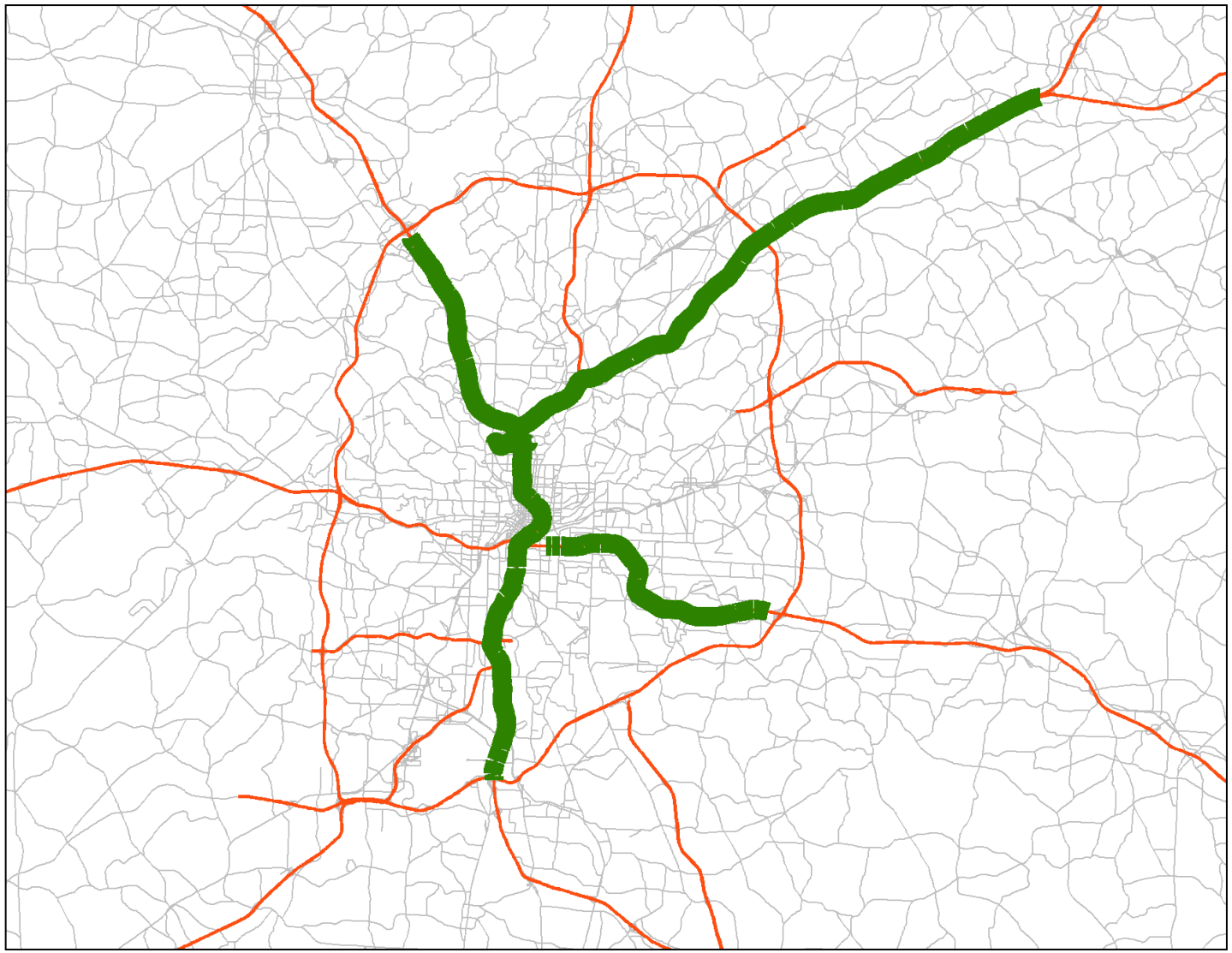
Regional HOV Facilities



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Coding Change

- Delete HOV links and two-way slip ramps
  - Keep any real world HOV-only ramps
- Add left side HOV lane to mainline links
  - Add lane-use records to limit vehicle access
- Move bus routes from original HOV links to mainline links
- Re-do network conversion to fix lane connectivity and remove pocket lanes

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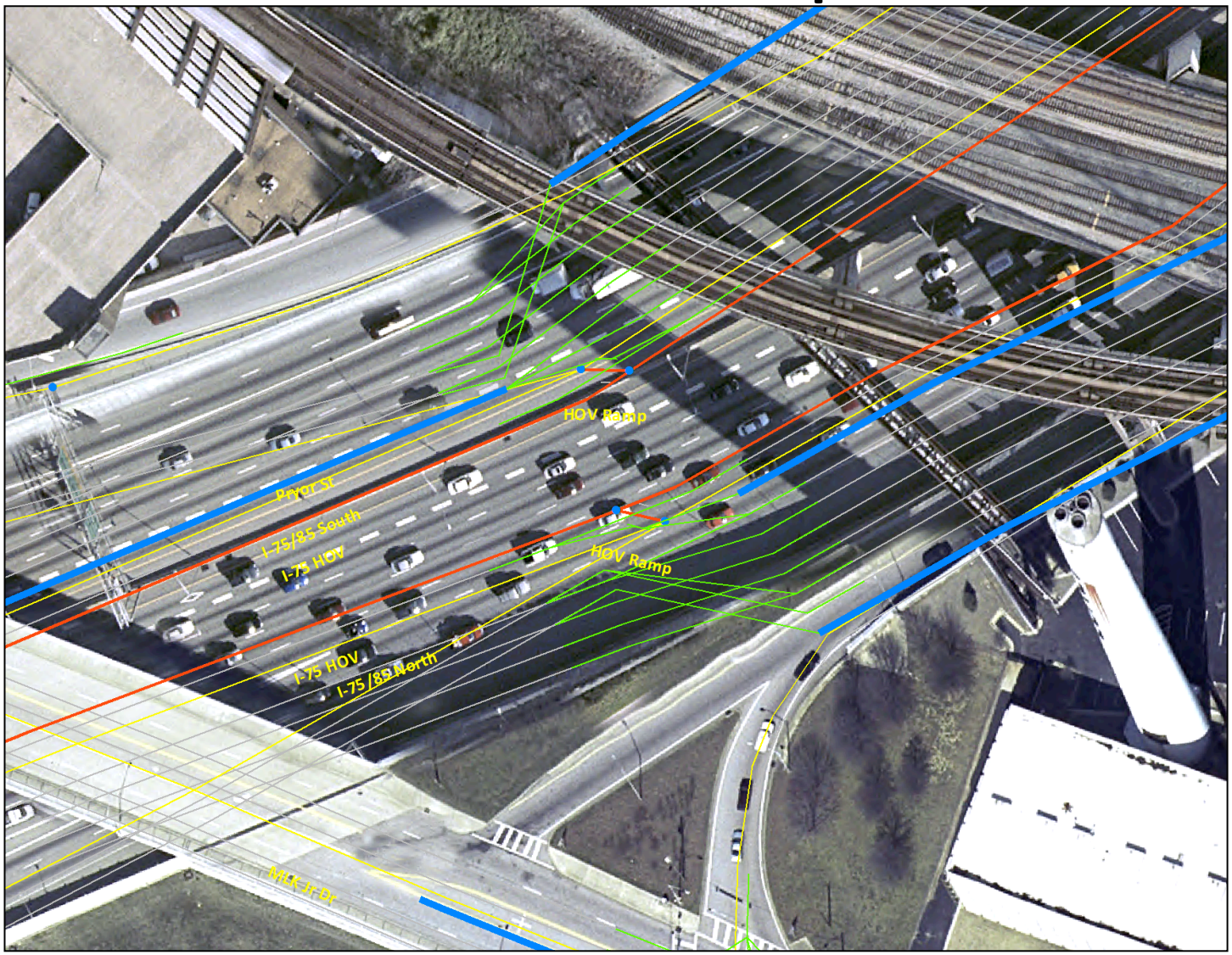
Simulation Impacts



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Airport Access Problems

- Too much traffic on the east side and not enough on the west side of the airport
- Caused by improper allocation of trips to activity locations within the airport zone
  - Too few links at the terminal and too many links on the support side of the airport
  - Spatial inconsistency between the terminal links and the zone boundary

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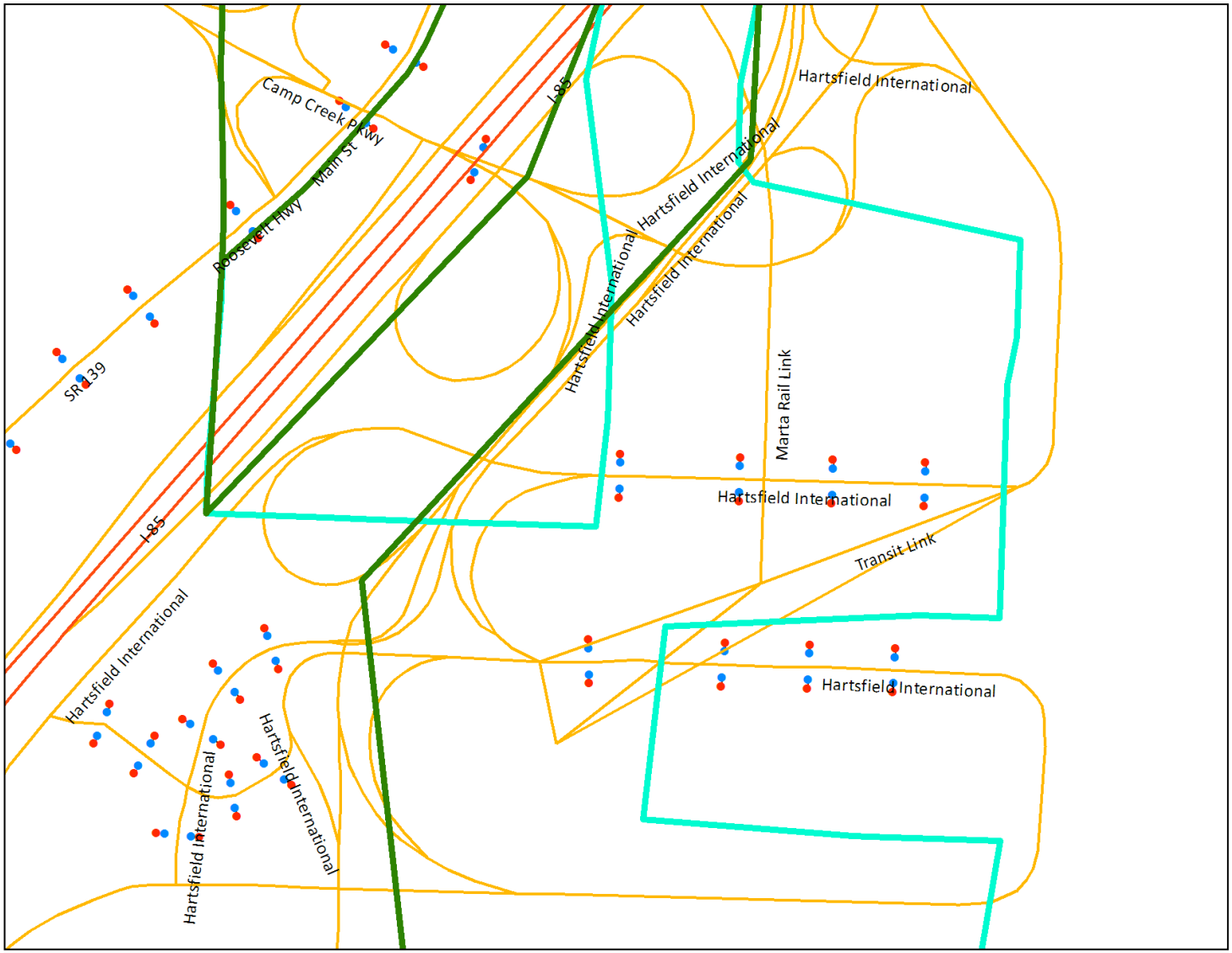
Terminal Access Locations



ARC Highway Assignments

- Static capacity constrained equilibrium
- 4 time periods
  - AM peak, midday, PM peak, and night
  - Volume-delay equations for each period
- 6 vehicle types
  - SOV, HOV2, HOV3+, commercial vehicles, medium-duty trucks, heavy-duty trucks
  - PCE factors for trucks

