Vehicle Probe Project

Web Conference

Arterial Data Quality

January 10, 2013

I-95 CORRIDOR COALITION

Call Courtesies

- Please keep your phone muted until asking a question or speaking (press *6 to mute/unmute individual phone lines)
- Please give your name and agency before asking your question (at least the first time)
- Please do not place call “on hold” as your hold music may be heard by the group
- Please call 610-662-5569 for difficulties with the web application

Introductions and Welcome

Marygrace Parker
I-95 Corridor Coalition

VPP Arterial Validation Effort

Stan Young
University of Maryland

- **Overview & History of VPP Arterial Validation**
- Phase 1 – Initial Investigation
- Phase 2 – Case Studies
- Phase 3 – Quantifying Effectiveness
- Questions and Discussions

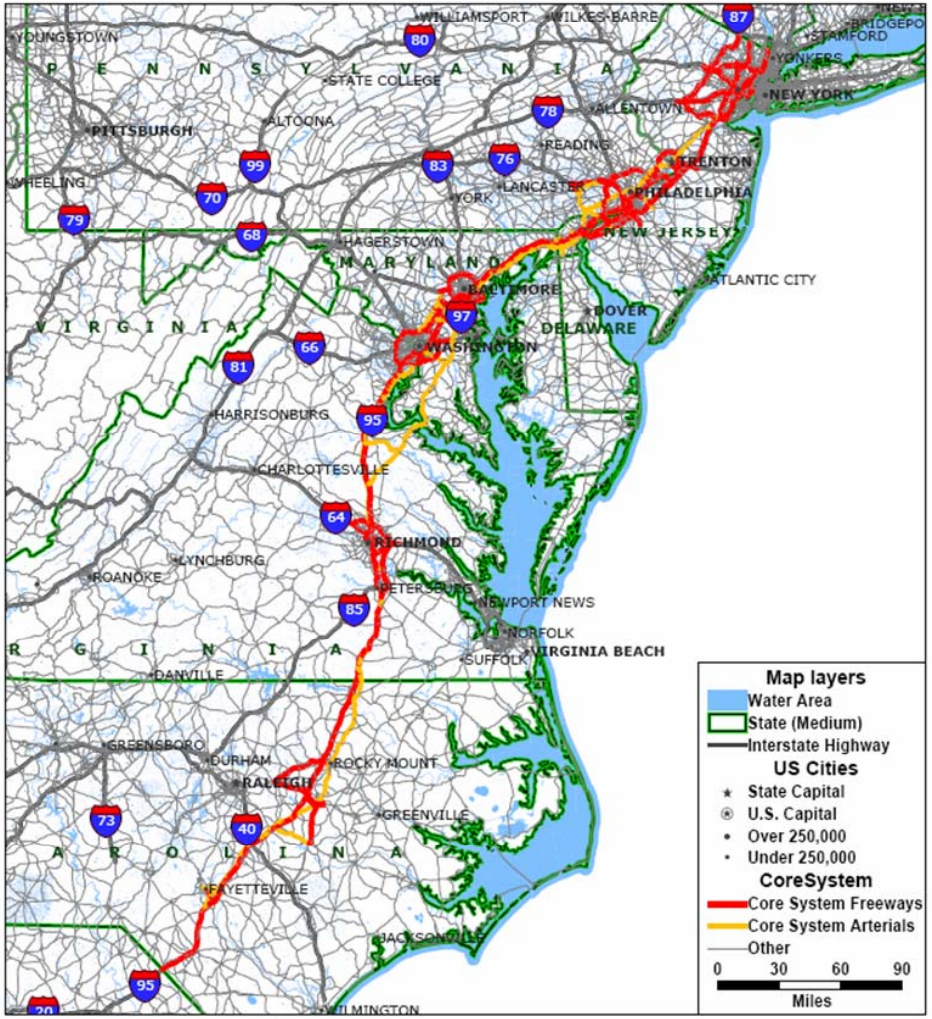
VPP in 2008

Core Coverage

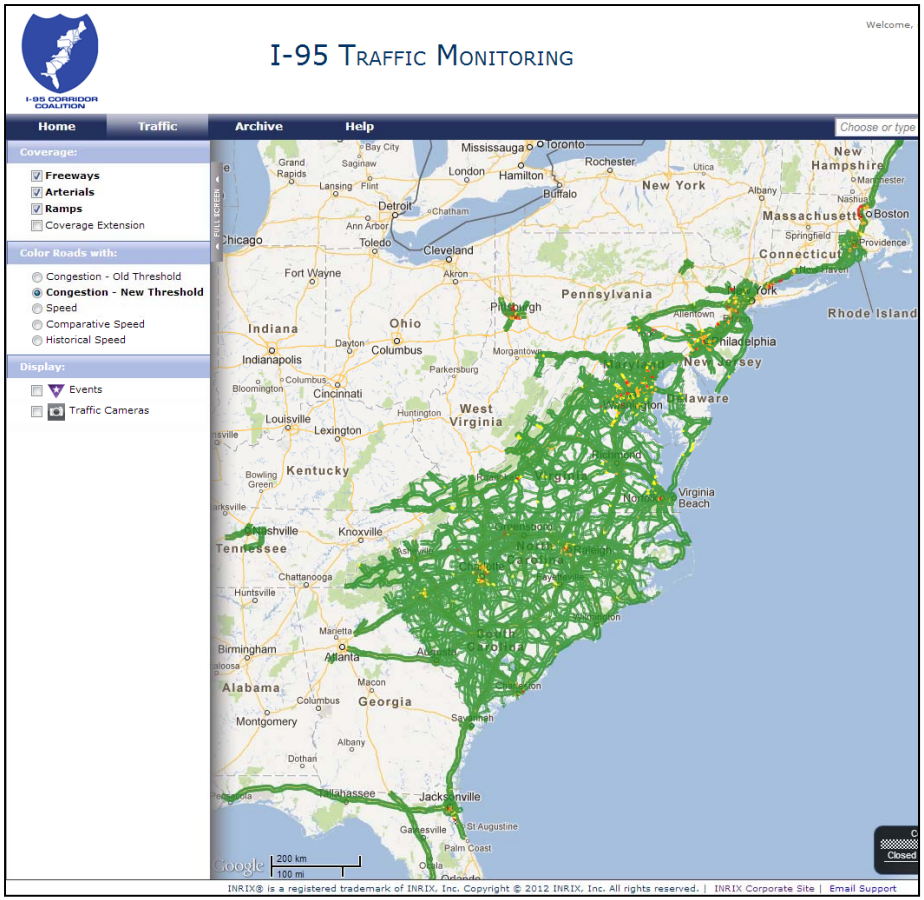
- 1500 Freeway miles
- 1000 Arterial miles
- New Jersey to North Carolina

Roadways

- I-95/Parallel Freeways
- Beltways & Cross-linking Freeways
- Alternate Route Arterials



VPP Now – Current Contracted Coverage



State	Freeway Miles	Other Miles	Total Miles
Maine	66	0	66
New Hampshire	16	0	16
Massachusetts	96	0	96
Rhode Island	162	597	759
Connecticut	111	0	111
New Jersey	895	63	958
Pennsylvania	637	118	755
Maryland	781	3779	4,560
Washington DC	31	233	264
Virginia	1,411	7,213	8,624
North Carolina	1,553	12,996	14,549
South Carolina	934	7,187	8,121
Georgia	398	0	398
Florida	718	0	718
Total	7,809	32,186	39,995

