

Using Travel Time for Model Validation



Presented by

Li Jin, PE

Mar. 22, 2024

Outline

- Context
- Probe Travel Time/Speed Data
- Probe Speed Data Coverage
- Modeling Project Experience Using Probe Speed Data
- Free-Flow Speed
- Travel Time Estimation
- Observations

Probe Travel Time/Speed Data

- Reasonable travel times are vital in demand models and important in transportation planning.
 - Most model components heavily rely on roadway travel time/speed data.
 - Some transportation performance measures are travel time-based which will need reliable travel times from travel models.
- Use observed roadway travel time/speed for the entire model network
 - Develop free-flow speed and volume delay function parameters (model development)
 - Verify estimated congested roadway speed (model validation)
- Objectives:
 - Reduced model calibration/validation effort
 - Increased confidence in applying model travel time for performance measures in short term or long-term analysis

Probe Travel Time/Speed Data

- Major probe speed data vendors:
 - HERE
 - INRIX
 - TomTom
- Proprietary data
- Probe GPS data is precise.
- Research study¹ compared probe speeds data with other traffic speed data resources.
 - The statistical validation results showed that vendors reflected the normal patterns of traffic travel speed.



¹ Zachary Vander Laan, Sara Zahedian, Sanaz Aliari, The Eastern Transportation Coalition Vehicle Probe Project: HERE, INRIX and TomTom Data Validation, Report for Tennessee Arterial Validation: Tennessee #01, 2021. experienced on the roadway.

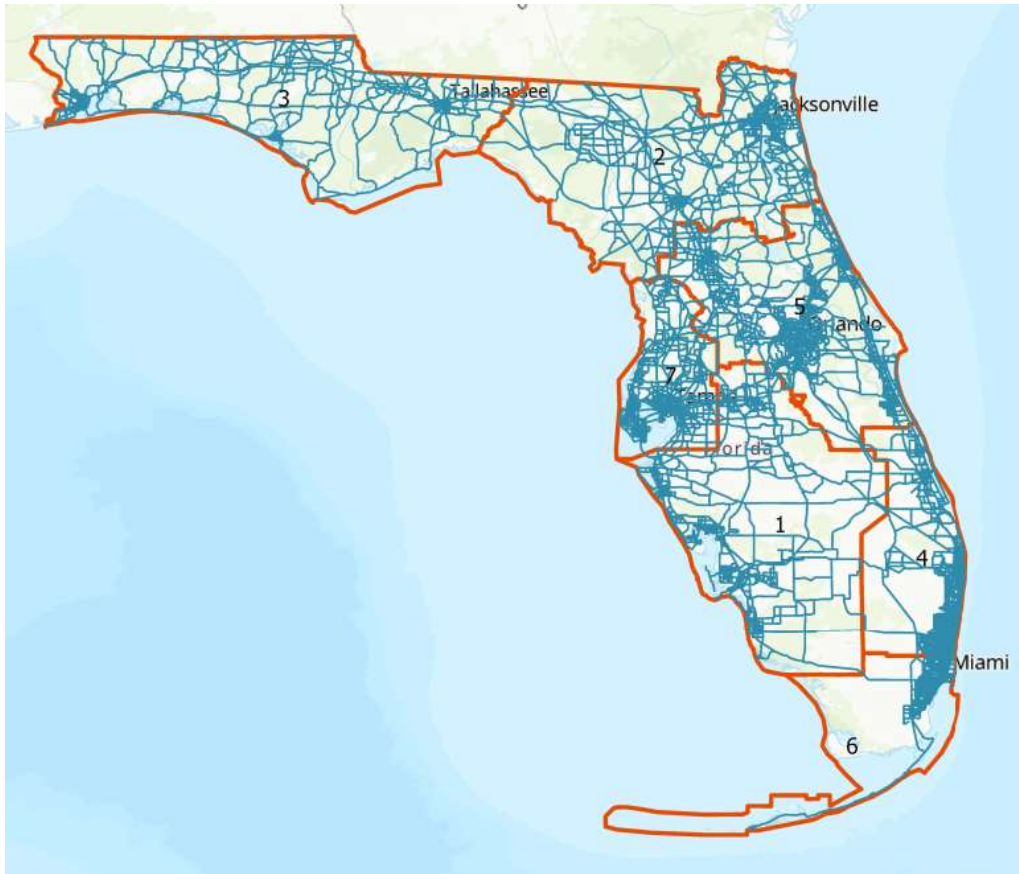
Probe Travel Time/Speed Data

- The probe time/speed data are in Don't Average, 5 minutes, 10 minutes, 15 minutes or 1-hour bin.
- Each Traffic Message Channel (TMC) has 35,040 15-minutes probe speeds data observations in a year.
- Each TMC segment has one unique 9-digit TMC Code.

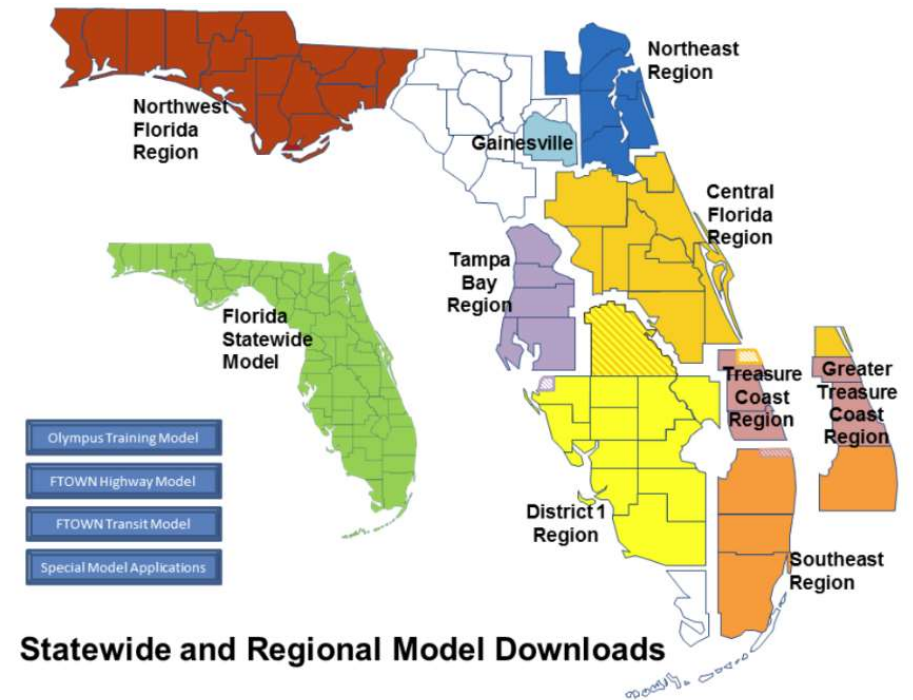
tmc_code	measurement_tstamp	speed	travel_time_seconds
102+04784	1/1/2015 0:00	60	129.57
102+04784	1/1/2015 0:15	54.32	143.11
102+04784	1/1/2015 0:30	55.7	139.58
102+04784	1/1/2015 0:45	54.38	142.95
102+04784	1/1/2015 1:00	49.91	155.75
102+04784	1/1/2015 1:15	49.53	156.96
102+04784	1/1/2015 1:30	52.53	147.99
102+04784	1/1/2015 1:45	51.61	150.63
102+04784	1/1/2015 2:00	50.68	153.41
102+04784	1/1/2015 2:15	46.94	165.62
102+04784	1/1/2015 2:30	48.84	159.19
102+04784	1/1/2015 2:45	50.06	155.3
102+04784	1/1/2015 3:00	54.38	142.97
102+04784	1/1/2015 3:15	59.86	129.89
102+04784	1/1/2015 3:30	59.49	130.68
102+04784	1/1/2015 3:45	60	129.57
102+04784	1/1/2015 4:00	58.49	132.92
102+04784	1/1/2015 4:15	59.71	130.2
102+04784	1/1/2015 4:30	60	129.57
102+04784	1/1/2015 4:45	60	129.57
102+04784	1/1/2015 5:00	58.27	133.43
102+04784	1/1/2015 5:15	59.37	130.95
102+04784	1/1/2015 5:30	56.14	138.48
102+04784	1/1/2015 5:45	60	129.57
102+04784	1/1/2015 6:00	60	129.57
102+04784	1/1/2015 6:15	60	129.57
102+04784	1/1/2015 6:30	57.77	134.57
102+04784	1/1/2015 6:45	59.61	130.43
102+04784	1/1/2015 7:00	60	129.57
102+04784	1/1/2015 7:15	59.87	129.85
102+04784	1/1/2015 7:30	60	129.57
102+04784	1/1/2015 7:45	59.87	129.85
102+04784	1/1/2015 8:00	58.15	133.7
...