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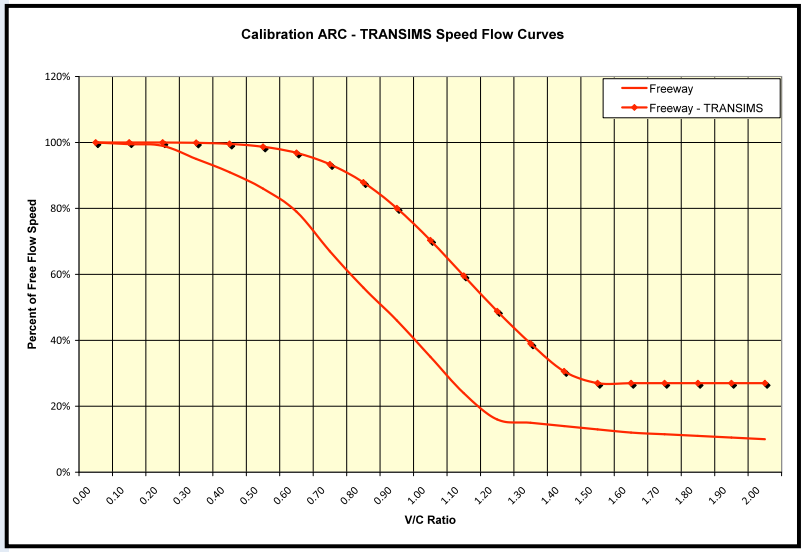
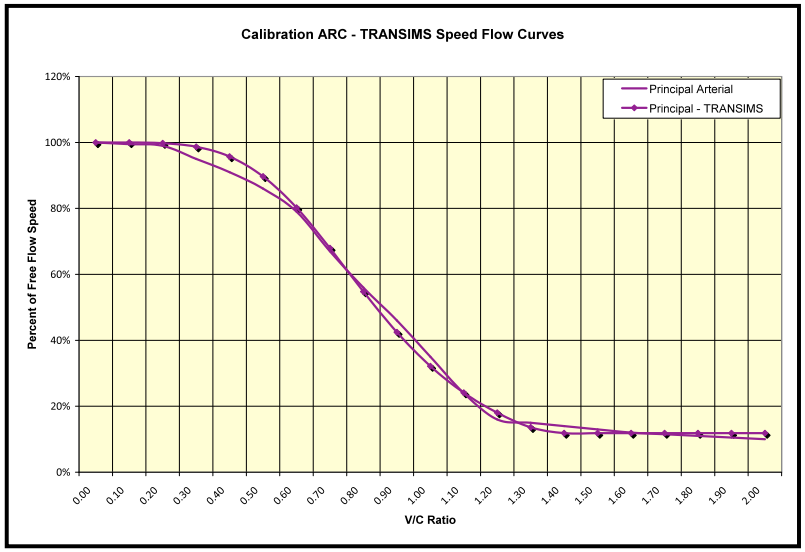
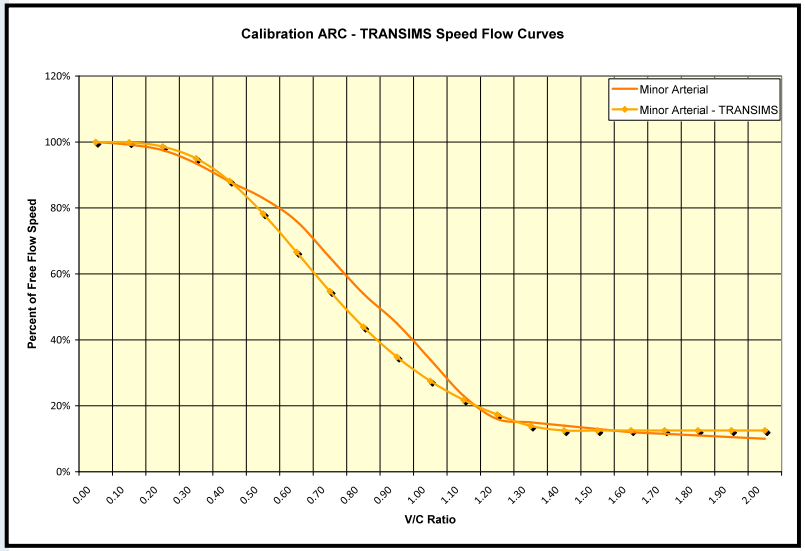
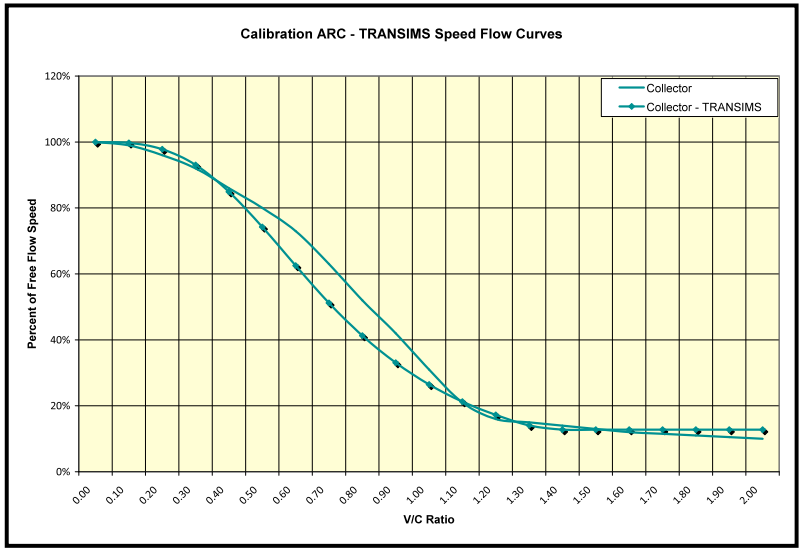
TRANSIMS Function Calibration









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Regional Router Comparison

TYPE	TRANSIMS	ARC Model	Difference	Deviation
Freeway	89,357,318	82,334,806	7,022,512	9%
Expressway	4,422,557	4,490,907	(68,349)	-2%
Principal Arterials	57,035,234	55,439,977	1,595,256	3%
Ramps	8,499,315	7,495,606	1,003,709	13%
Externals	1,518,900	1,526,892	(7,991)	-1%
Major Roads	***160,833,324***	***151,288,188***	***9,545,137***	**6%**
MINOR	67,079,751	45,561,556	21,518,195	47%
COLLECTOR	26,103,181	14,596,337	11,506,844	79%
Local	1,611,142	1,397,323	213,819	15%
Zone Connectors*1.5	-	38,565,203	-	-
Minor Roads	***94,794,074***	***100,120,419***	***(5,326,345)***	***-5%***
Total	**255,627,398**	**251,408,607**	**4,218,791**	**2%**
Vehicle Miles	**159,767,124**	**157,130,379**	**2,636,745**	**2%**

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Router Value of Distance Tests

Volumes on Freeway/Expressway (TRANSIMS Vs Directional Counts)

Distance Value	Dir Count VMT	TRANSIMS VMT	Diff	% Diff
0.60*	48,145,249	53,110,295	4,965,046	10%
0.70	48,145,249	51,266,262	3,121,013	6%
0.85	48,145,249	49,881,723	1,736,474	4%
1.00	48,145,249	48,588,564	443,315	1%

Volumes on Freeway/Expressway (TRANSIMS Vs Radial Counts)

Distance Value	Radial Count VMT	TRANSIMS VMT	Diff	% Diff
0.60*	30,099,756	35,408,421	5,308,665	18%
0.70	30,099,756	34,398,891	4,299,135	14%
0.85	30,099,756	33,493,636	3,393,880	11%
1.00	30,099,756	32,661,737	2,561,981	9%

* - Currently used in TRANSIMS model

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Intrazonal Trip Impacts

- Total trips loaded in TRANSIMS were much higher than ARC loadings in TP+
- ARC trips tables total 13.6 million trips
  - 1.8 million (13%) are intrazonal
    - (100,000 HBW, 1,080,000 HBO, 560,000 NHB)
  - 11.8 million trips loaded in TP+
- Removed intrazonal trips from trip tables used in ConvertTrips

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Impact of Intrazonal Change

- Change in the difference between TRANSIMS volumes and ARC volumes
  - Daily 18% → 14%
  - AM Peak Period 10% → 9%
  - Midday 35% → 31%
  - PM Peak Period 2% → 1%
  - Night 20% → 14%

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Short Interzonal Trips

- The ARC network includes 617 interzonal interchanges with direct paths between zone connectors
  - An additional 202,000 trips are only loaded to zone connectors in the ARC model, but are loaded to network links in TRANSIMS

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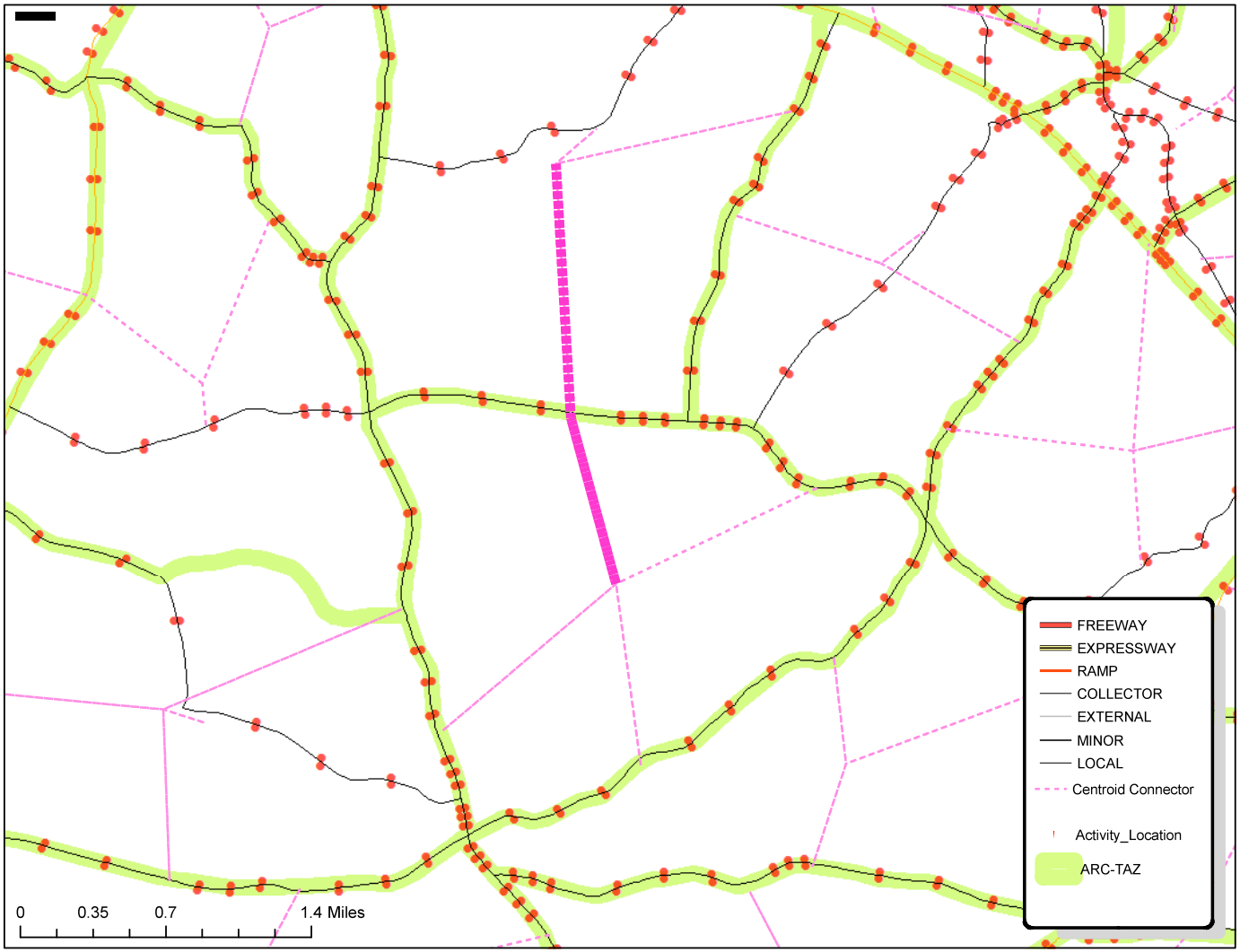
Interzonal Zone Connections