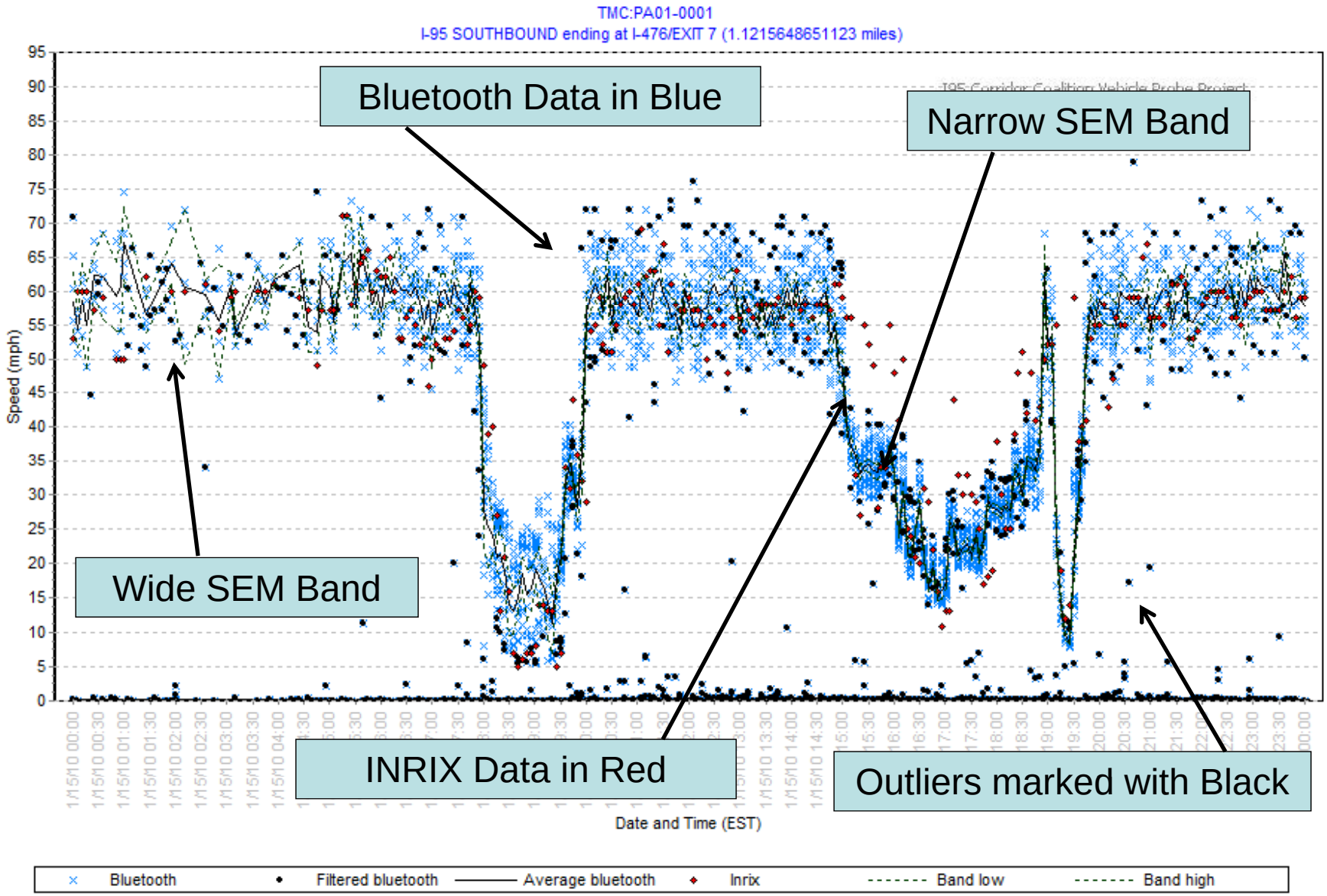
Freeway Data Quality Specifications

- Data items:
  - Travel Time / Space Mean Speed
  - Confidence Score
  - Historical and Expected Values
- Specs are applied when flow exceeds 500 vph
- Travel Time / Speed Data
  - Accuracy is assessed in four flow regimes

    0 - 30 MPH 30-45 MPH

    45-60 MPH > 60 MPH
- In each range the following apply
  - Max average absolute speed error: 10 MPH
  - Speed error bias: +/- 5 MPH Max