15-minutes probe speed data example from one TMC

Probe Speed Data Coverage



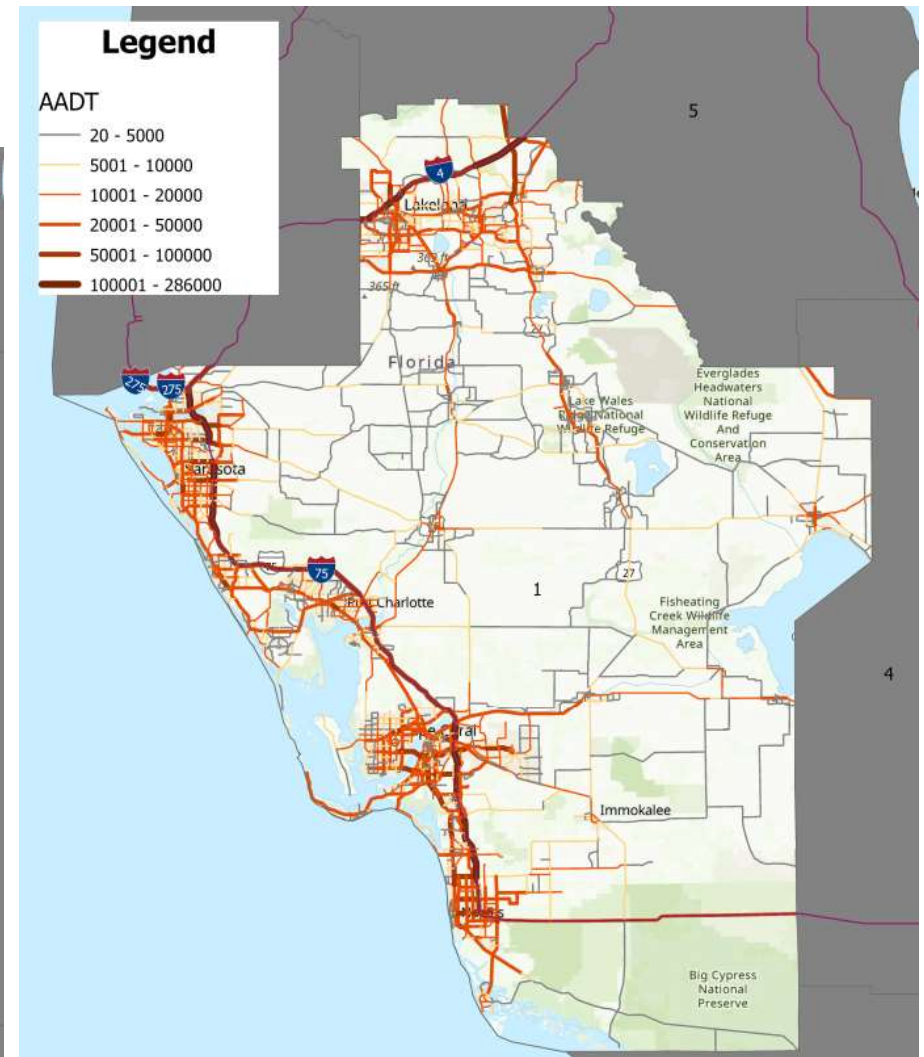
Total 58,545 TMCs in Florida in 2022



Travel Demand Model Region

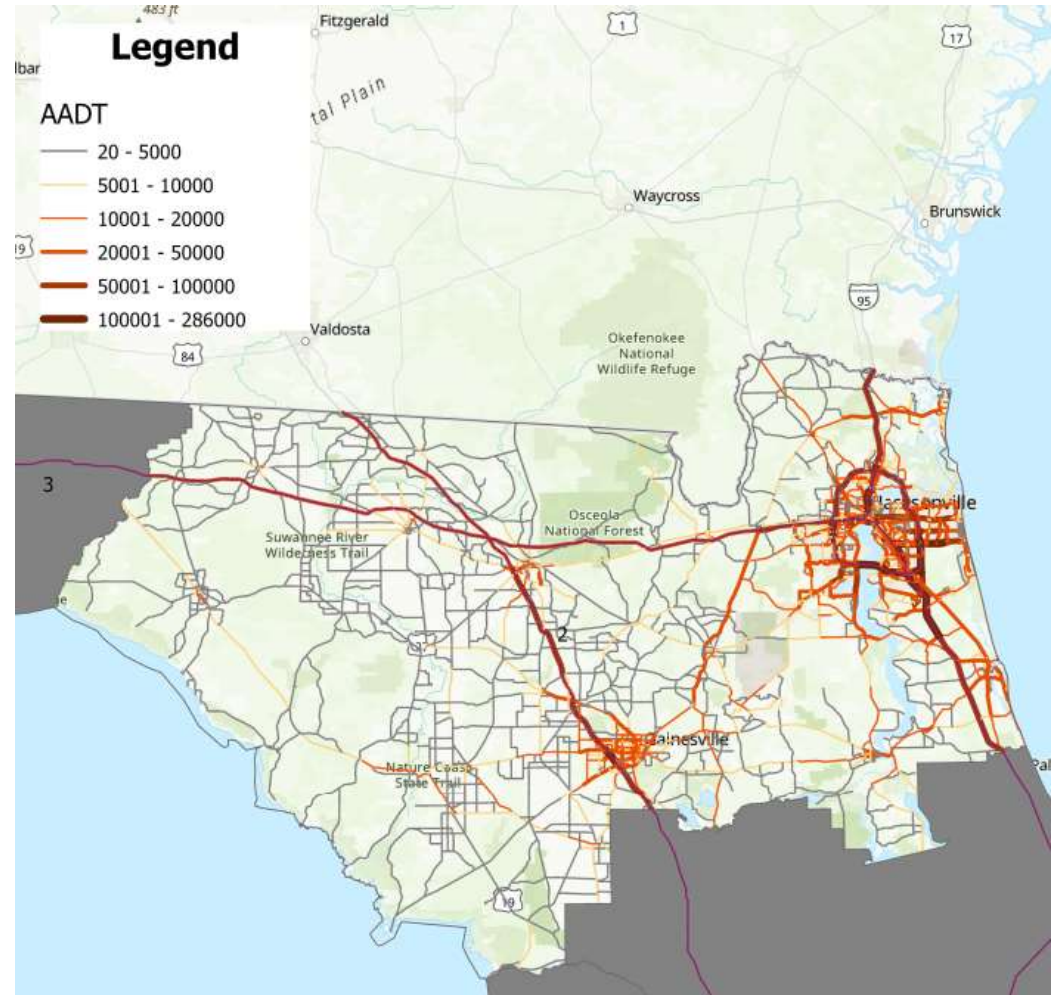
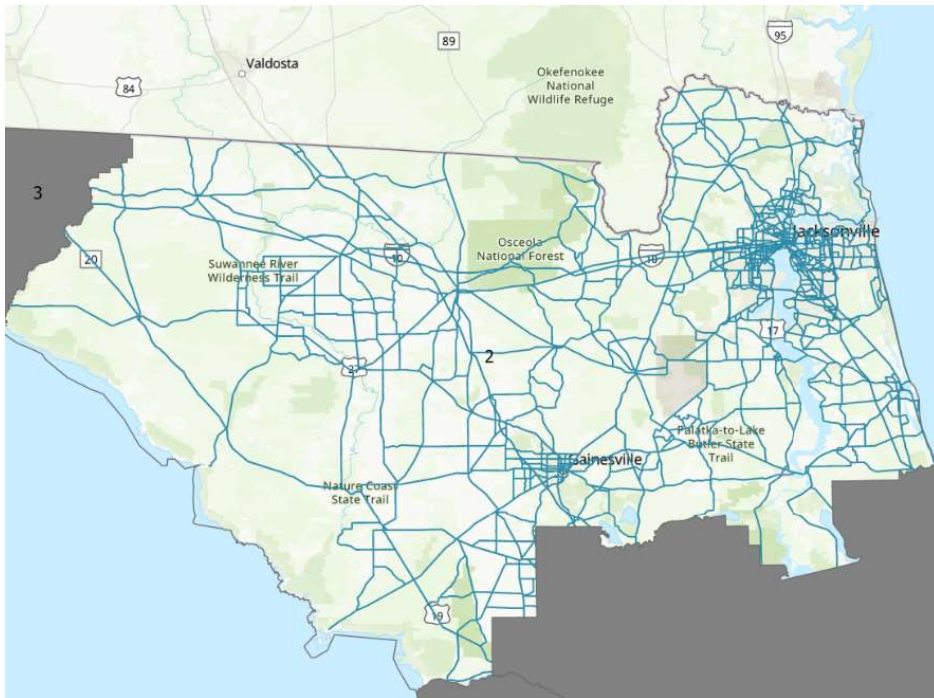
Probe Speed Data Coverage

- District 1 Region



Probe Speed Data Coverage

- District 2 Region



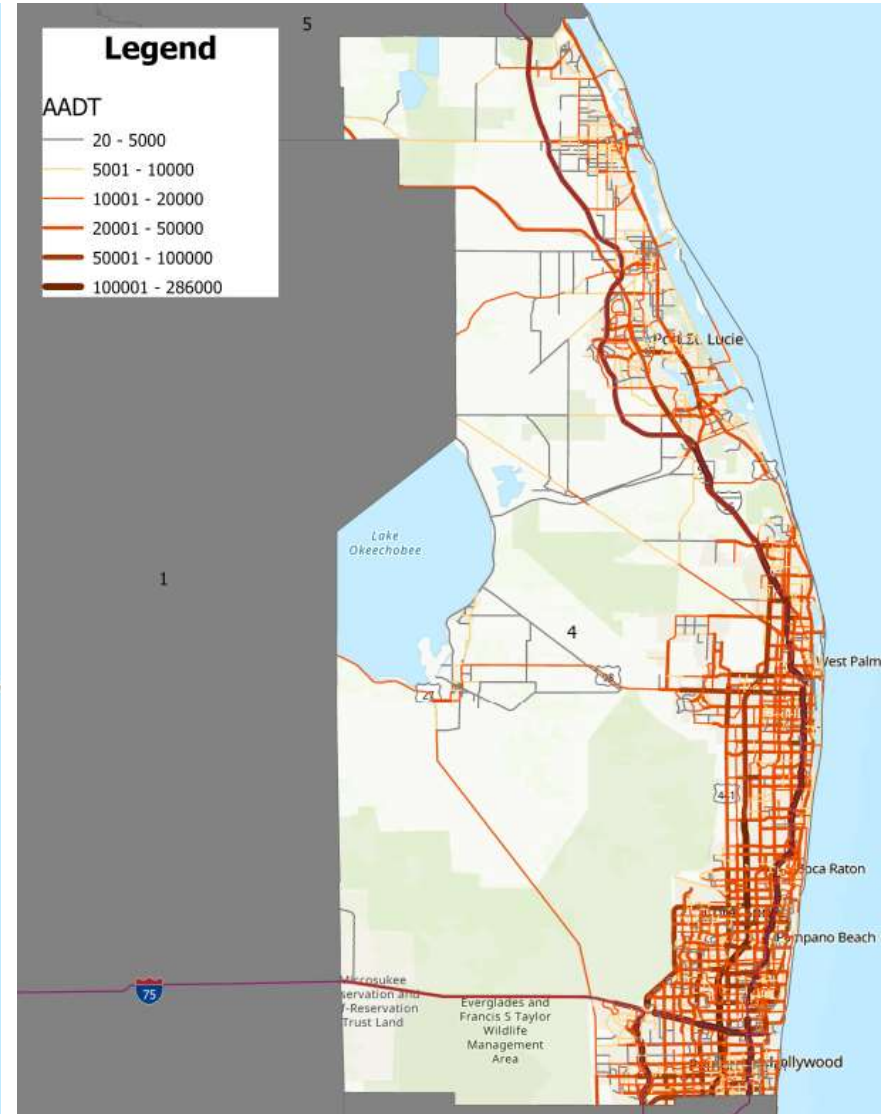
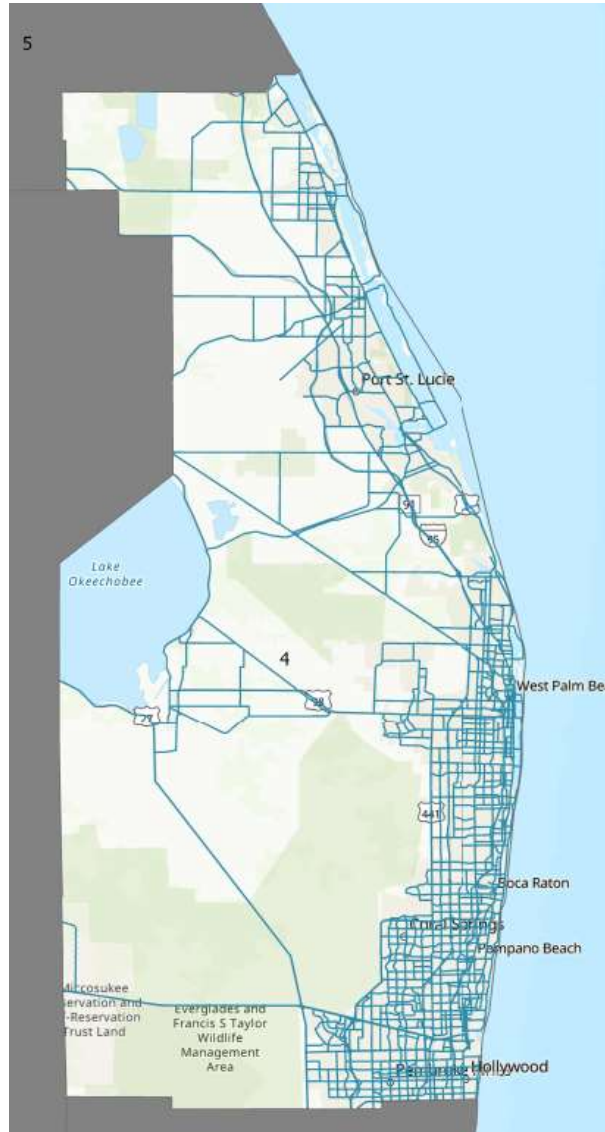
Probe Speed Data Coverage