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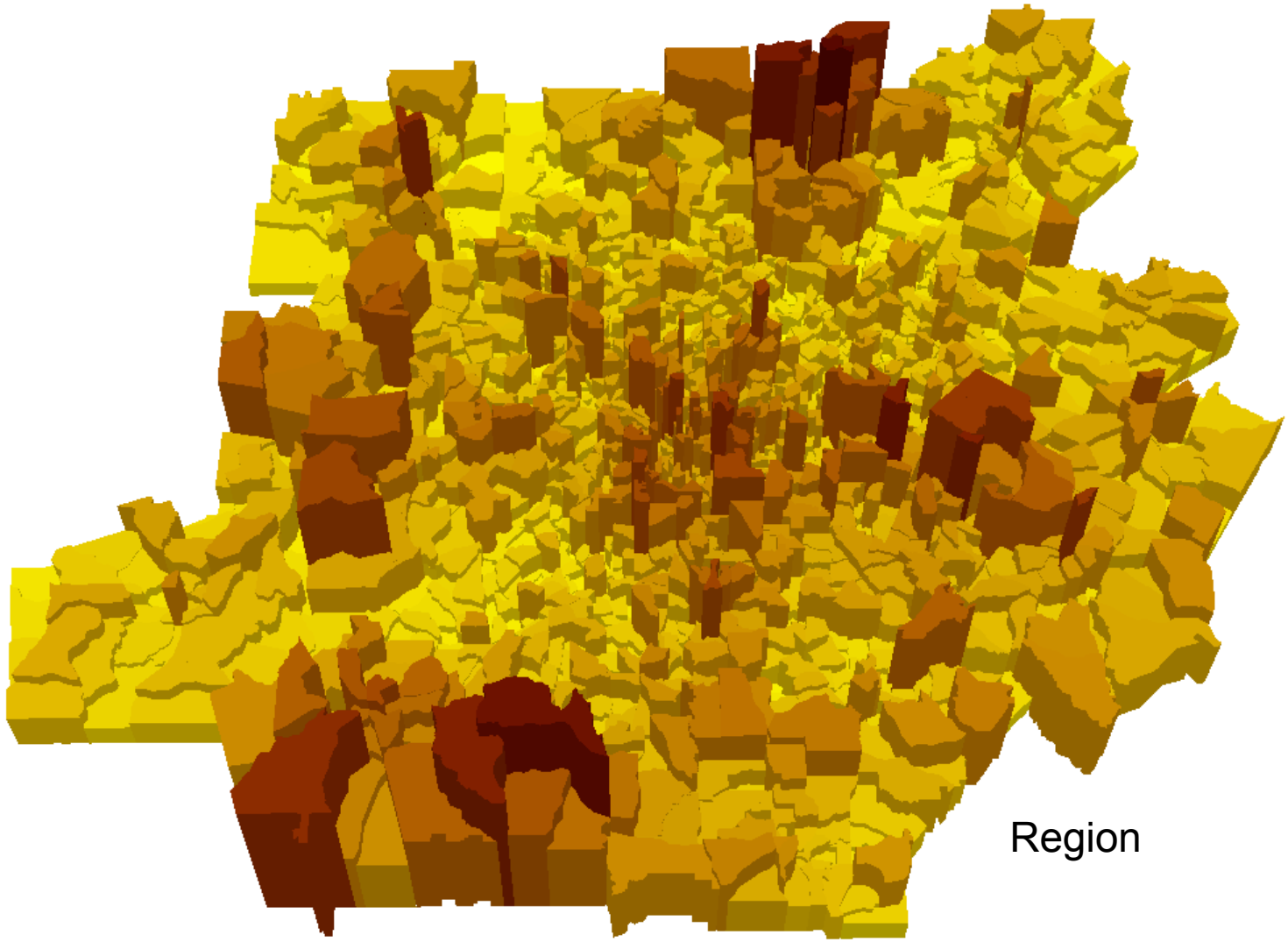
Activity Location Density by TAZ



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Diurnal Adjustment Options

- 15 minute radial freeway counts suggest:
  - Too many peak and mid-day trips
  - Not enough morning and night trips
- Adjustment Options:
  - Smooth and spread the ARC distributions
    - Trip purpose and orientation based
  - Apply Matrix Variegator methodology
    - Hourly vehicle demand vs. count comparisons

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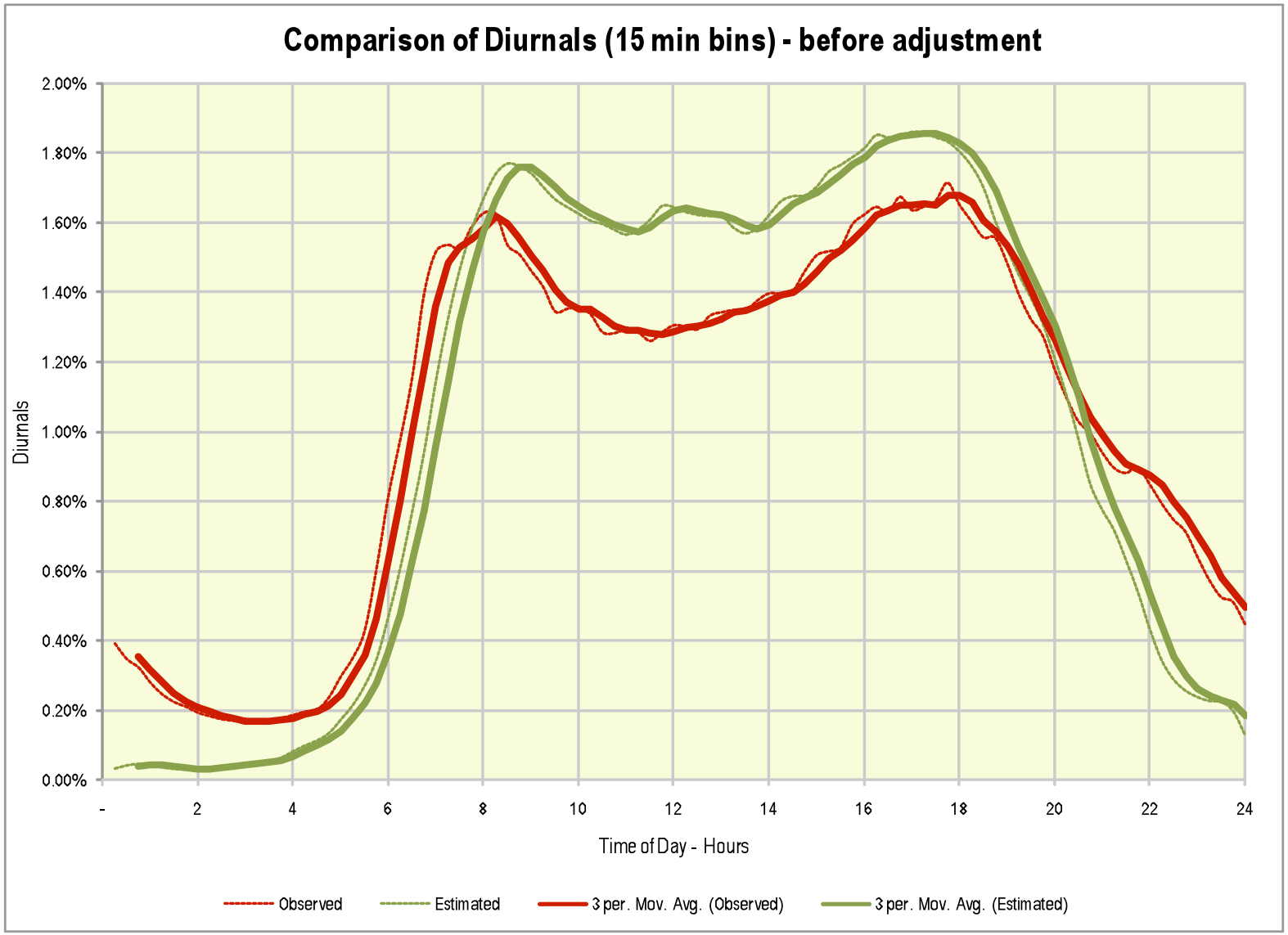
Radial Freeway Comparison



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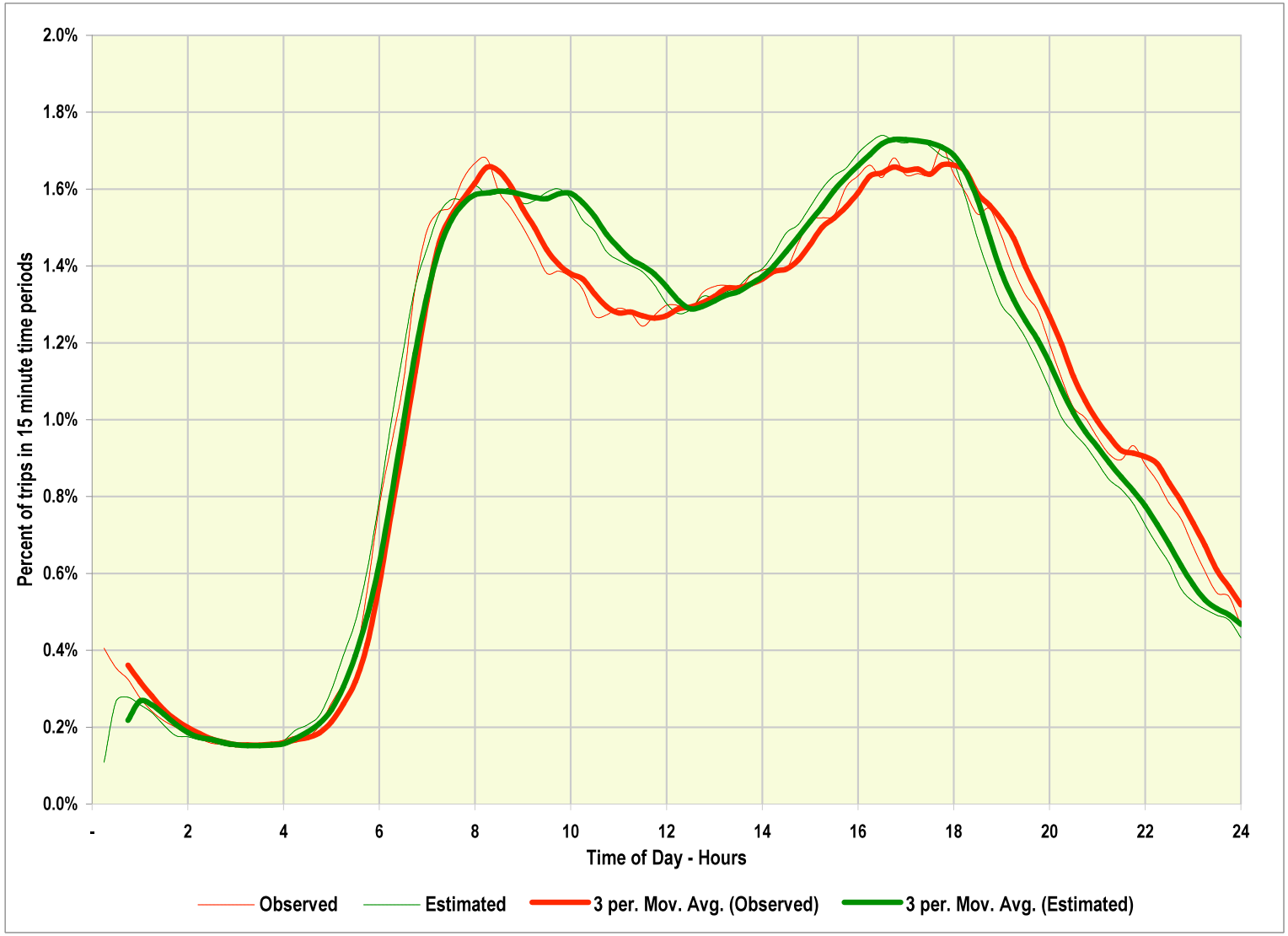
Radial Freeways After Adjustments