PA Validation – Jan 2010



- Overview & History of VPP Arterial Validation
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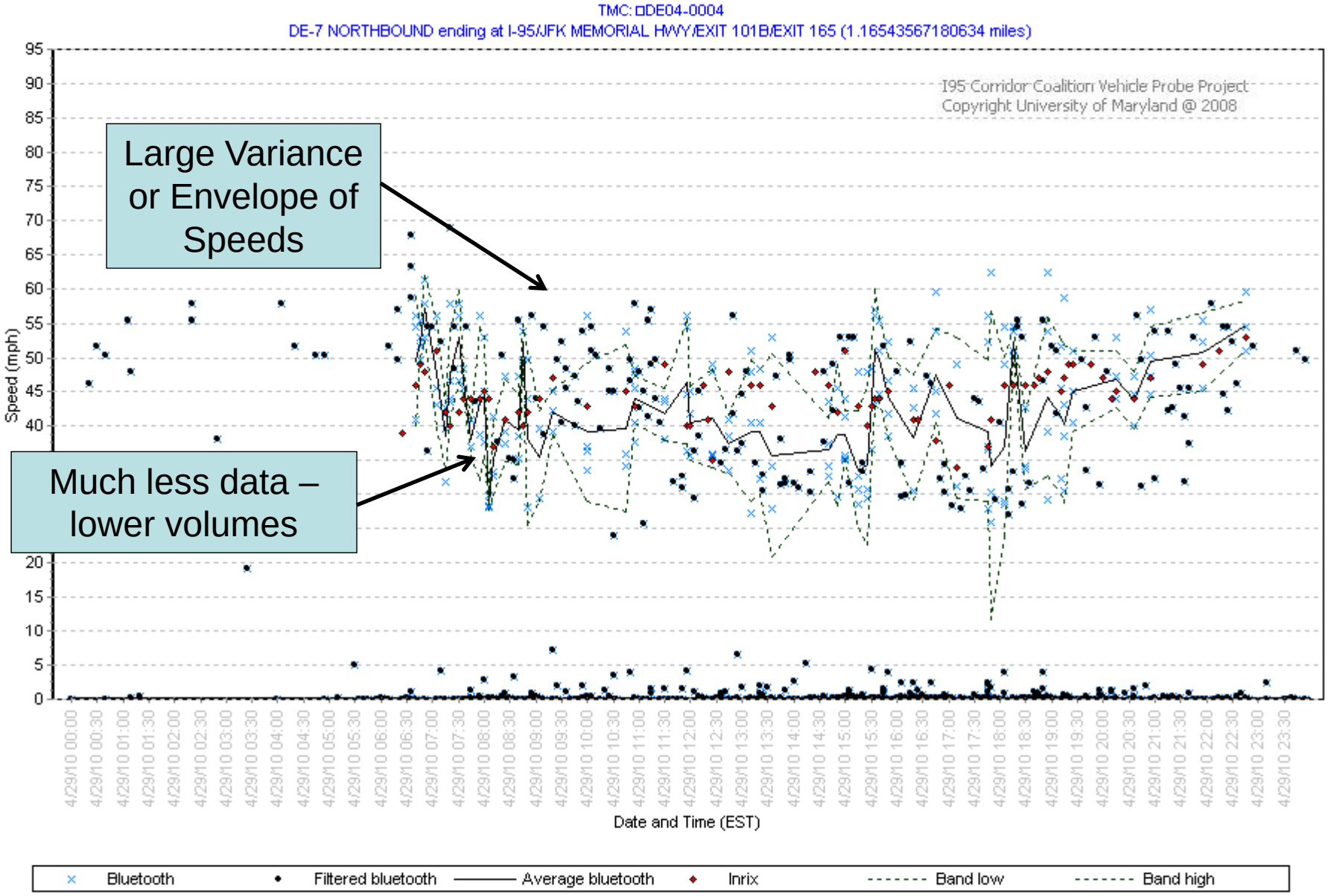
Timeline of Validation

- Jul 2008 – Dec 2009
  - Confirming Freeway Data Quality
- Jan 2010 – Dec 2010
  - Initial look at Arterial Data Quality
  - Identified Issues
  - Applied Freeway Methodology
  - Data Collection Began
  - Webinar / White Paper