- District 3 Region



Probe Speed Data Coverage

- District 4 Region



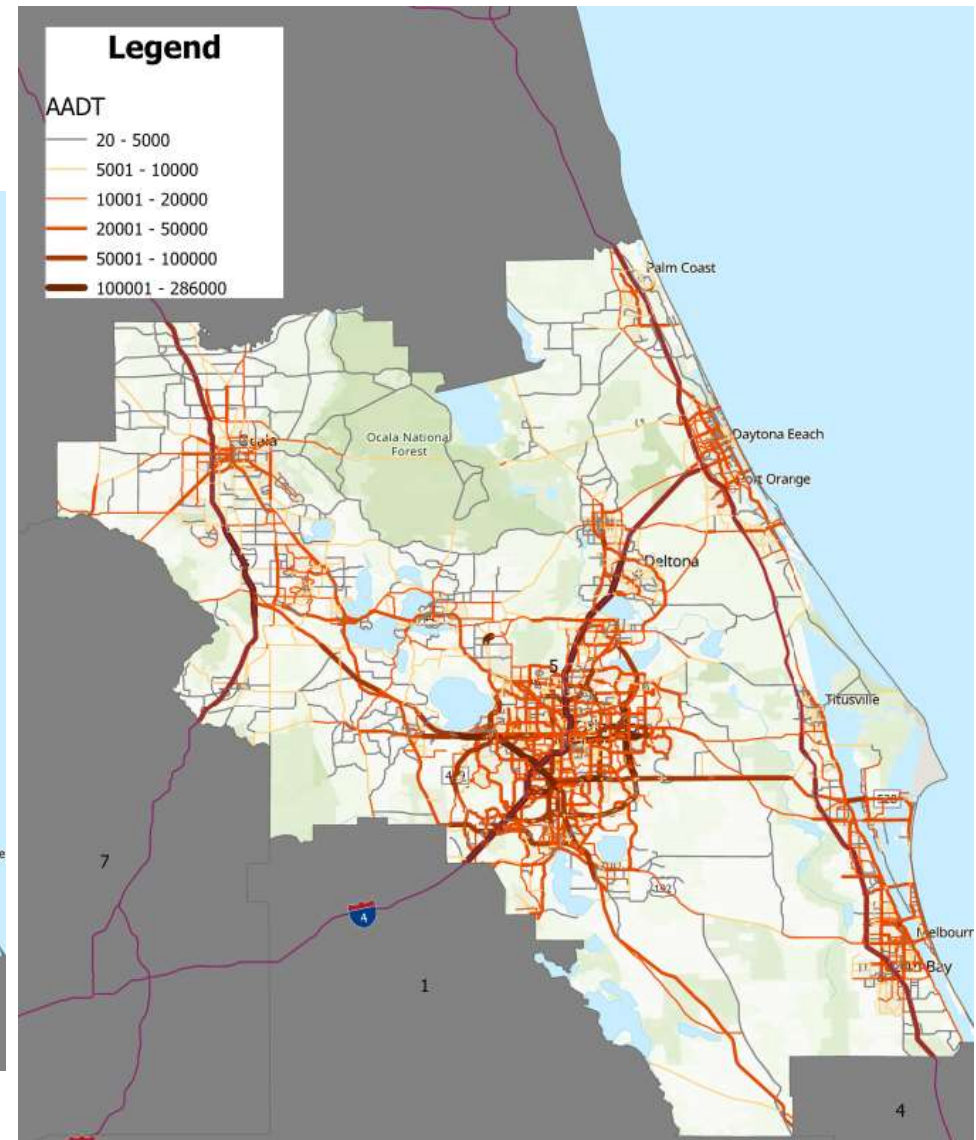
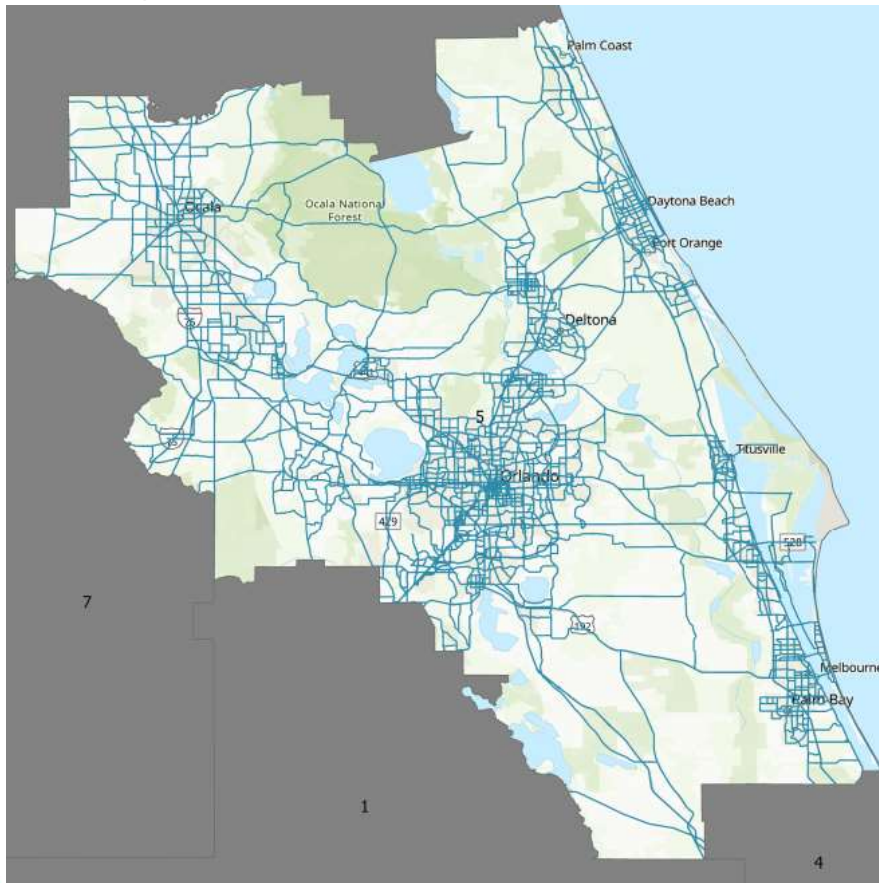
Probe Speed Data Coverage

- District 4 Region (zoom in)



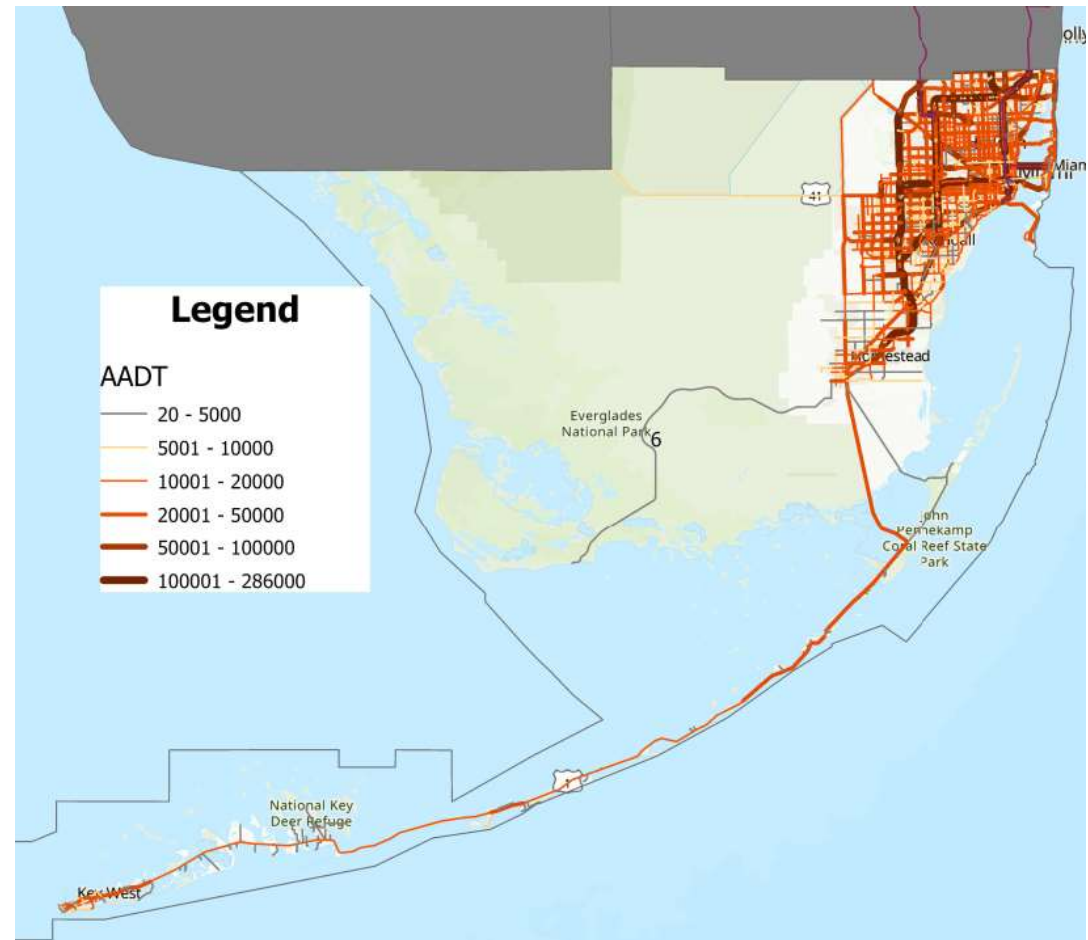
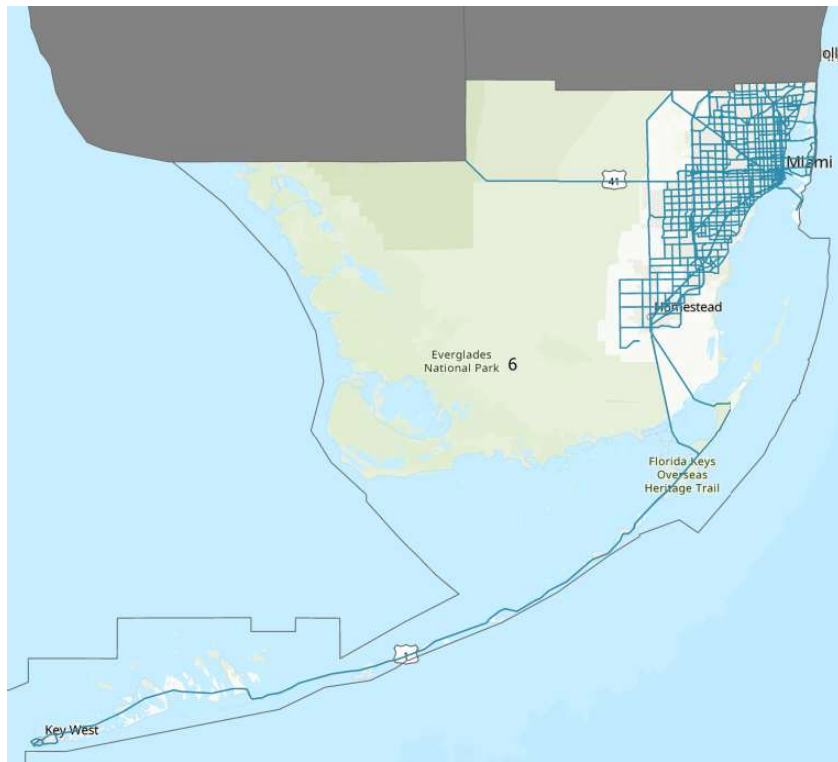
Probe Speed Data Coverage