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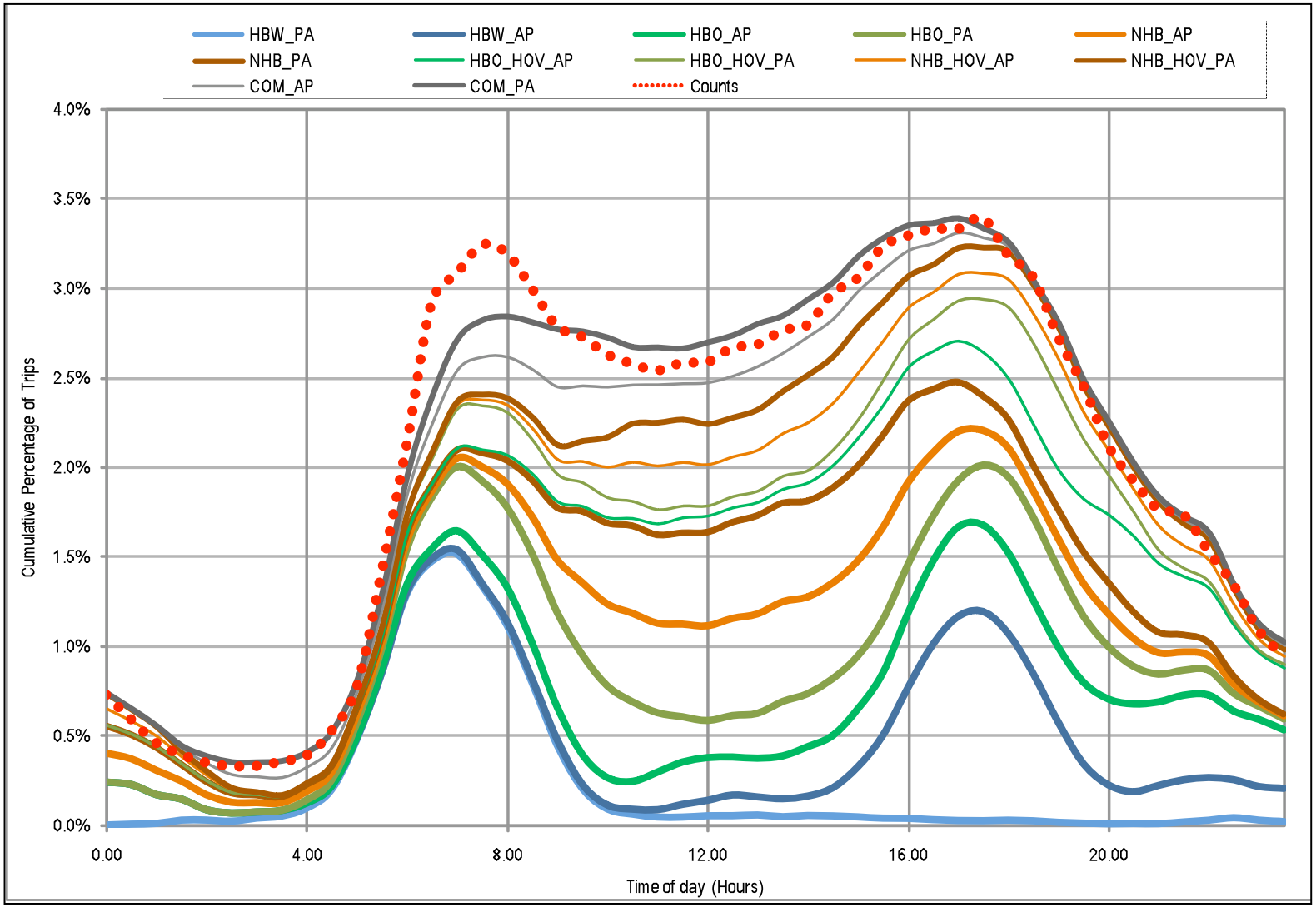
Smoothed Diurnals



Matrix Variegator Method

- Developed by PBS&J for I-285 simulation
  - Hourly peak period and daily ramp counts
- Six trip tables
  - SOV, HOV2, HOV3+, commercial vehicles, medium-duty trucks and heavy-duty trucks
- Split into hourly trip tables based on comparisons between hourly counts and assigned volumes

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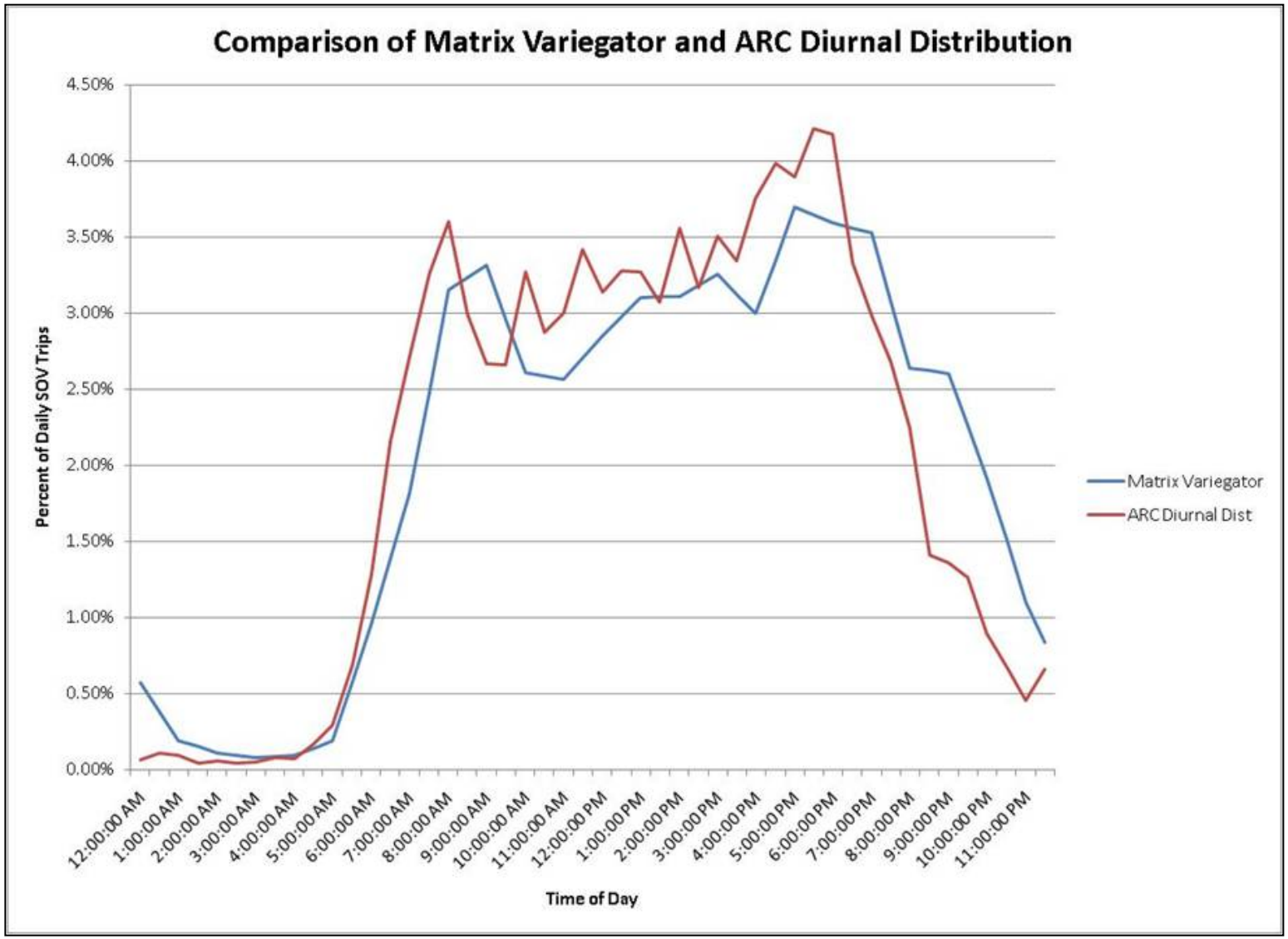
Hourly Diurnal Distributions



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I-285 Subarea Router Demand

TYPE	TRANSIMS	ARC Model	Difference	Deviation
Freeway	37,384,572	33,288,407	4,096,164	12%
Expressway	389,773	473,683	(83,910)	-18%
Principal Arterials	7,161,421	7,414,186	(252,765)	-3%
Ramps	5,149,993	4,793,996	355,996	7%
Externals	-	-	-	0%
Major Roads	***50,085,758***	***45,970,273***	***4,115,485***	**9%**
MINOR	4,536,472	3,613,514	922,958	26%
COLLECTOR	7,497,854	4,334,993	3,162,861	73%
Local	710,738	514,725	196,013	38%
Zone Connectors*1.5	-	6,231,510		-
Minor Roads	***12,745,065***	***14,694,742***	***(1,949,677)***	***-13%***
Total	**62,830,823**	**60,665,015**	**2,165,808**	**4%**
Vehicle Miles	**39,269,264**	**37,915,634**	**1,353,630**	**4%**

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Northwest Subarea Validation

	Num.	Volume		Difference		Abs.Error		Std.	
Facility Type	**Obs.**	**TRANSIMS**	**Count**	**Volume**	**%**	**Avg.**	**%**	**Dev.**	**% RMSE**
Directional Counts - DAILY									
Freeway	71	5,076,770	4,797,712	279,058	5.8	9,948	14.7	10,094	20.9
Expressway	14	350,196	262,005	88,191	33.7	7,441	39.8	4,423	45.8
Principal Arterial	262	4,223,394	3,202,295	1,021,099	31.9	4,735	38.7	4,120	51.3
Minor Arterial	342	1,936,917	1,534,305	402,612	26.2	1,901	42.4	1,786	58.1
Collector	163	941,218	708,240	232,978	32.9	2,170	49.9	1,668	62.9
Local Street	4	6,575	8,130	-1,555	-19.1	397	19.5	335	24.2
TOTAL	**856**	**12,535,070**	**10,512,687**	**2,022,383**	**19.2**	**3,571**	**29.1**	**4,604**	**47.4**

	Num.	Volume		Difference		Abs.Error		Std.	
Time Period	**Obs.**	**TRANSIMS**	**Count**	**Volume**	**%**	**Avg.**	**%**	**Dev.**	**% RMSE**
Radial Freeway Counts									
Daily	58	4,233,545	3,588,013	645,532	18.0	13,743	22.2	16,084	34.0
AM Peak Period	58	1,076,947	815,689	261,258	32.0	4,993	35.5	5,185	51.0
PM Peak Period	58	1,094,308	919,509	174,799	19.0	3,981	25.1	4,734	38.8

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Subarea Simulation Strategy

- Regional routing and subarea simulation
  - Consider the full path and travel options
  - Split the plans into subareas for simulation
- Focuses resources on the areas of interest
  - Computational resources
    - Runs on standard desktop computers
    - Reduces data storage / processing requirements
  - Staff / budget resources
    - Research project to demonstrate capabilities

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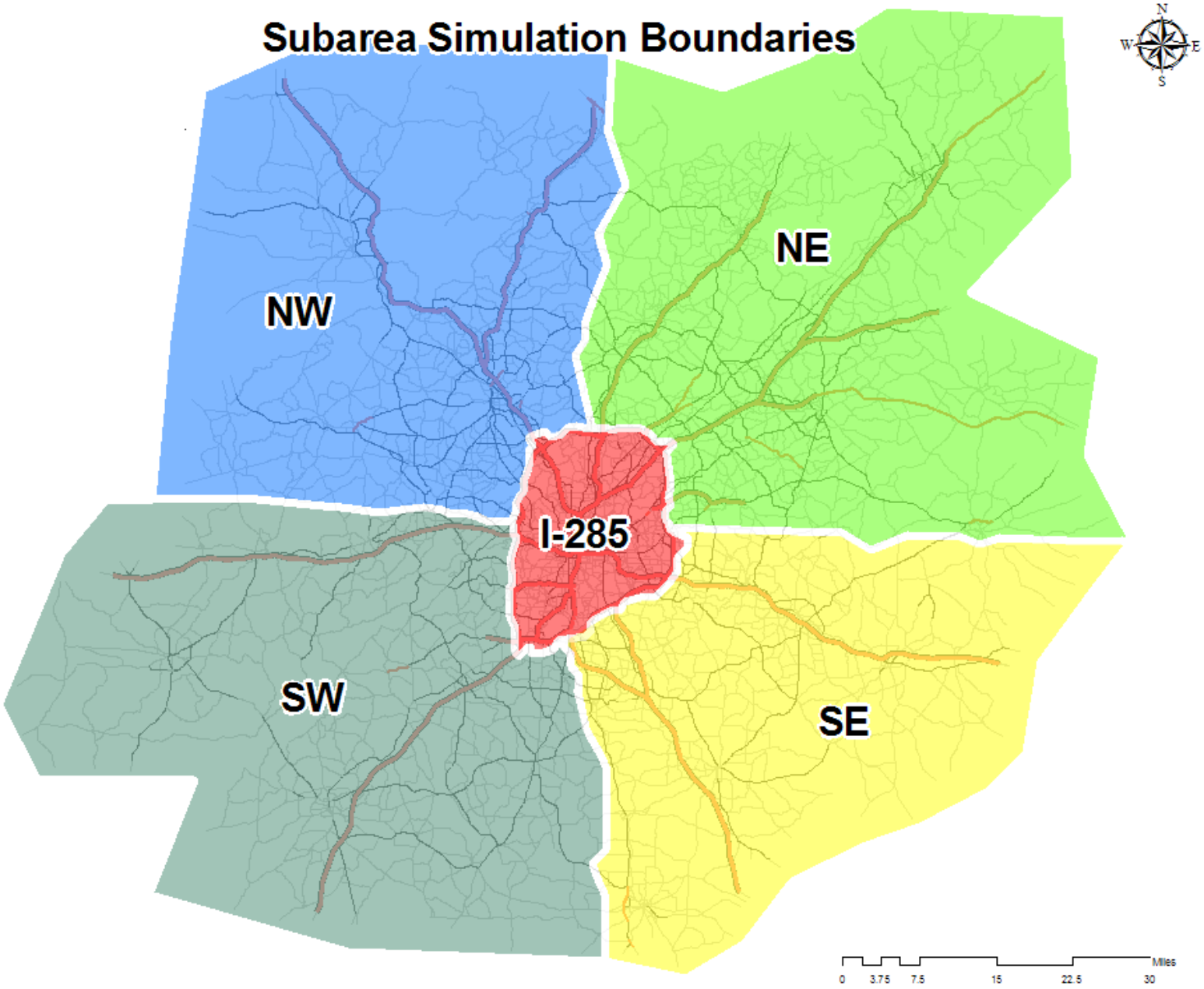