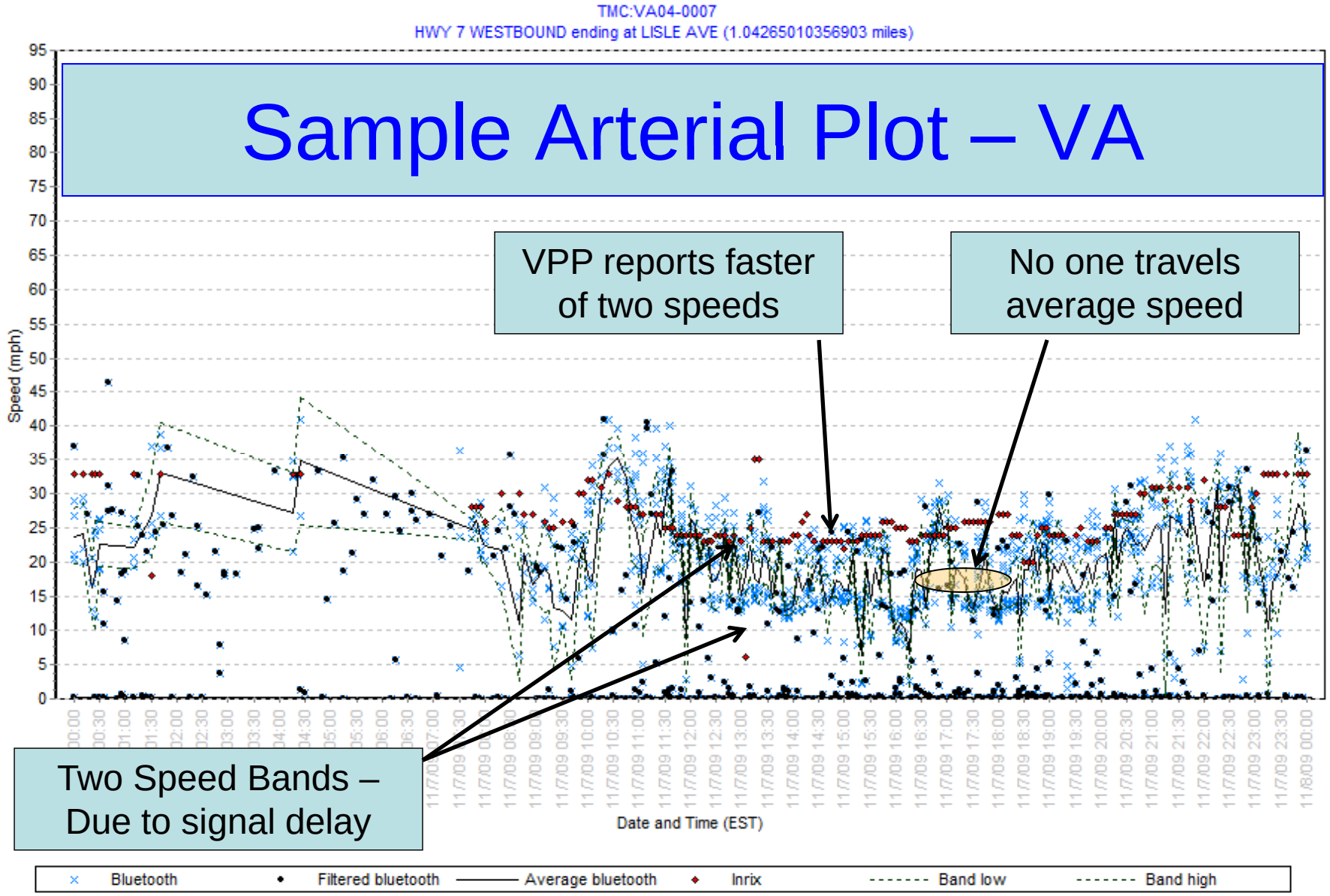
Freeways vs. Arterials

	Freeways	Arterials
Volume	2200 vphpl	1400 vphpl on green
Speed Range	20-70 mph	10-45 mph
Freeflow	65 mph	Unknown
Congestion Types	Recurring / Non-recurring	Cycle Failure / Mid-Block Friction
Congestion Signature / Incident	Slowdowns < 55 mph	Difficult to recognize
Flow characteristic	Uniform	Higher Variance, Frequently Bi-Modal

Arterial Data Example



Sample Arterial Plot – VA



Summary of Issues

- Broad definition of Arterials
- Freeway methodology and specifications inappropriate
- Congestion patterns are more complex
  - Signal timing changes
  - Delay induced at signals
- Travel time frequently not uniform
- TMC codes problematic

Freeway Speed Ranges

LOS Criteria for Basic Freeway Segments - HCM 2000

Criteria	LOS					
	A	B	C	D	E	F
Average Speed	60	57	54	46	30	<30

HCM 2000 Table A-1

- Compared to VPP Speed Categories
  - >60 MPH LOS A
  - 45-60 MPH LOS B,C,D
  - 30-45 MPH LOS E
  - < 30 MPH LOS F
- Accuracy spec 10 MPH AASE
  - 1/3 of speed from LOS A to LOS E/F

Arterial Speed Ranges

LOSDefinitions for Urban Streets

Criteria	LOS					
	A	B	C	D	E	F
Percent of Freeflow	90%	70%	50%	40%	33%	<33%

HCM 2000 - Level of Service Urban Street Definitions

For a 45 MPH Arterial (Speed Limit)

Criteria	LOS					
	A	B	C	D	E	F
Speed Threshold	40.50	31.5	22.5	18	15	<15 MPH

- Suggests speed ranges of
  - >40 mph 20-40mph 15-20mph <15mph
- Suggested accuracy spec
  - 25 mph differentiation between LOS A to LOS F
  - Implies accuracy spec ~ 8 mph AASE