- District 5 Region



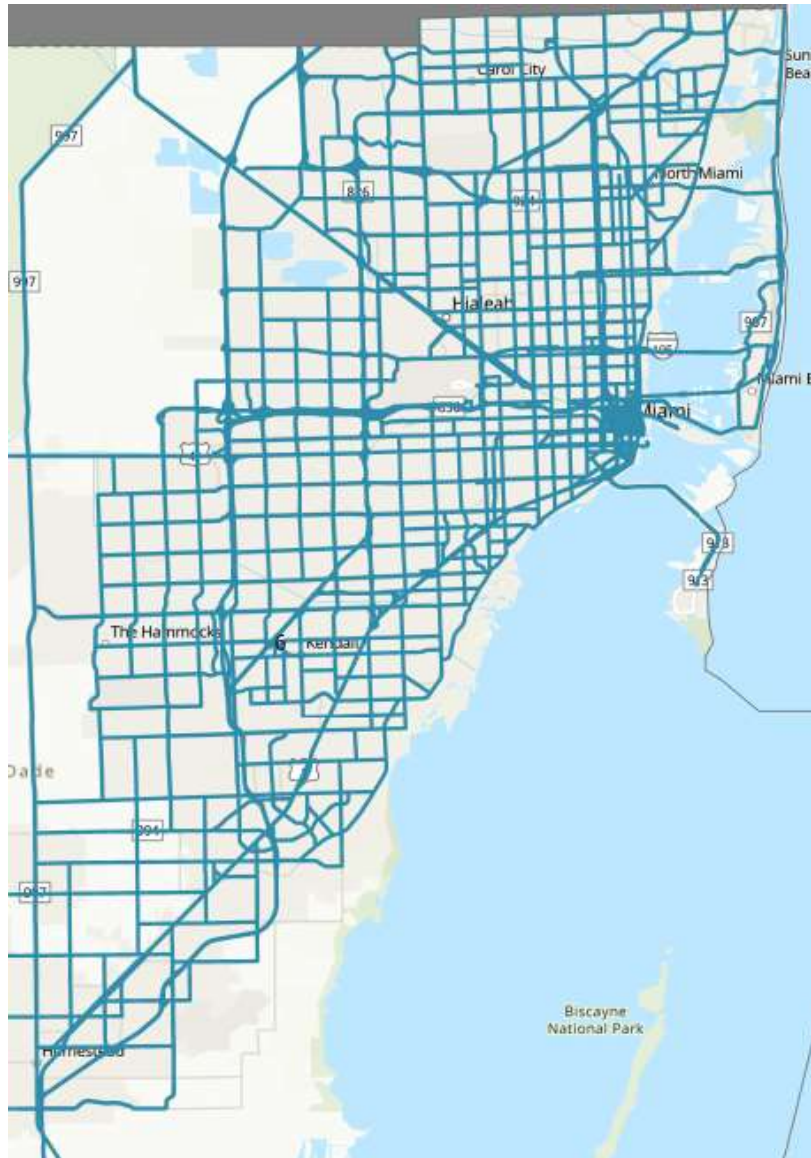
Probe Speed Data Coverage

- District 6 Region



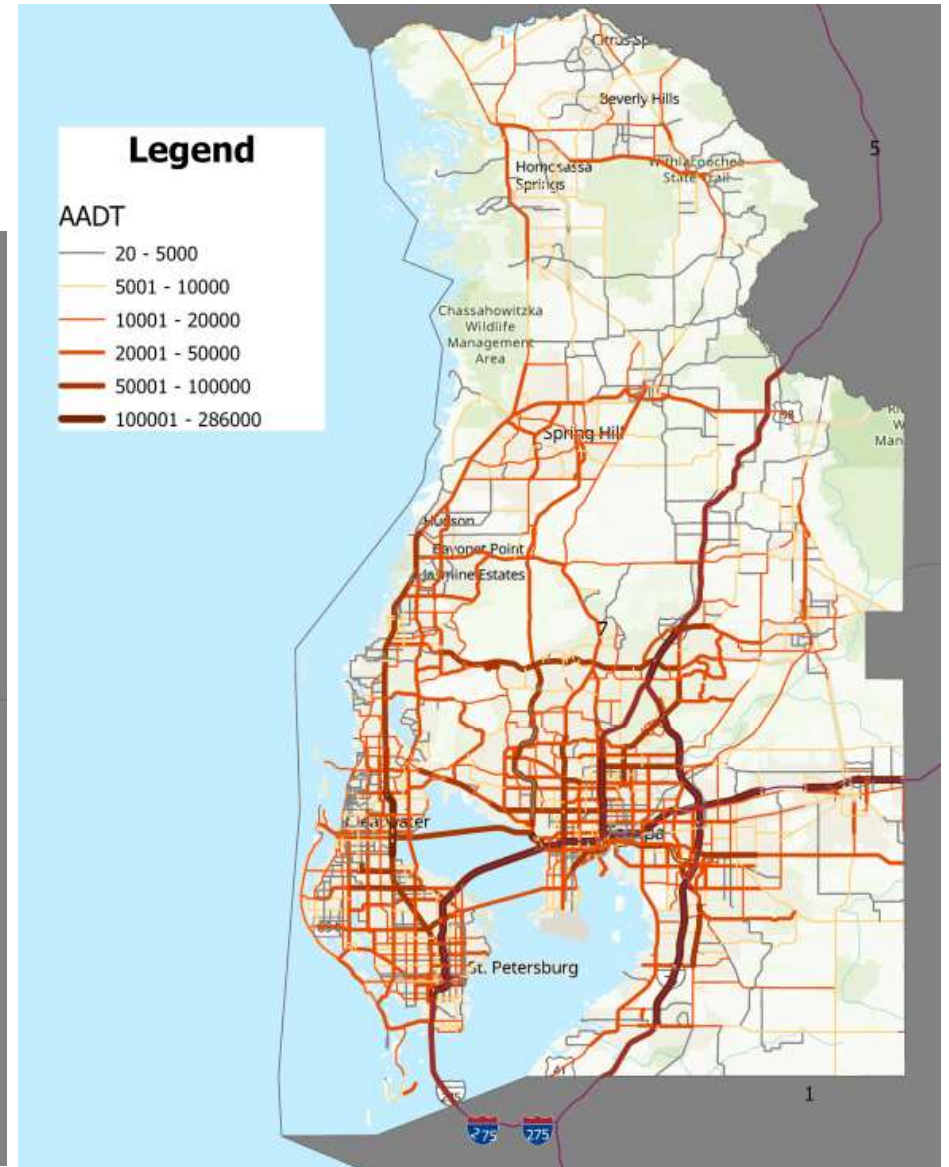
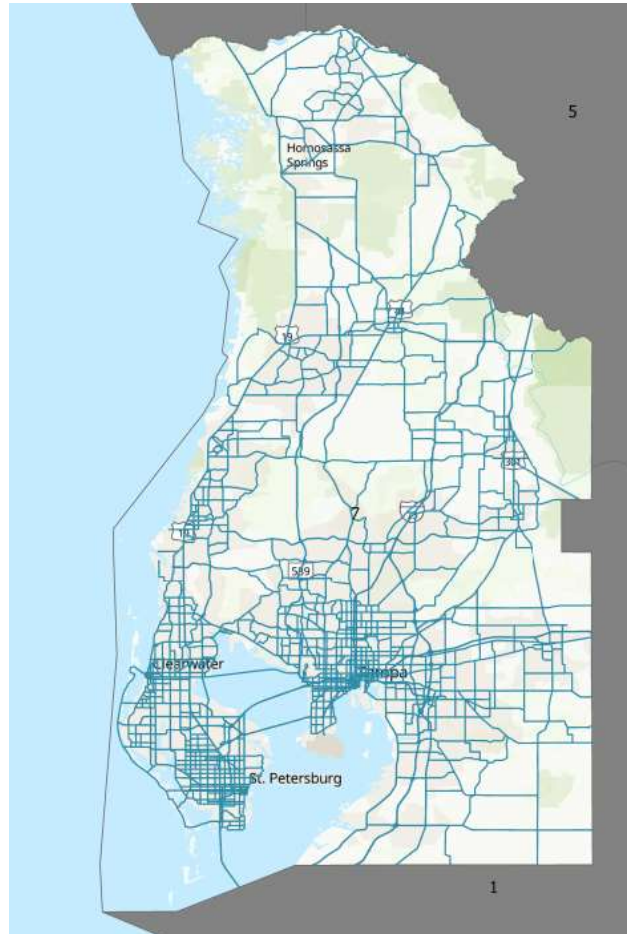
Probe Speed Data Coverage

- District 6 Region (zoom in)

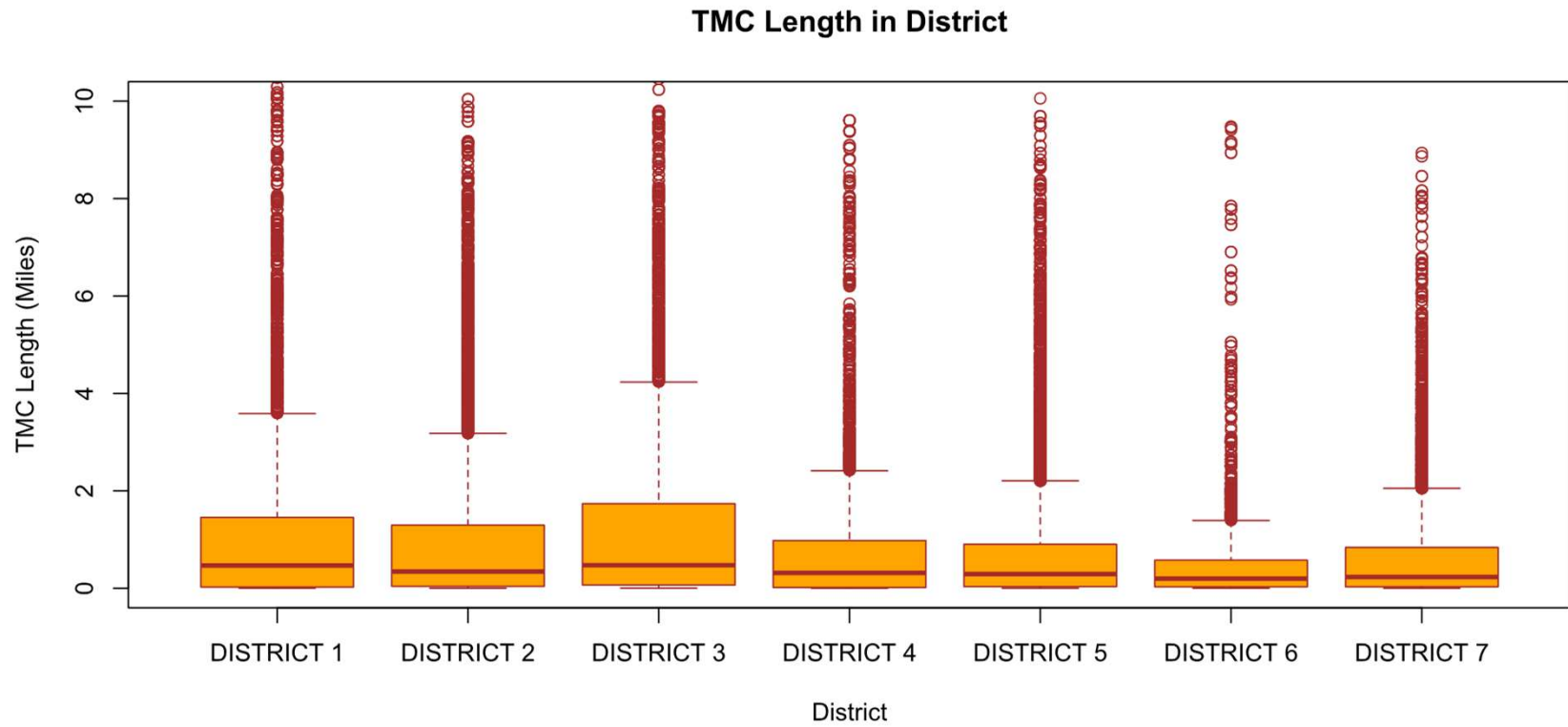


Probe Speed Data Coverage

- District 7 Region

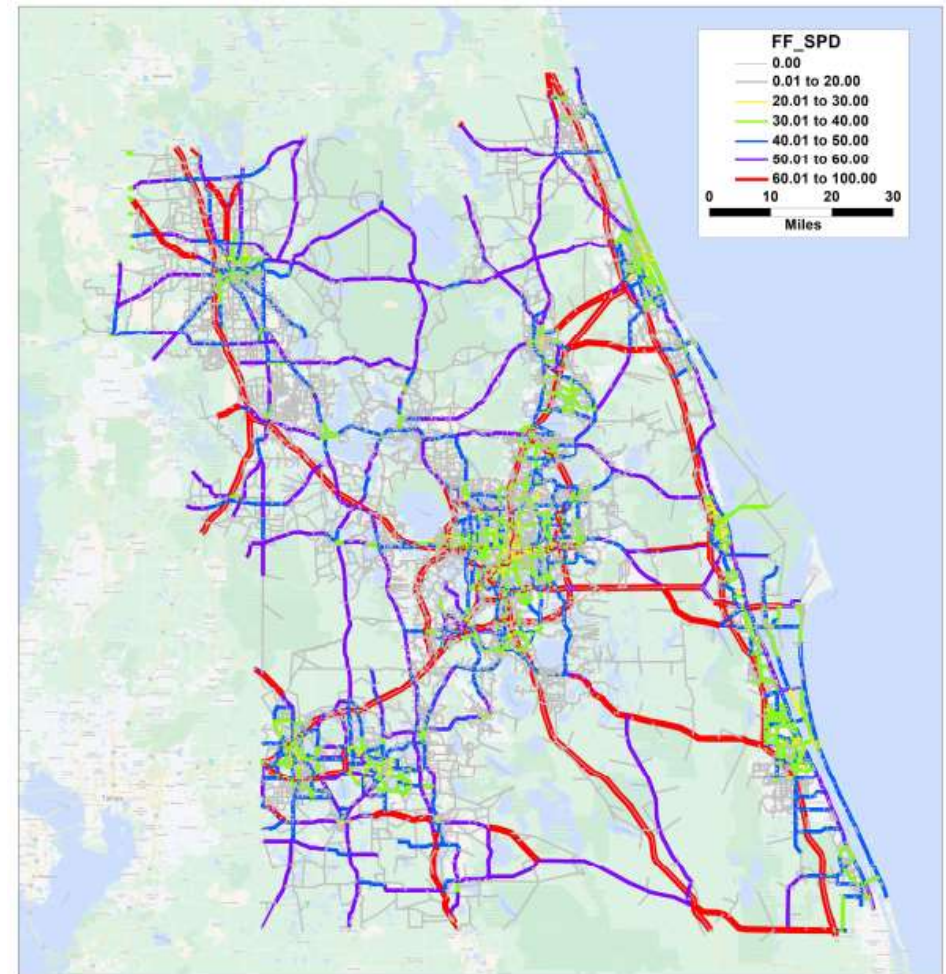


Probe Speed Data Coverage



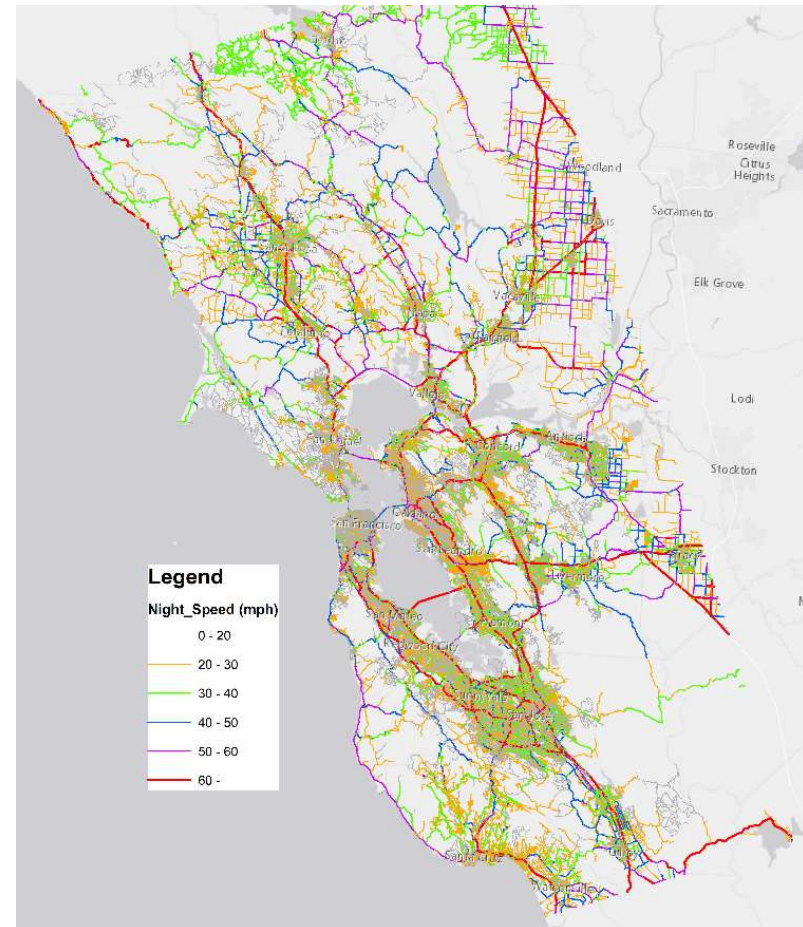
Modeling Project Experience Using Probe Speed Data

- Central Florida Regional Planning Model
 - 11 Counties, Five MPOs
 - 4.6 million population
- Around 29% of roadway network has HERE probe speeds in 2015.