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I-285 Simulation Comparison

I- 285 Subarea		Smooth diurnal distribution			Matrix Variegator		
TYPE	ARC Model	TRANSIMS	Difference	Deviation	TRANSIMS	Difference	Deviation
Freeway	26,451,381	28,051,376	1,599,995	6%	29,679,649	3,228,268	12%
Expressway	994,096	842,154	(151,942)	-15%	880,107	(113,989)	-11%
Principal Arterials	11,461,247	11,248,531	(212,716)	-2%	11,504,602	43,355	0%
Ramps	3,070,178	3,026,145	(44,033)	-1%	3,054,003	(16,175)	-1%
Externals	-	-	-	0%	-	-	
Major Roads	***41,976,902***	***43,168,206***	***1,191,304***	3%	***45,118,361***	***3,141,459***	7%
MINOR	7,354,207	8,924,318	1,570,111	21%	8,731,043	1,376,836	19%
COLLECTOR	4,575,397	6,993,942	2,418,545	53%	7,001,013	2,425,616	53%
Local	471,531	557,659	86,128	18%	555,206	83,675	18%
Zone Connectors*1.5	6,231,510	-		-	-		
Minor Roads	***18,632,645***	***16,475,919***	***(2,156,726)***	***-12%***	***16,287,262***	***(2,345,383)***	***-13%***
Total	**60,609,547**	**59,644,125**	**(965,422)**	**-2%**	**61,405,623**	**796,076**	**1%**
Vehicle Miles	**37,880,967**	**37,277,578**	**(603,389)**	**-2%**	**38,378,514**	**497,548**	**1%**

Calibrated Parameters

- Facility Type attributes:

Facility Type	Driver reaction time	Slow down probability	Slow down percentage
Freeway	0.6	20	15
Expressway	0.6	20	15
Principal Arterial	1.0	25	25
Major Arterial	1.0	25	25
Minor Arterial	1.0	25	25
Collector	1.0	25	25
Local	1.0	25	25
External	1.0	25	25
Ramp	0.6	20	15
Other	1.0	25	25

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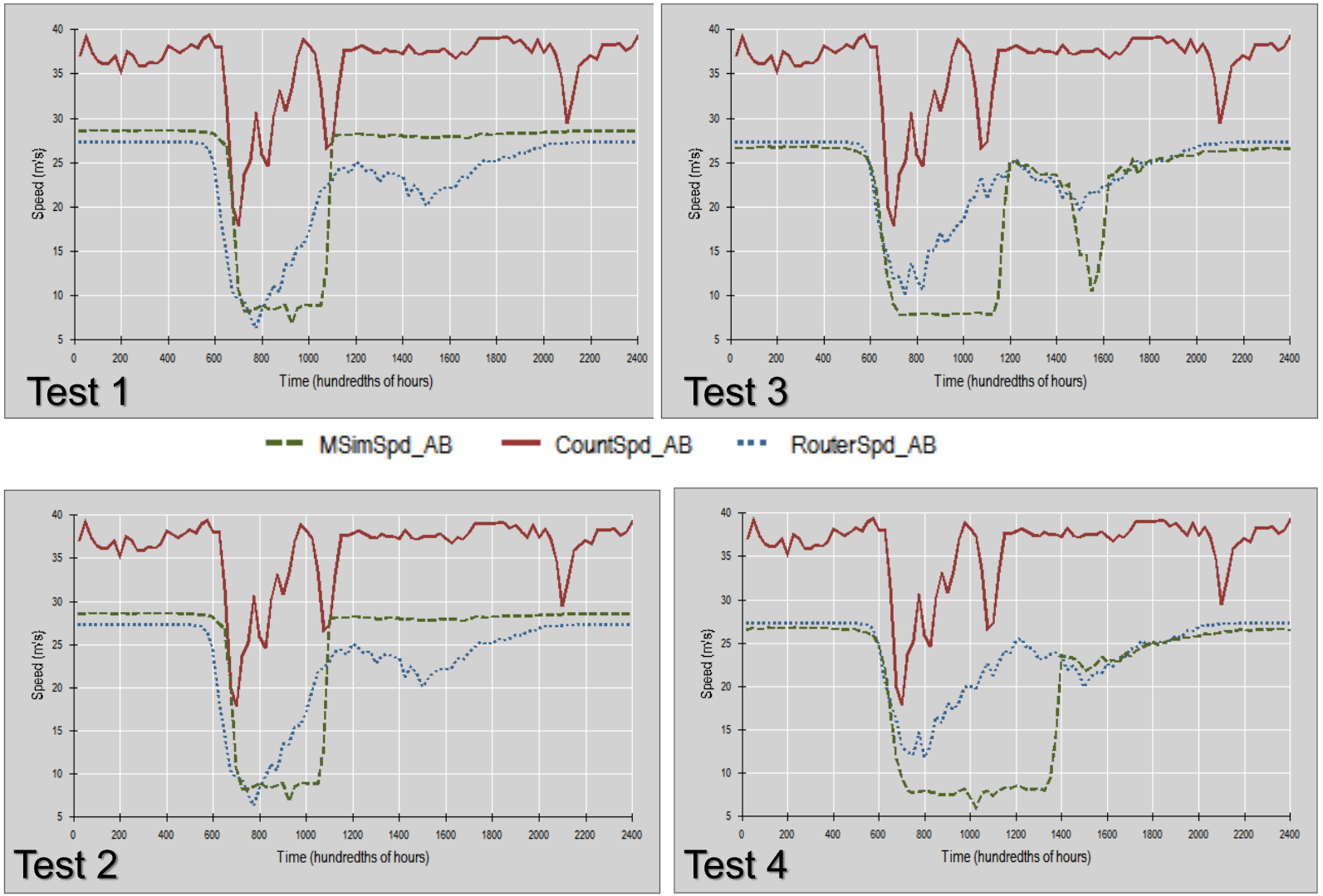
Speed Test Results (I-20 WB)



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Maximum Speed Adjustment

- Calibration could not generate high enough speeds for low volume conditions
  - ARC free-flow speeds on freeways are too low
- The three highest 15 minutes speeds for each radial freeway link were averaged and used
  - 80+ mph in many cases
  - The average increase was 5 percent
  - Some links increased by as much as 35 percent

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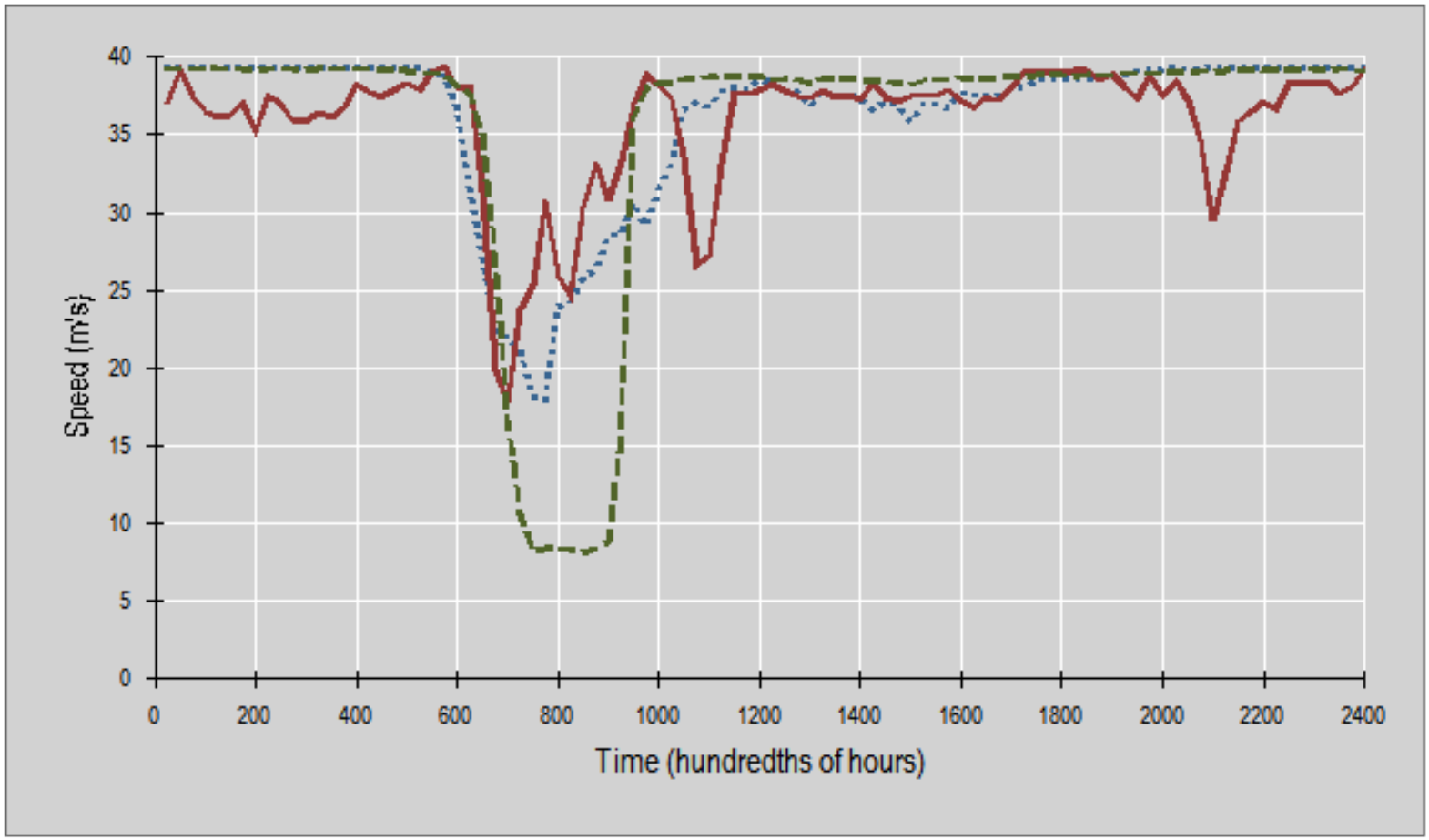
Maximum Speed Adjustment (I-20 WB)