Direction in Dec 2010

- Recommend use of VPP data only on
  - High volume arterials
  - Medium to low mid-block friction
  - Sparse signal spacing
  - Through movement dominant
- Continue to study remaining arterials
- Summary White Paper in Nov 2010

- Overview & History of VPP Arterial Validation
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- **Phase 2 – Case Studies**
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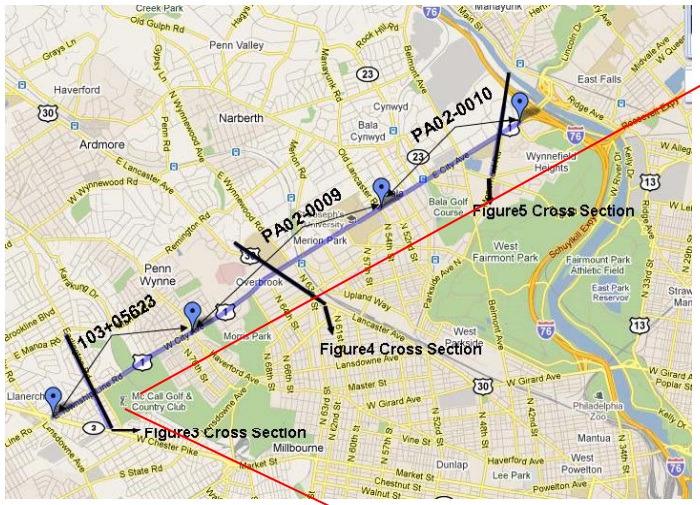
Phase II – Arterial Case Studies

- PA, Aug 2010, US-1, 6 segments
- VA, Sept 2010, US-1, 2 segments
- MD, Sept 2010, Rt. 3, 4 segments
- DE, Nov 2010, Rt. 13, 4 segments

Pennsylvania US-1

TYPE	TMC	HIGHWAY	STARTING AT	ENDING AT	COUNTY	DIRECTION	LENGTH (mile)
Arterial	**PA02-0007**	US-1	PRESIDENTIAL BLVD	54TH ST (BALA CYNWYD) (EAST)	PHILADELPHIA and MONTGOMERY	SB	1.6
Arterial	**103-04821**	US-1	54TH ST (BALA CYNWYD) (EAST)	US-30/ LANCASTER AVE	MONTGOMERY	SB	1.2
Arterial	**PA02-0008**	US-1	US-30/ LANCASTER AVE	PA-3/W CHESTER PIKE	MONTGOMERY and DELAWARE	SB	2.5
Arterial	**103+05623**	US-1	PA-3/W CHESTER PIKE	HAVERFORD RD/ HAVERFORD AVE	MONTGOMERY	NB	1.6
Arterial	**PA02-0009**	US-1	HAVERFORD RD/ HAVERFORD AVE	54TH ST (BALA CYNWYD) (WEST)	MONTGOMERY	NB	2.1
Arterial	**PA02-0010**	US-1	54TH ST (BALA CYNWYD) (WEST)	PRESIDENTIAL BLVD	PHILADELPHIA and MONTGOMERY	NB	1.5