Modeling Project Experience Using Probe Speed Data

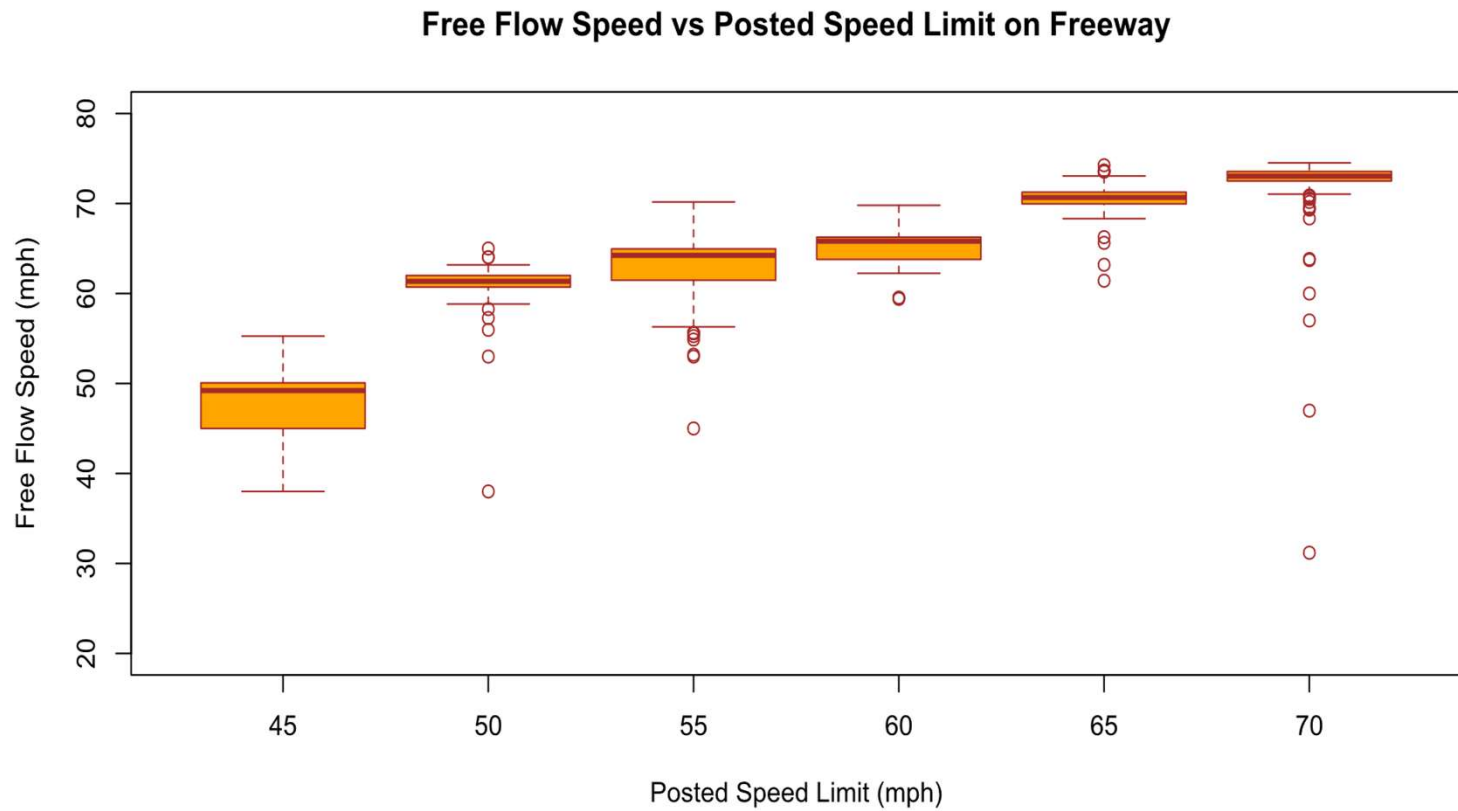
- Link21 Model
 - New transbay rail tunnel connecting Oakland and San Francisco
- Around 55% of links in the model network have probe speeds.



Free-Flow Speed

- Free-flow speeds were estimated using the probe speed data on Sunday from 7-8 am.
- Time-of-period observed speeds were developed using the weekday probe speed data.
 - In CFRPM example
 - AM peak period (7:00 am to 10:00 am)
 - PM peak period (3:30 pm to 6:30 pm)
 - Midday (10:00 am to 3:30 pm)
 - Night (6:30 pm to 7:00 am)

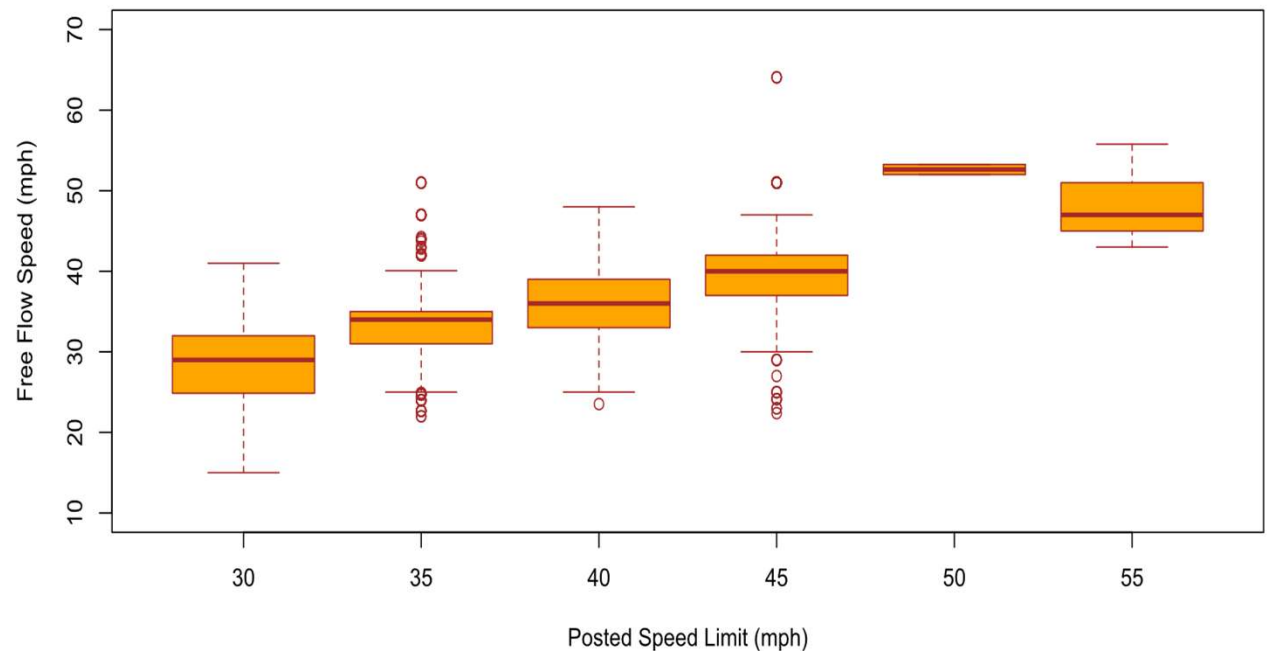
Free-Flow Speed



Free-Flow Speed

- Class II refers to arterials with an average signal density from 2–4.5 signals per mile.
- Class III refers to arterials with an average signal density of at least 4.5 signals per mile.
- Class IV refers to arterials in the downtown cores in urbanized areas that have at least 1,000,000 people.

Free Flow Speed vs Posted Speed Limit on Divided Arterial II, III, IV



Free-Flow Speed

- Observed free-flow speed was considered as dependent variable and posted speed as an independent variable.

- $Y = a * X$

Where:

- Y = free-flow speed
- X = posted speed
- a = slope

Facility Type	Free-Flow Speed
Freeways (Toll & Non-Toll)	1.05 * Posted Speed
Unsignalized Arterials	1.00 * Posted Speed
Class I Arterials	0.95 * Posted Speed
Class II/III/IV Arterials	0.90 * Posted Speed
Local Roads	0.90 * Posted Speed
Freeway and Other on/off Ramps	1.00 * Posted Speed
Freeway-to-Freeway Ramps and Freeway-Collector/Distributor Ramps	1.05 * Posted Speed

Free-Flow Speed

- Observed HERE travel speed used to develop / confirm free-flow speeds
- Result: 2/3rds of links have free-flow speed within 10% of observed values
- Observations:
 - Data is noisy
 - Data not available for some road types
 - Professional judgement still needed

County	Percentage of Links with Est./Obs. FF Ratio			Number of Links
	< 0.9 (less than 10%)	0.9–1.1 (within 10%)	> 1.1 (greater than 10%)	
Brevard	12.7	73.0	14.3	3,487
Flagler	15.2	69.1	15.7	362
Indian River	23.3	65.4	11.3	335
Lake	22.7	74.0	3.3	1,157
Marion	15.8	73.6	10.6	1,857
Orange	8.4	60.9	30.6	4,274
Osceola	11.8	65.8	22.5	842
Polk	26.5	53.7	19.7	3,321
Seminole	7.3	77.8	14.9	1,252
Sumter	33.5	64.6	1.9	418
Volusia	16.5	67.8	15.7	2,825
Region	15.7	66.2	18.0	20,130

Table from CFRPM 7 Validation Report

Travel Time Estimation

Bureau of Public Roads (BPR) volume-delay function:

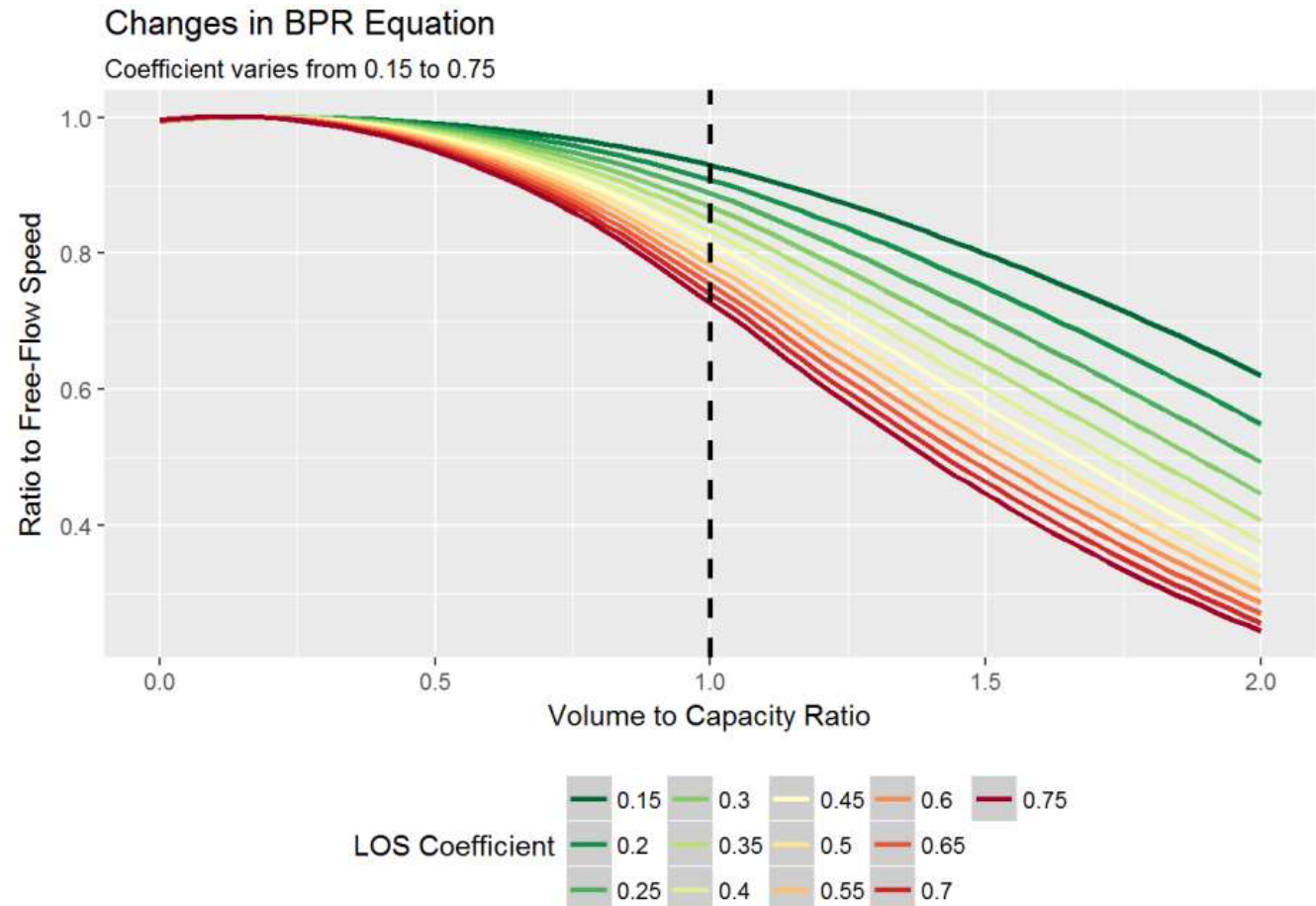
$$S_1 = S_f / (1 + d * a * (vol/cap)^b)$$

Where:

- S_f is the free-flow speed
- d is the damping factor
- a is the LOS coefficient
- vol is the traffic volume of a network link
- cap is the capacity of a network link
- b is the BPR Exponent
- S_1 is the computed travel speed

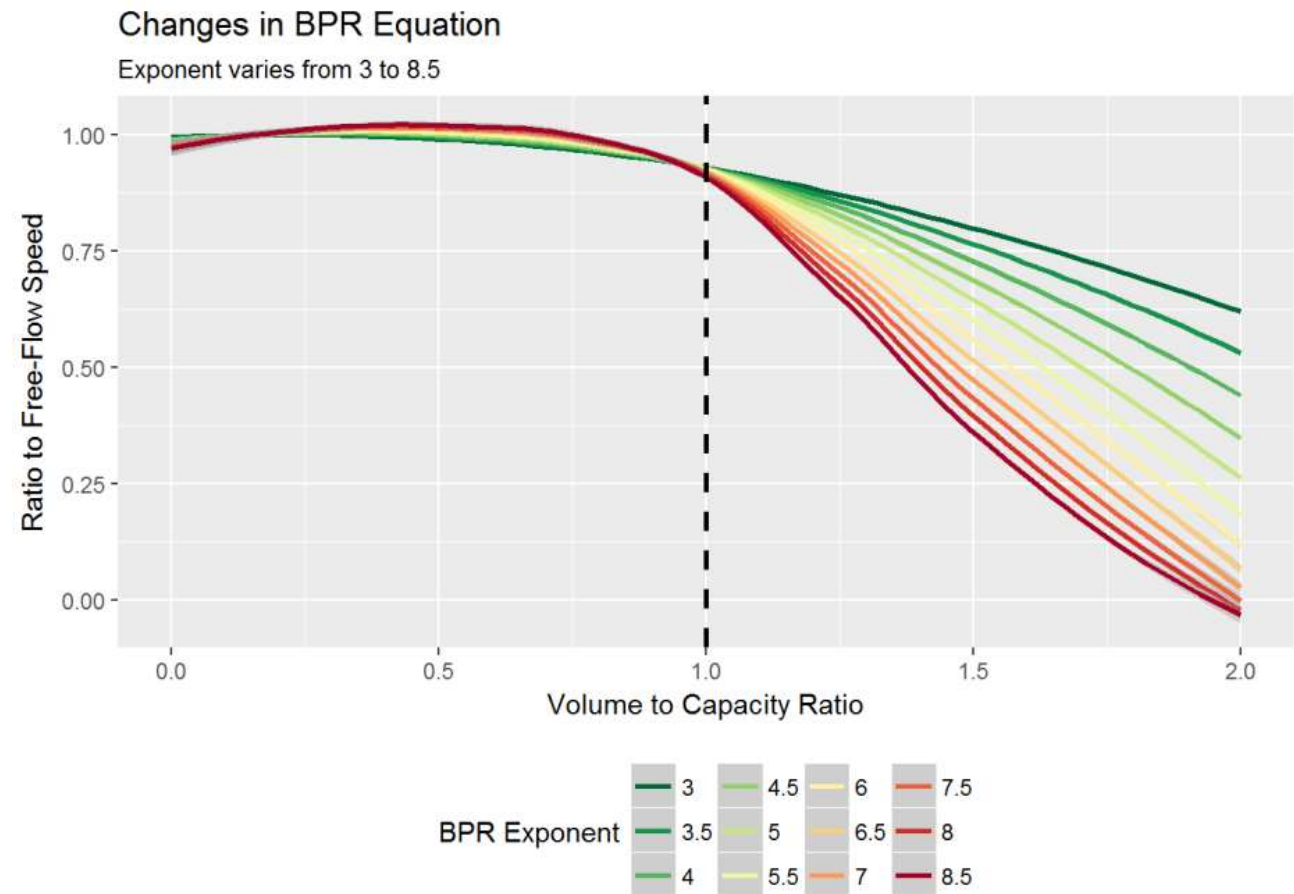
Travel Time Estimation

- In this example, the exponent is set at 3 and the damping factor is set at 0.5.



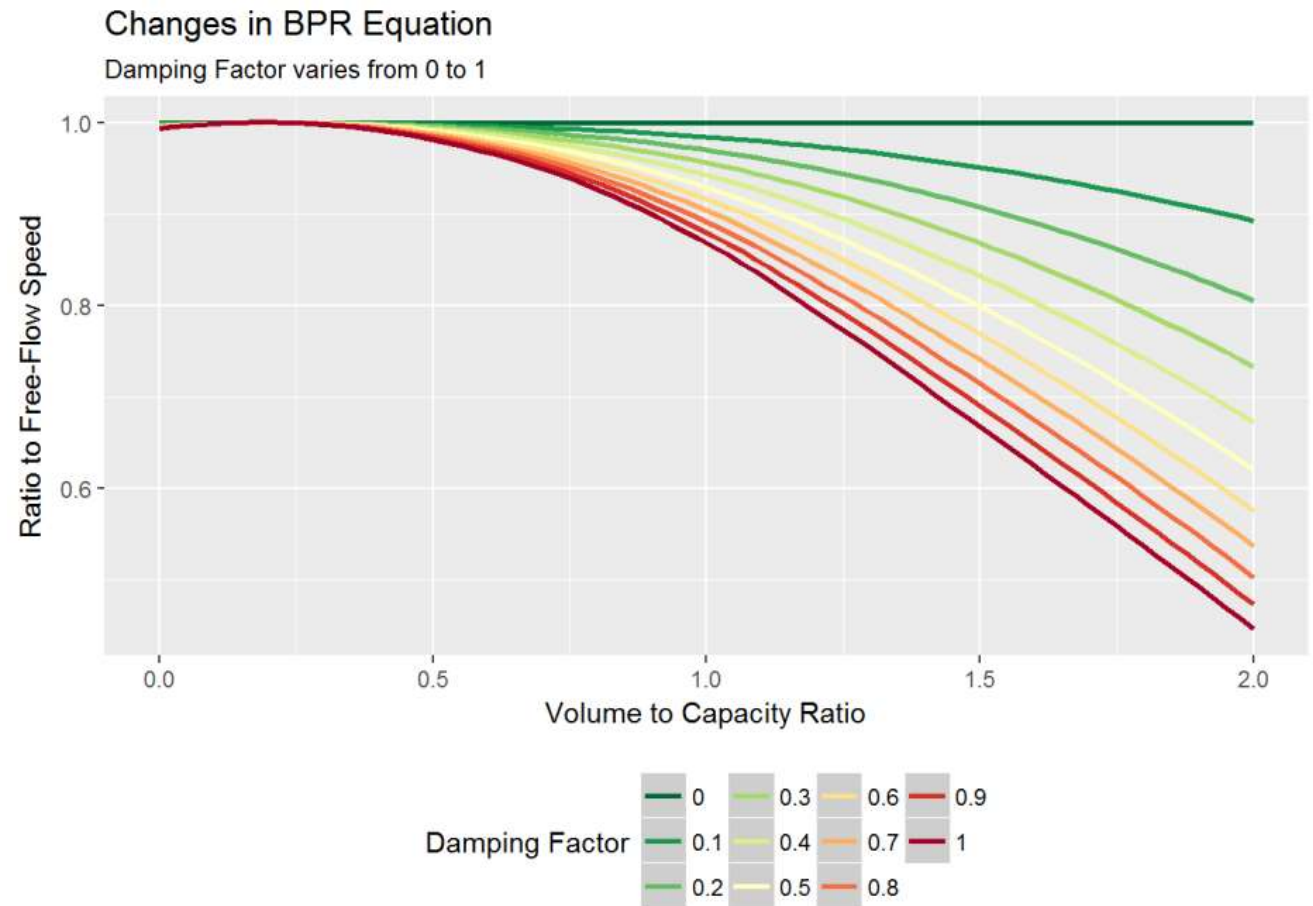
Travel Time Estimation

- In this example, the LOS coefficient is 0.15 and the damping factor is 0.5.