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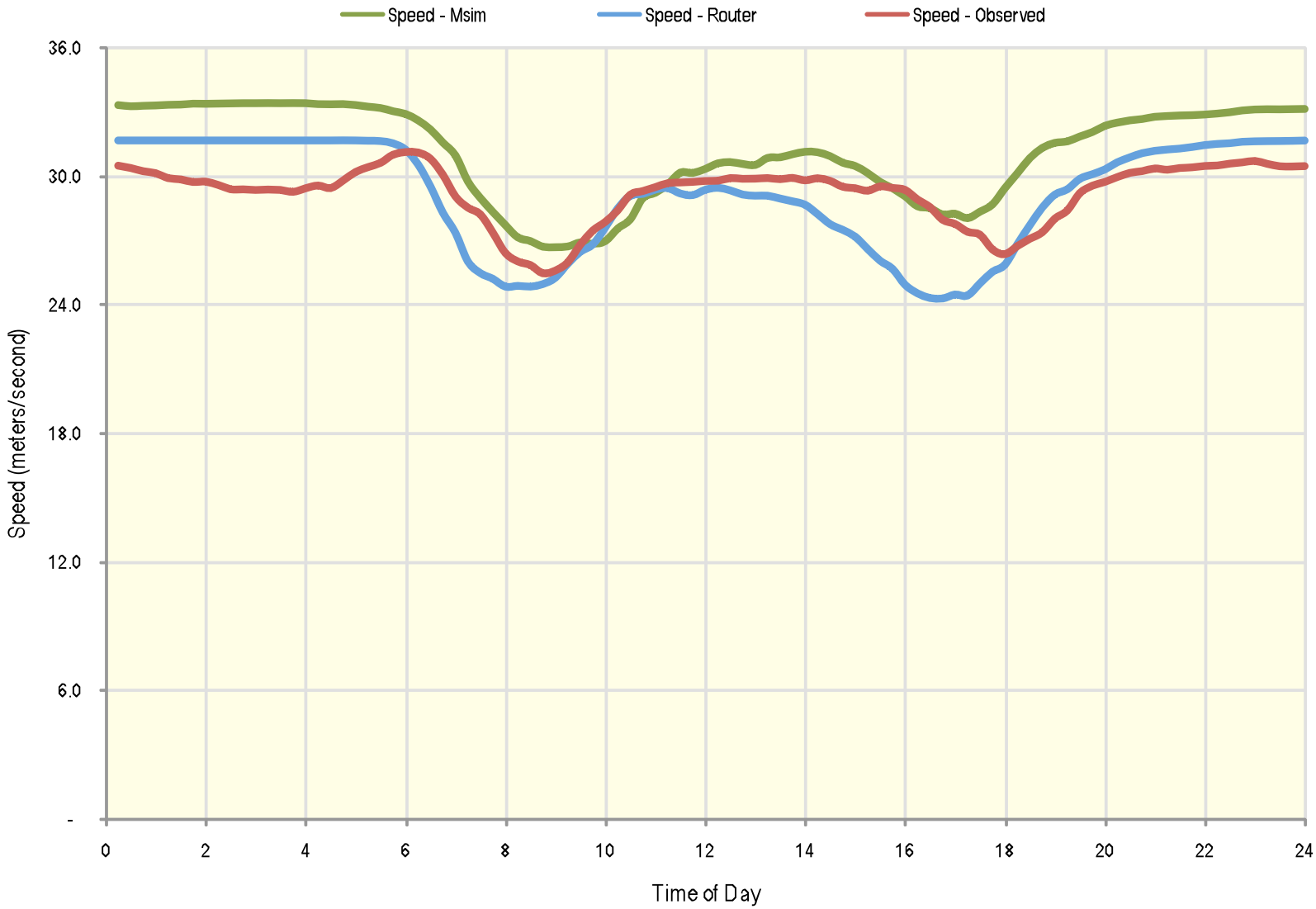
Composite Speed Profile



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Post-Review Model Adjustments

- Centroid Connectors as Local Streets
- Exclusion of Intra-zonal and 'short-circuited' trips
- Use of GDOT count data for diurnal curve adjustments

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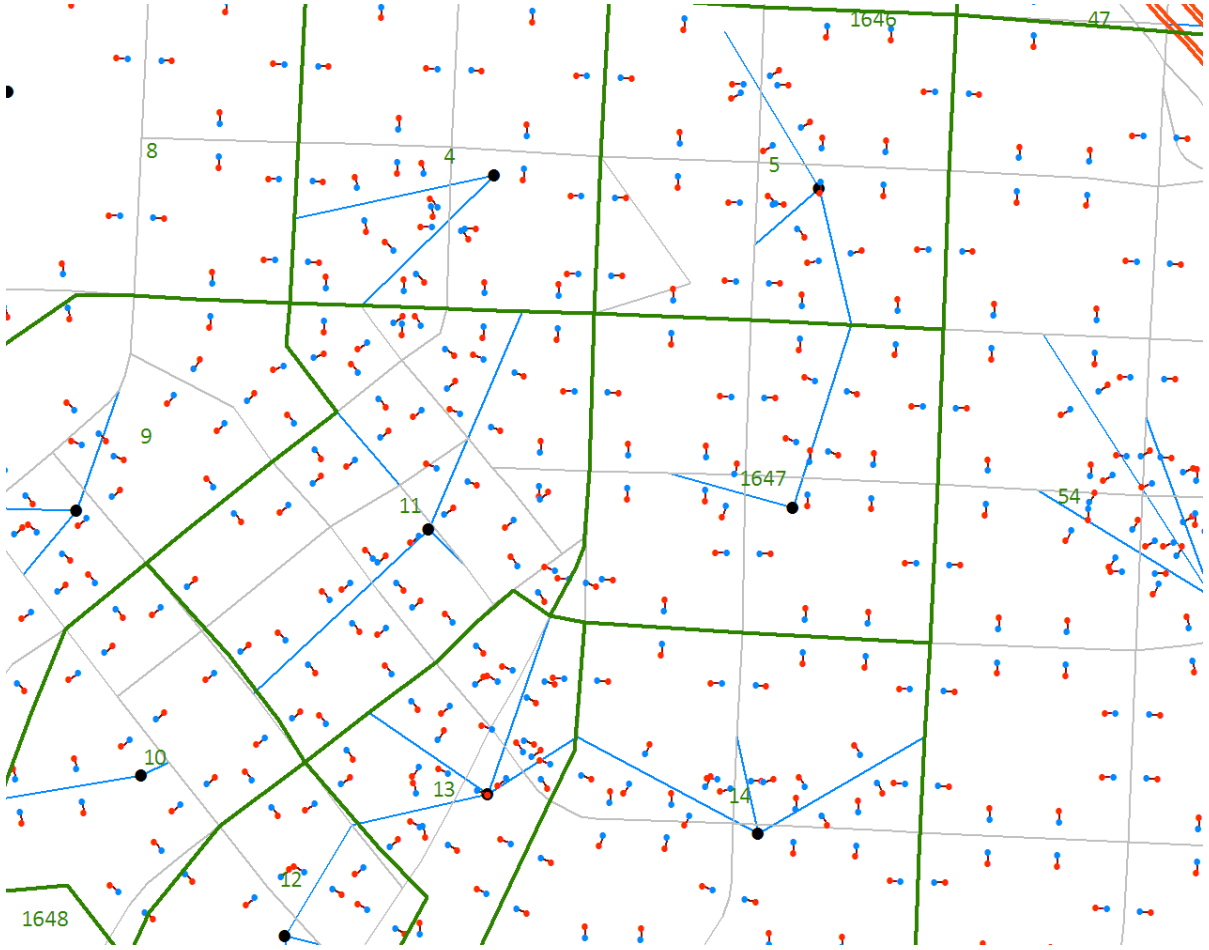
Calibration Adjustments: Zone Connectors as Local Streets



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Intrazonals

- Intra Zonal Trips Excluded
  - Including “short circuited” trips with common nodes
- Trip Maximization Logic Disabled
  - New feature added to ConverTrips
    - DISTANCE_WEIGHT_FLAG_ *

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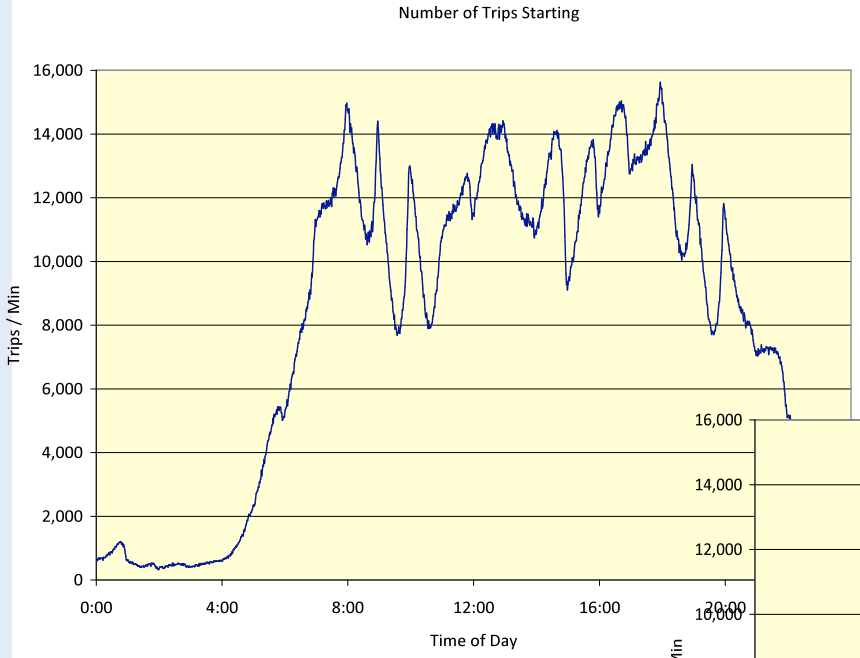
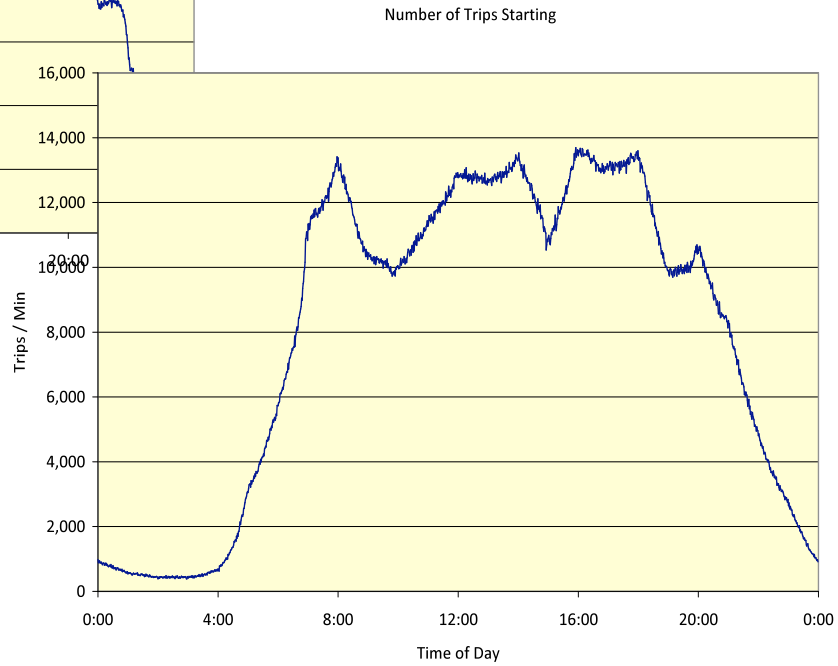
Diurnal Distribution Smoothing





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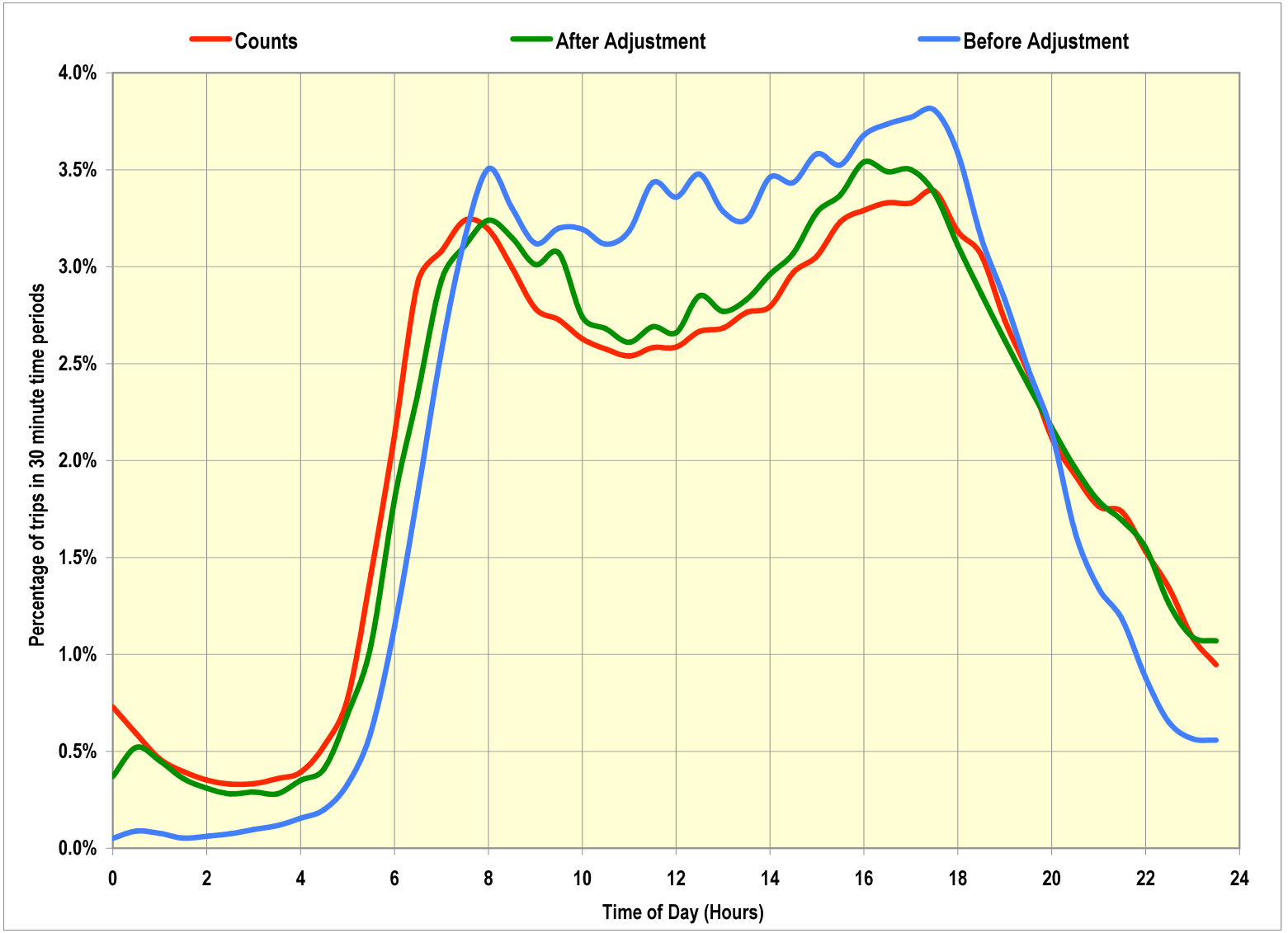
Total Before and After Adjustments