Sample Cross Sections



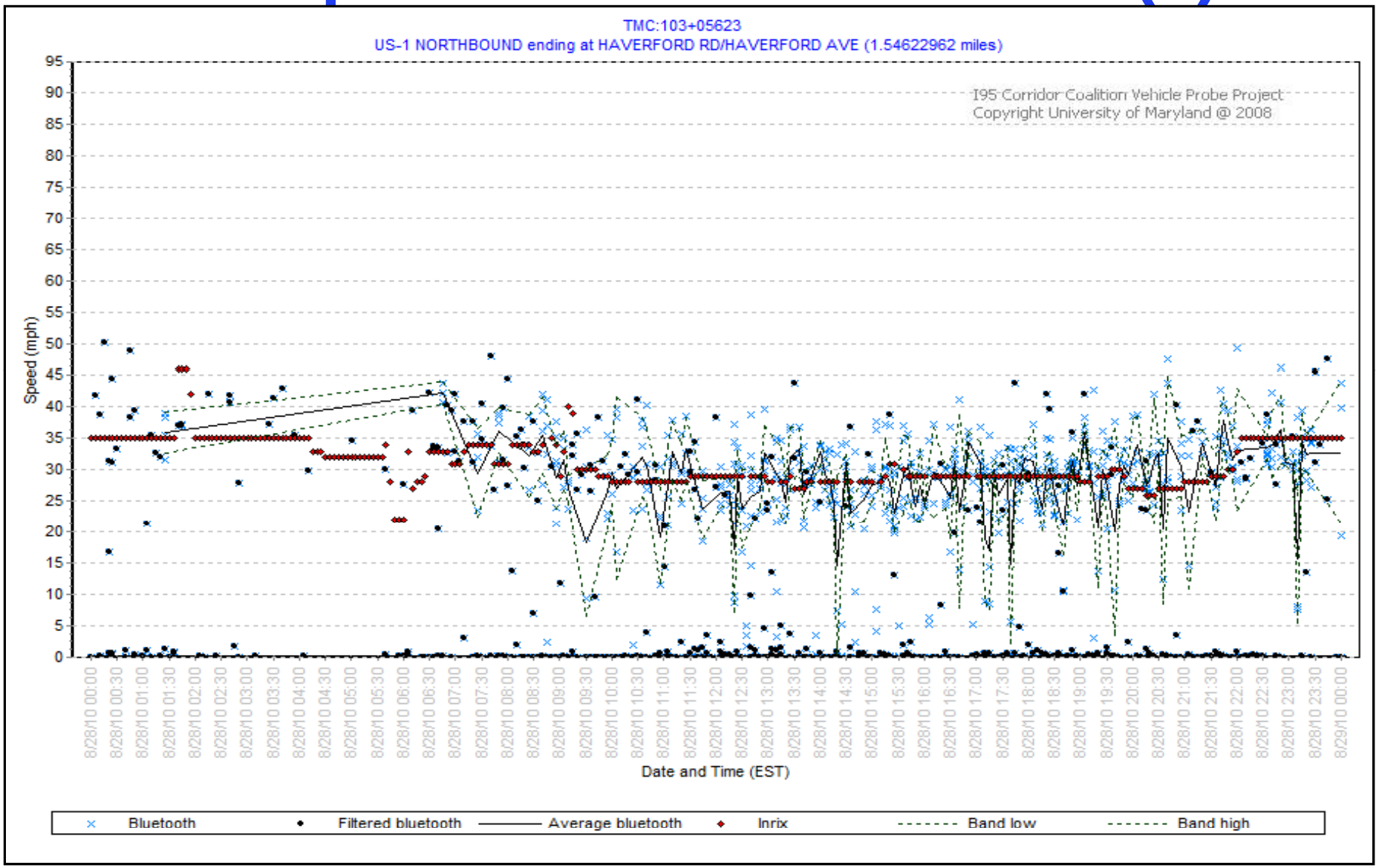
TMC name	Number of Lanes	Number of Signals	Number of Right Exits Other than Signals	Number of Left Exits Other than Signals
PA02-0007	2,3	9	13	12
103-04821	2	8	9	10
PA02-0008	2	12	25	23
103+05623	2	8	18	14
PA02-0009	2	12	20	17
PA02-0010	2,3	9	17	9