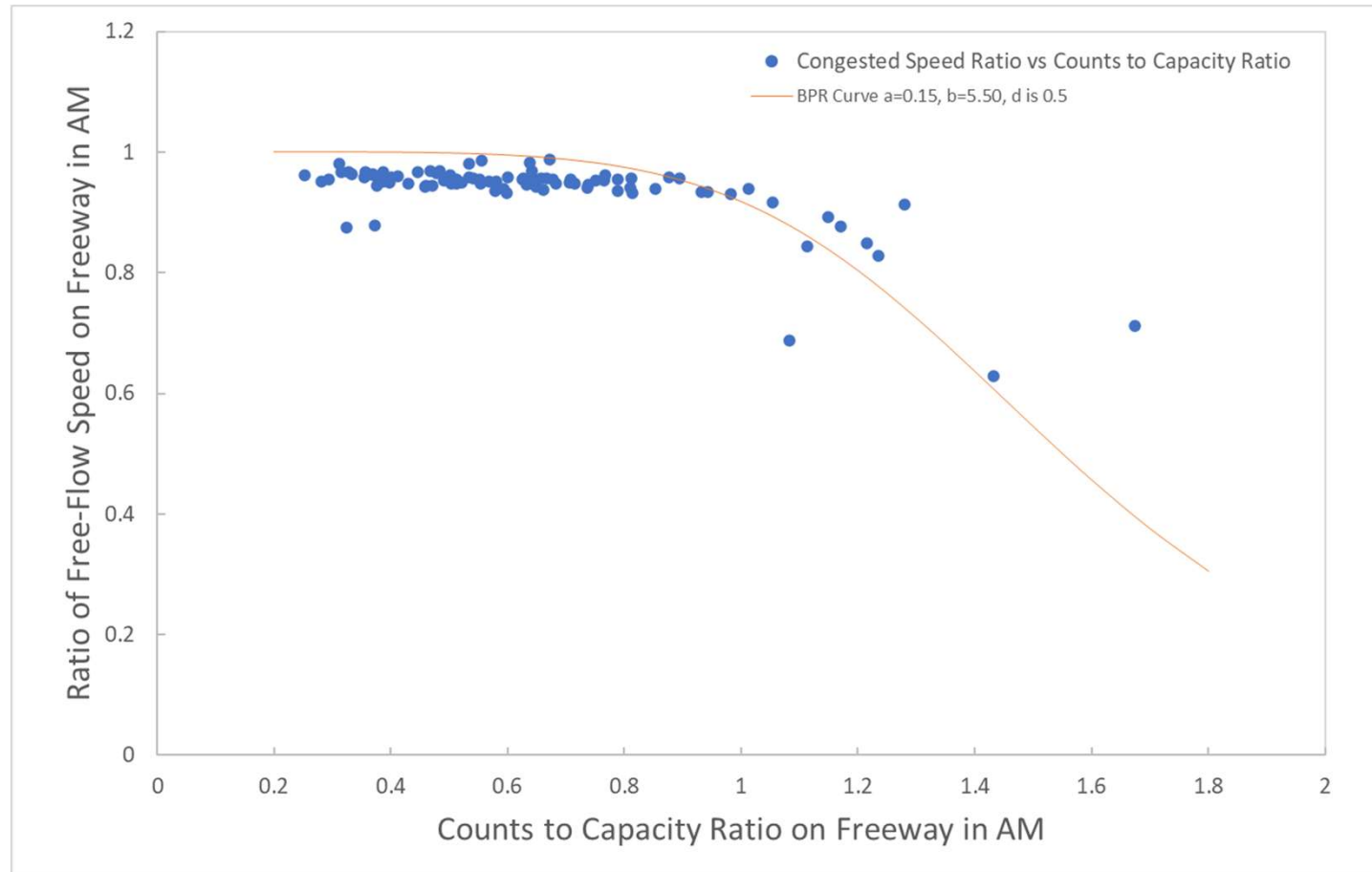


Travel Time Estimation

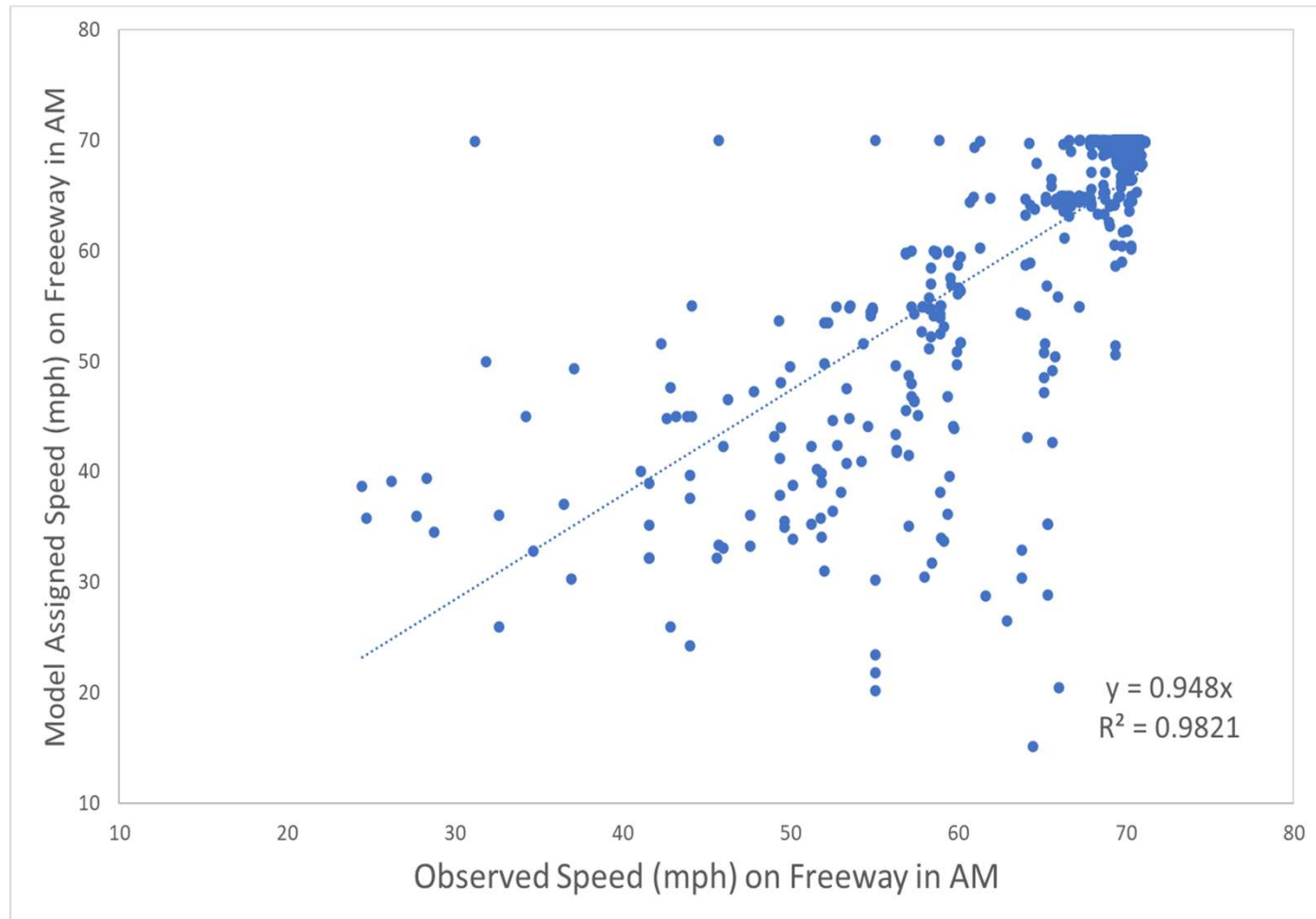
- In this example, the LOS coefficient is 0.15 and the exponent is 3.