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Recap

- Two approaches with Matrix Variegator
  - #1: Hourly tables from the MV with diurnal distributions
  - #2: Smoothed distribution based on hourly targets
    - Distance-maximization feature in ConvertTrips turned off
    - Skims from previous assignment w/ Router-Microsimulator iterations
- Diurnal curves in ConvertTrips adjusted with GDOT counts
  - Using 44 itinerants generated from ARC's trip tables
    - "Smoothing" of demand spikes
    - Decrease in the number of iterations to convergence
  - Count distributions used for speed refinement and to validate microsimulator parameters
- Router only assignments performed
  - Centroid-connectors as locals to mimic ARC modeling process
  - Loading/unloading trips only at the centroids

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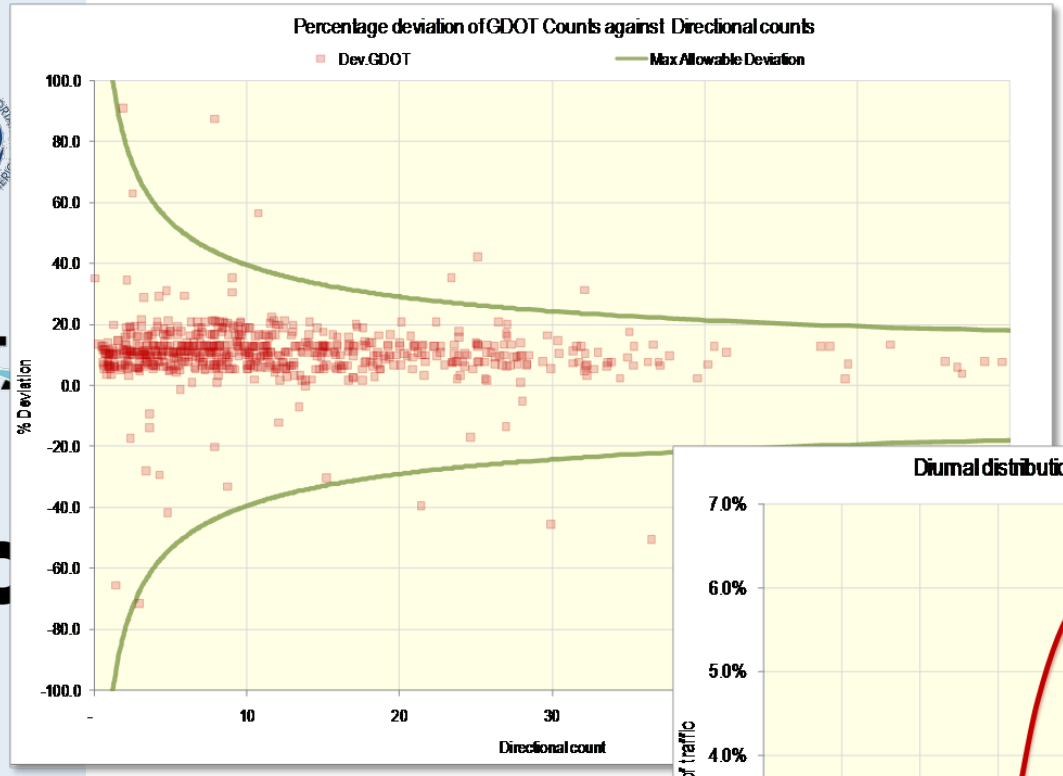
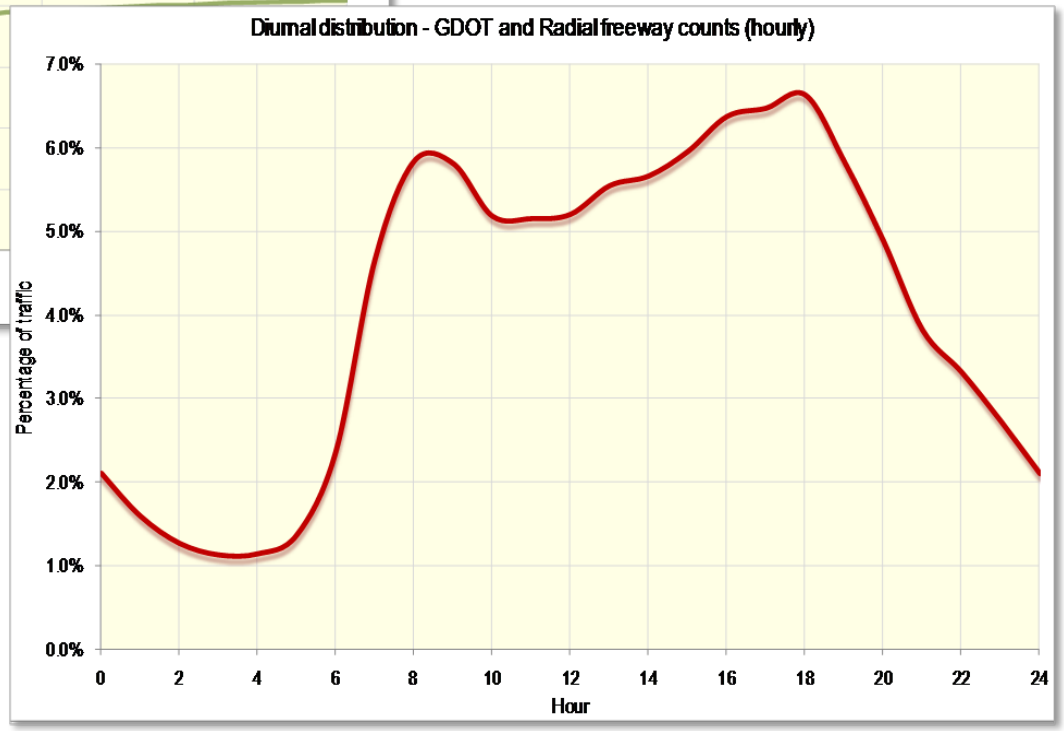
GDOT Count Normalization





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Transims Applications

- Example project
- Other illustrative projects
- Practical lessons learned
- Recommendations

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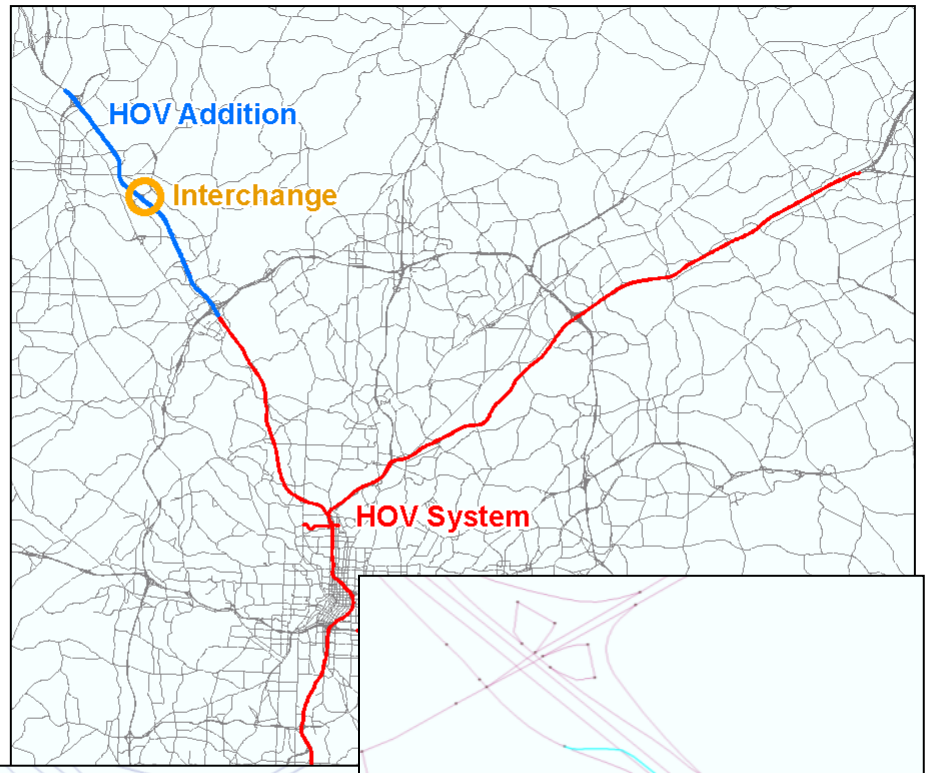
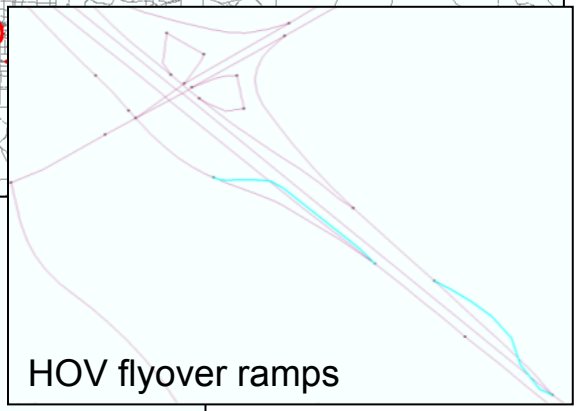
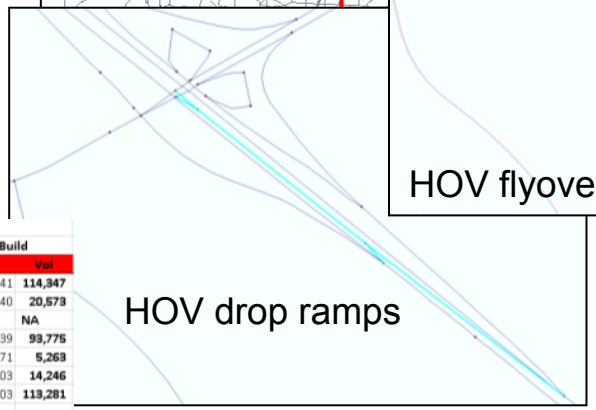
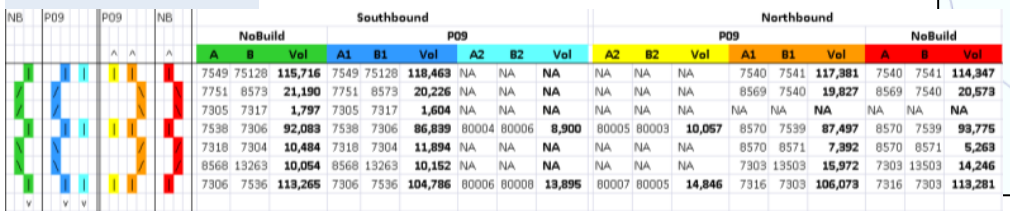
Example Project

- Add HOV lane
  - Add 1 lane in each direction to a freeway corridor
- Interchange reconfiguration
  - Add flyover ramps from HOV to existing ramps
  - Add drop ramps to HOV lanes by splitting roadway links
- Travel demand model results
  - Congestion impacts: regional vehicle hours of delay
    - HOT addition: +1%
    - Interchange: +2%
  - Example link by link analysis









			Southbound									Northbound								
NB	P09	P09	NB	NoBuild			P09						P09					NoBuild		
				A	B	Vol	A1	B1	Vol	A2	B2	Vol	A2	B2	Vol	A1	B1	Vol	A	B	Vol
				7549	75128	115,716	7549	75128	118,463	NA	NA	NA	NA	NA	NA	7540	7541	117,381	7540	7541	114,347
				7751	8573	21,190	7751	8573	20,226	NA	NA	NA	NA	NA	NA	8569	7540	19,827	8569	7540	20,573
				7305	7317	1,797	7305	7317	1,604	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
				7538	7306	92,083	7538	7306	86,839	80004	80006	8,900	80005	80003	10,057	8570	7539	87,497	8570	7539	93,775
				7318	7304	10,484	7318	7304	11,894	NA	NA	NA	NA	NA	NA	8570	8571	7,392	8570	8571	5,263
				8568	13263	10,054	8568	13263	10,152	NA	NA	NA	NA	NA	NA	7303	13503	15,972	7303	13503	14,246
				7306	7536	113,265	7306	7536	104,786	80006	80008	13,895	80007	80005	14,846	7316	7303	106,073	7316	7303	113,281

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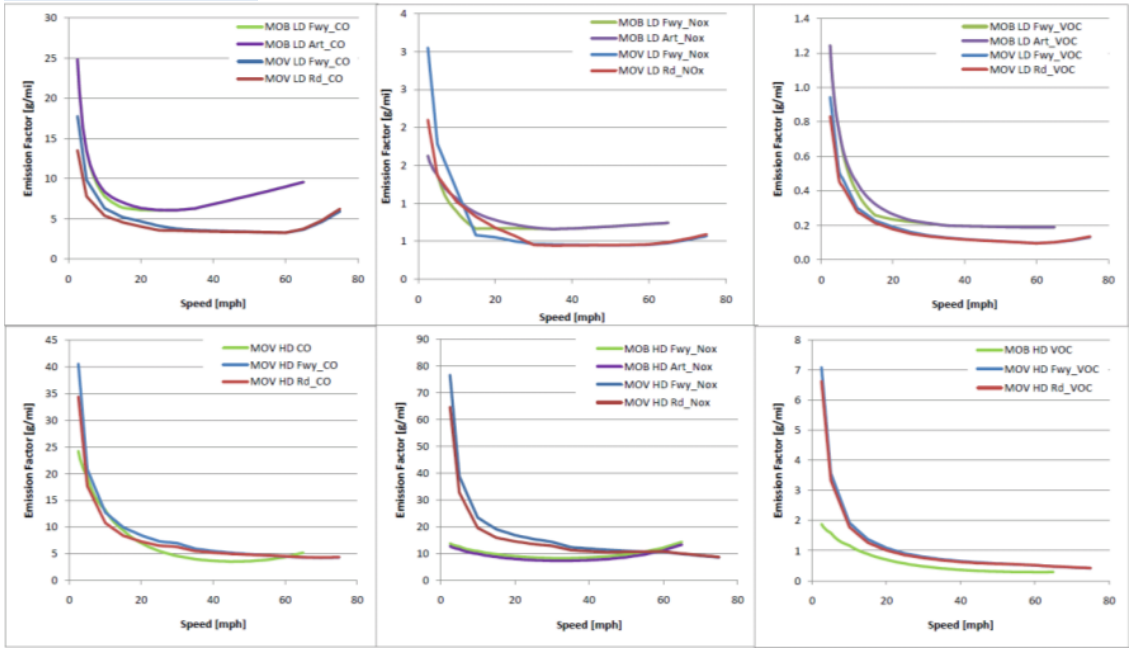
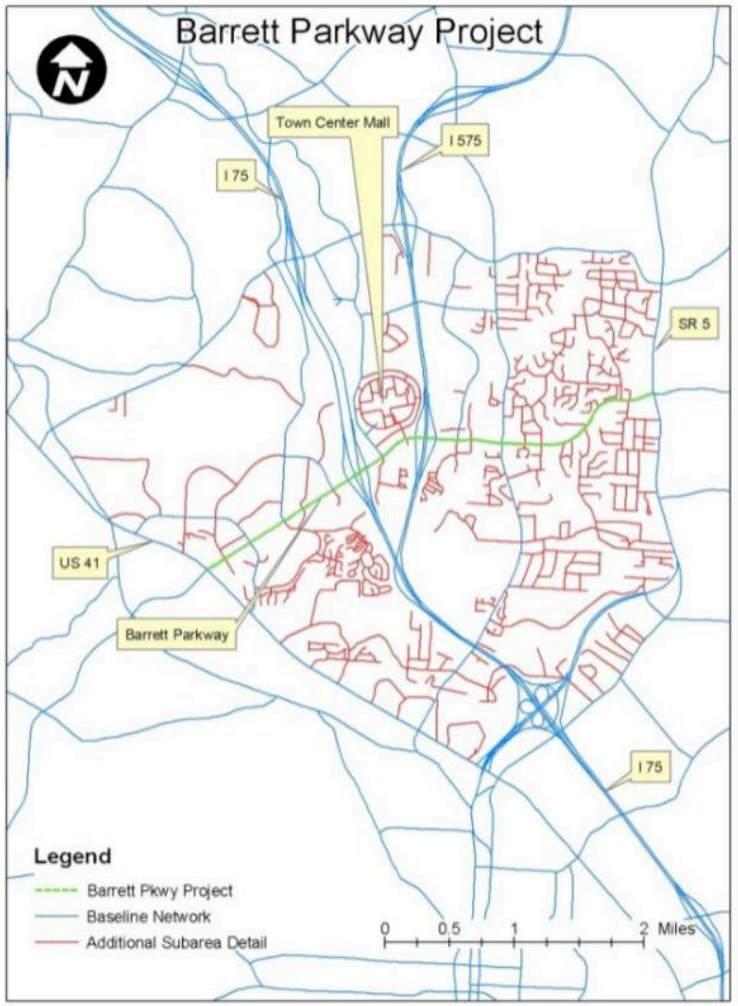
Other Illustrative Projects

- Add a lane to a major arterial
  - 3 network variations: standard, refined, & detailed
- Signal Timing
- Transit queue jumper lane
- Arterial streetcar
- HOT
- Turn off all regional transit





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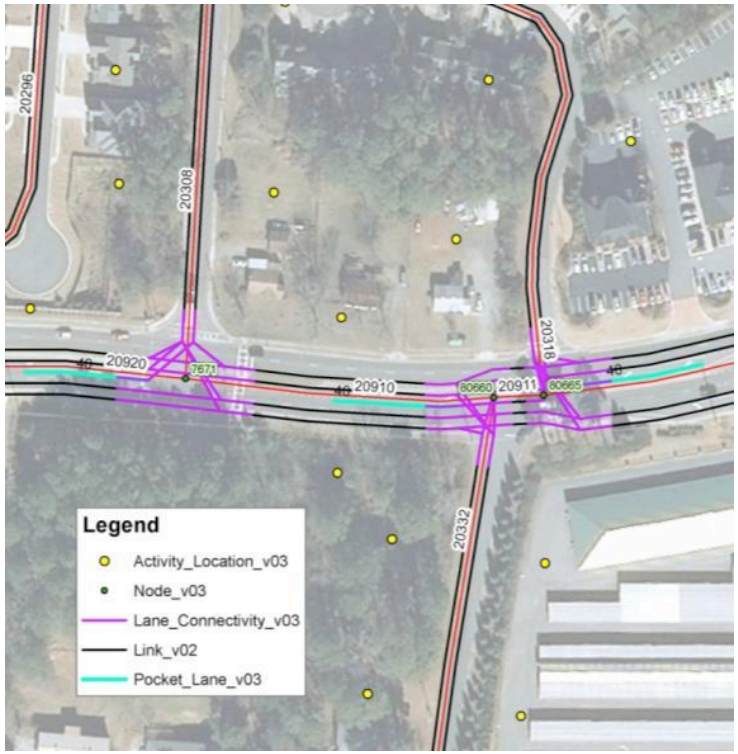
Practical Lessons Learned

Network Editing

- ArcNet GIS checking tools
  - Useful for verifying and troubleshooting
- Link, Pocket Lane, Lane Connectivity attribute dependencies
  - Requires referencing, repetition
  - More intuitive network management and editing system desirable
    - Including automatic update of attributes across relevant files
- "Stitching in" detailed network
  - Detailed "bookkeeping" required
- Loss of network refinements if TransimsNet rerun
- Looking forward to network editor



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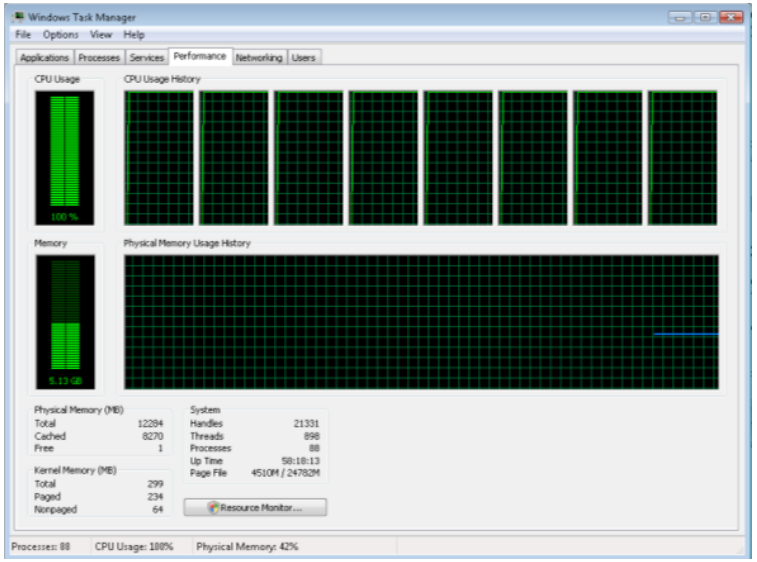
Practical Lessons Learned

Run Times

- Computing resources
  - Dual Intel Xeon E5520 2.27 GHz quad-core processors
  - 12 GB RAM
  - 64-bit Windows Vista Business Edition
  - Installed Cygwin to enable Unix scripting
- Router run time
  - 11.8 million trips
  - 8 partitions
  - 50 minutes
- Microsimulator run times
  - NW Quadrant subarea
    - 2.9 million trips
    - 188 minutes
  - NW I-75 HOV subarea
    - 1.1 million trips
    - 26 minutes
  - Barrett Parkway subarea
    - 800,000 trips
    - 19 minutes
- Router-Microsimulator iteration run times
  - 1-4 hours depending on size of subarea
- Similar run times obtained using TRACC Cluster and 8 processors

General Comments

- File management
  - Need consistency in folder structure, network update versions
- TRANSIMS Studio
  - Definite improvement
- Deployment effort
  - Current capabilities, learning curve, manual processes pose challenges to widespread deployment



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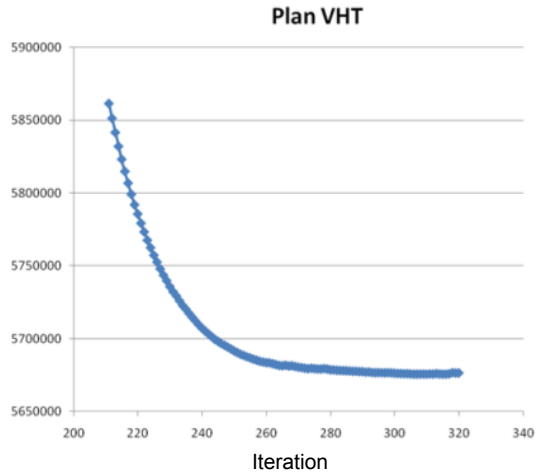
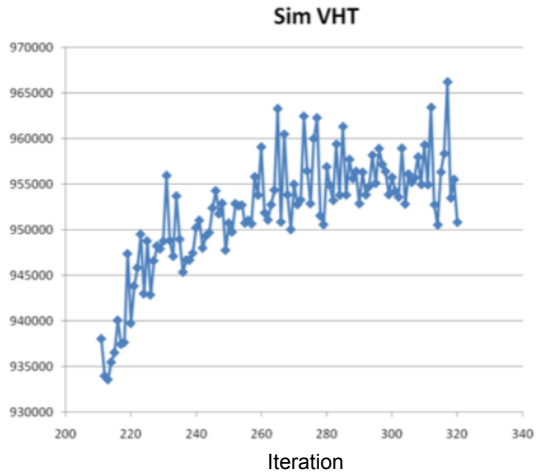
Recommendations for Further R&D

- Develop recommended measure(s) for Router-Microsimulator equilibrium, corresponding closure criterion/-a, and implementation algorithms/software





- Develop recommended measure(s) for Router-Microsimulator equilibrium, corresponding closure criterion/-a, and implementation algorithms/software
- Develop methodology to determine subarea needed to capture most (e.g., "X %") of project impacts while minimizing computing resources
- Recommended How-to Documents
  - Compare congestion impacts of project alternatives
  - Use MOVES with TRANSIMS
  - Update networks and intersection controls following a network edit that adds/deletes/ modifies links and/or nodes
  - Relocate trips to new activity locations following a network edit that adds/deletes/ modifies activity locations and reroute the affected trips

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