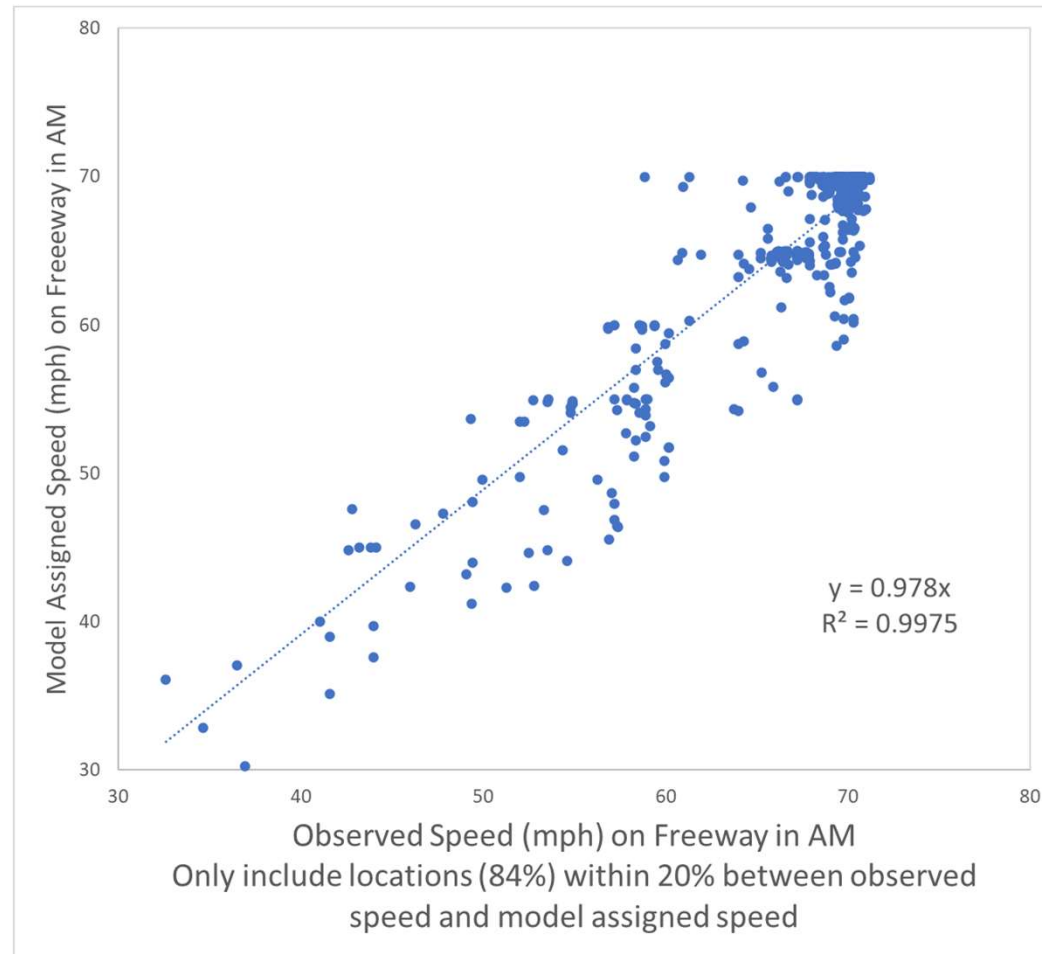
Travel Time Estimation



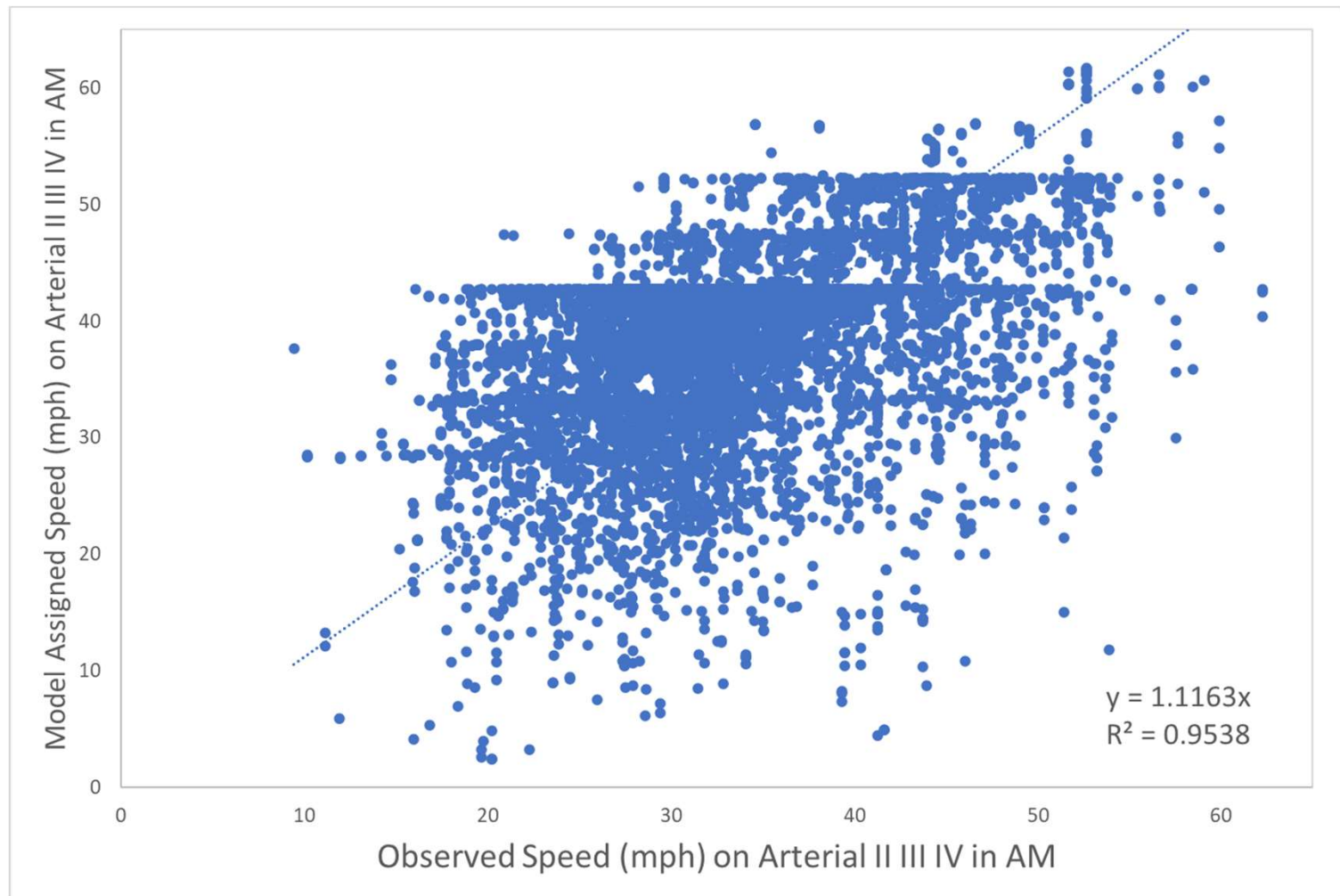
Travel Time Estimation



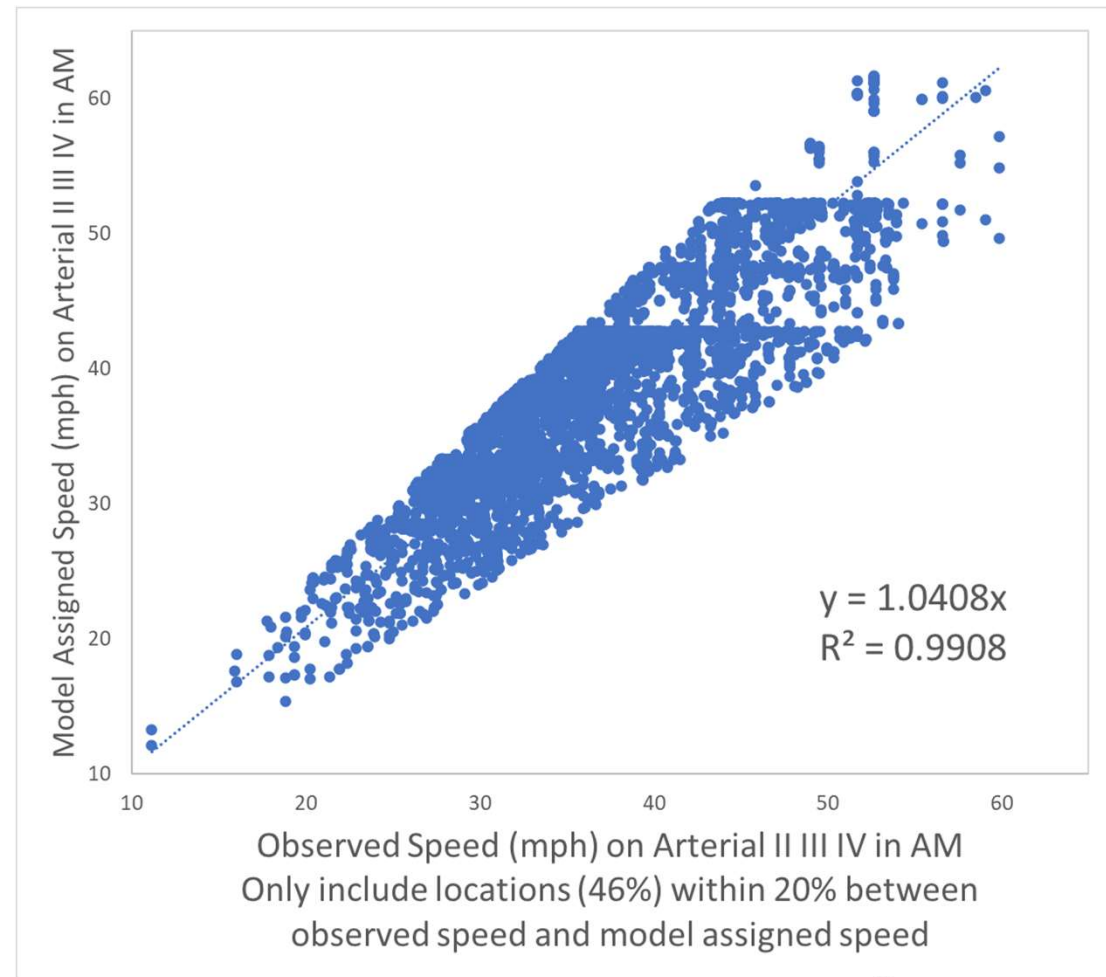
Travel Time Estimation



Travel Time Estimation

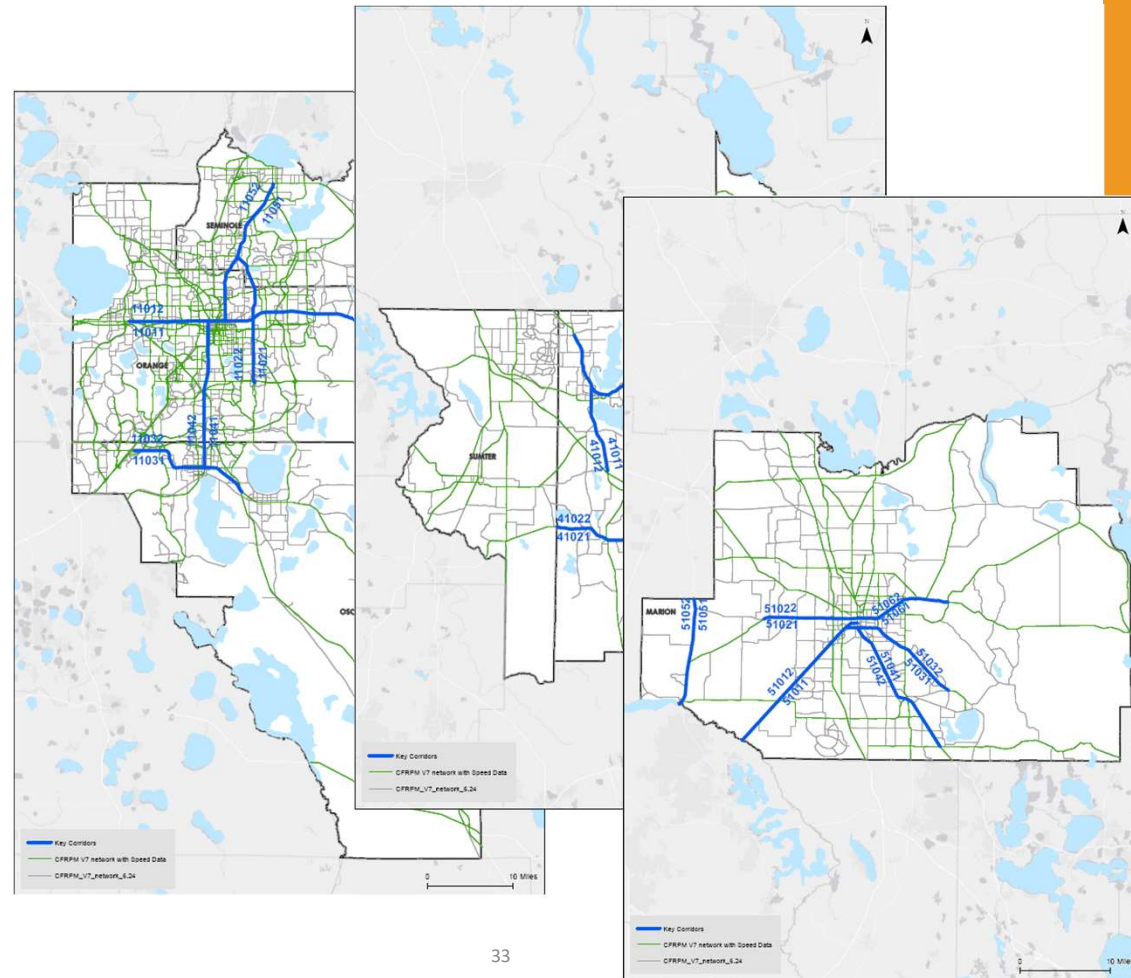


Travel Time Estimation



Travel Time Estimation

- Compared HERE travel time data with congested speed from highway assignment at a corridor-level
- Identified 100 roadway corridors throughout region
 - Includes all freeways/limited-access roadways
 - Also includes selected major arterials
 - Each corridor 10+ miles in length to smooth out individual link anomalies
- Developed validation benchmarks:
 - 80% of corridors $\leq 20\%$ of observed
 - 50% of corridors $\leq 10\%$ of observed
- Benchmarks applied to all 4 time periods



Travel Time Estimation

Period	Acceptable Percentage*	Acceptable Standard	Preferable Percentage*	Preferable Standard
AM	88% of links are within 20%	80% of links are within 20%	62% of links are within 10%	50% of links are within 10%
MD	83% of links are within 20%	80% of links are within 20%	52% of links are within 10%	50% of links are within 10%
PM	82% of links are within 20%	80% of links are within 20%	53% of links are within 10%	50% of links are within 10%
NT	99% of links are within 20%	80% of links are within 20%	94% of links are within 10%	50% of links are within 10%

**Green* = Within Range; *Red* = Out of Range

Sources: CFRPM 7; FDOT. 2008. Model Calibration and Validation Standards Report

Table reflects roadway corridors of 10+ miles in length, not links as stated

Travel Time Estimation

Road	Dir	Section	Length (mile)	AM Travel Time (min)			MD Travel Time (min)			PM Travel Time (min)			NT Travel Time (min)		
				Obs.	Est.	%Δ	Obs.	Est.	%Δ	Obs.	Est.	%Δ	Obs.	Est.	%Δ
I-4	EB	North Polk boundary to SR 408	24.9	27.2	47.8	76	27.5	29.2	6	31.5	28.5	-9	24.7	30.1	22
I-4	WB	SR 408 to North Polk boundary	24.9	25.6	27	6	25.1	29.8	19	31.6	48.1	52	25	29.5	18
I-4	EB	SR 408 to I-95	49.5	47.9	48.6	2	47.6	51	7	55.6	70.4	27	46.6	50.1	8
I-4	WB	I-95 to SR 408	48.7	50	61.6	23	45.8	49	7	49.3	50.8	3	45.5	48.5	7
SR 429	NB	I-4 to SR 441	41.4	39	38	-3	38.9	36.2	-7	38.5	37	-4	39	36.1	-7
SR 429	SB	SR 441 to I-4	41	38.2	36	-6	38.6	35.7	-7	38.2	37.2	-2	38.8	35.7	-8
SR 417	NB	I-4 to I-4	52.3	47.6	48.3	1	47.8	45.4	-5	48.7	48.6	0	48.2	45.4	-6
SR 417	SB	I-4 to I-4	51.4	46.9	45.9	-2	46.8	44.5	-5	47	47.4	1	47	44.5	-5
Florida's Turnpike	NB	West Indian River boundary to SR 417	58.7	49.8	51.2	3	49.8	50.6	2	49.9	50.4	1	50.5	50.5	0
Florida's Turnpike	SB	SR 417 to West Indian River boundary	59.7	51.1	51.2	0	51	51.5	1	51	53.4	5	51.7	51.3	-1
Florida's Turnpike	NB	SR 417 to East Lake boundary	24.1	21.5	25.4	18	21.4	21.4	0	21.4	22.9	7	21.5	21.2	-1
Florida's Turnpike	SB	East Lake boundary to SR 417	23.9	21	22.8	9	21	21.3	1	21.3	25.2	18	21.1	20.7	-2
SR 528	EB	I-4 to SR 417	14.6	16.4	15.6	-5	15.7	15.5	-1	16.8	17.4	4	16.1	15.4	-4
SR 528	WB	SR 417 to I-4	14.7	15.2	16.4	8	15.2	15.6	2	17.3	16	-7	15.4	15.6	1
SR 528	EB	SR 417 to SR A1A	38.4	36.1	34.6	-4	36.4	34.8	-4	36.1	43.9	21	36.7	34.7	-5
SR 528	WB	SR A1A to SR 417	38.2	35	43.6	25	34.9	34.6	-1	34.7	34.8	0	35.4	34.6	-2
SR 408	EB	Florida's Turnpike to SR 50	22.3	23.2	25.3	9	22.6	22.6	0	24	24.6	3	22.8	22.5	-1
SR 408	WB	SR 50 to Florida's Turnpike	21.7	23.1	23.6	2	21.6	22	2	22	25.1	14	21.7	21.9	1
SR 50	EB	SR 429 to SR 520	28.9	58	52	-10	63.2	51.2	-19	68.9	67.5	-2	47.8	49.1	3
SR 50	WB	SR 520 to SR 429	28.9	60.2	64.5	7	63.6	49.2	-23	65.3	53.9	-17	47.3	49	4
SR 436	NB	SR 528 to US 17	15.2	30.5	25.3	-17	31.4	23.2	-26	34.1	26.6	-22	24.3	22.4	-8
SR 436	SB	US 17 to SR 528	14.9	30.4	24.7	-19	31.8	23.4	-26	35	26.3	-25	24.3	22.6	-7
IIS 192	FR	I-4 to Florida's Turnpike	15.1	28.8	22.6	-22	32.4	23.2	-29	35.1	31.7	-10	25	22.7	-9

Observations

- Data match speed observation:
 - Successfully achieved travel time benchmarks
 - Overall, estimated travel times are reasonable
 - Congestion overestimated along some portions of freeway

Observations

- Observations:
 - Travel time results help practitioners know if the model is good or not in their corridor
- Achieved desired increase in confidence in model travel time/speed for performance measures or other planning needs

Observations

- Observations:
 - Use probe speed data to calculate site to site travel time with comparison of model results.
 - Use probe speed data to review over-assignment and under-assignment issues for subarea model validation.

Questions