Volume and Score

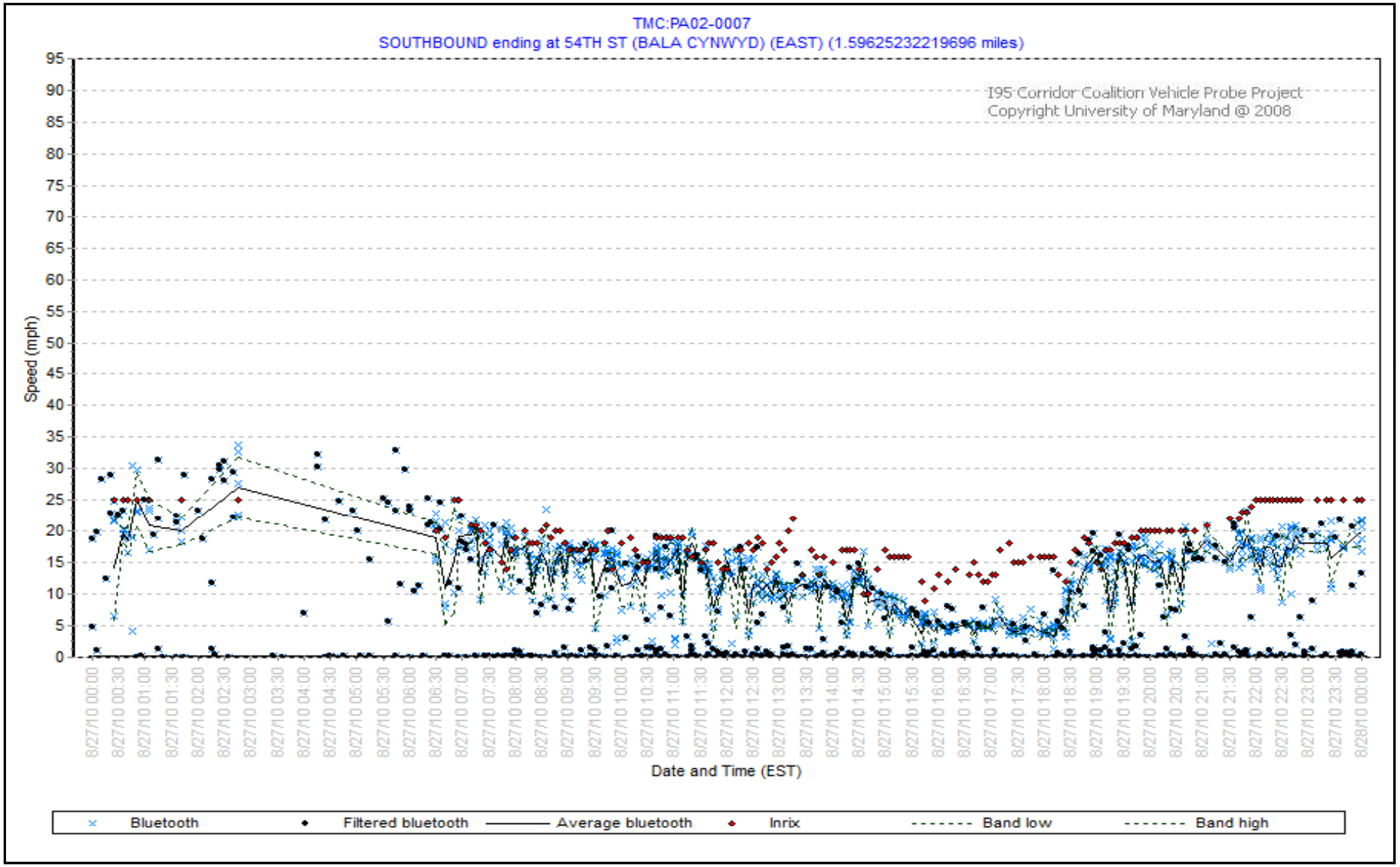
- Estimated volume from HPMS and Bluetooth factoring
  - Bluetooth estimate 16000 – 28000
  - HPMS from DVRPC 20,000
- Percent Score = 30 analysis

	All Time	6 AM-9 PM
Whole Period	38%	55%
Weekdays	50%	71%
Weekends	19%	27%

Sample Data Validation Plot (1)



Sample Data Validation Plot (2)



Arterial Case Studies

Summary of VPP's arterial case study sites.

State - Time, Location	# of Test Paths	Length of Paths (mi)	# of signals	Numer of lanes per direction	Estimated AADT	Free-Flow Speed	Weekday Daytime %Score >25	Effectiveness of VPP
PA - Aug 2010, Route 1	3 NB & 3 SB	1.2 - 2.7	8-12 per segment	Primarily 2	20,000	15-30 MPH	71%	Very Low
MD - Sep 2010, Route 3	2 NB & 2 SB	1.8-2.0	4	2-3	40,000	45	57%	Good
VA- Sep 2010, Route 1	NB & SB	2.3	2	2	9,000-12,000	40-45	3.15%	Not Effective
DE - Nov 2010, Route 13	1 SB	1.06	4	3	20,000-34,000	40	76%	OK

Phase II - Conclusions

Key Findings and Observations

1. Initial case studies indicate that VPP data effectiveness is primarily volume dependent.
2. Arterials requires a higher sampling rate to attain the same level of data quality.
3. Roadway geometrics influence the consistency in travel time observations.
4. Traffic signals tend to divide traffic in pulsed flows, with two or more distinct travel times.
5. Difficult to discern congested flow on arterials from free-flow.
6. Trip purposes and therefore land-use pattern of surroundings areas also impact the VPP's effectiveness.

Summary / Recommendations

Recommendations

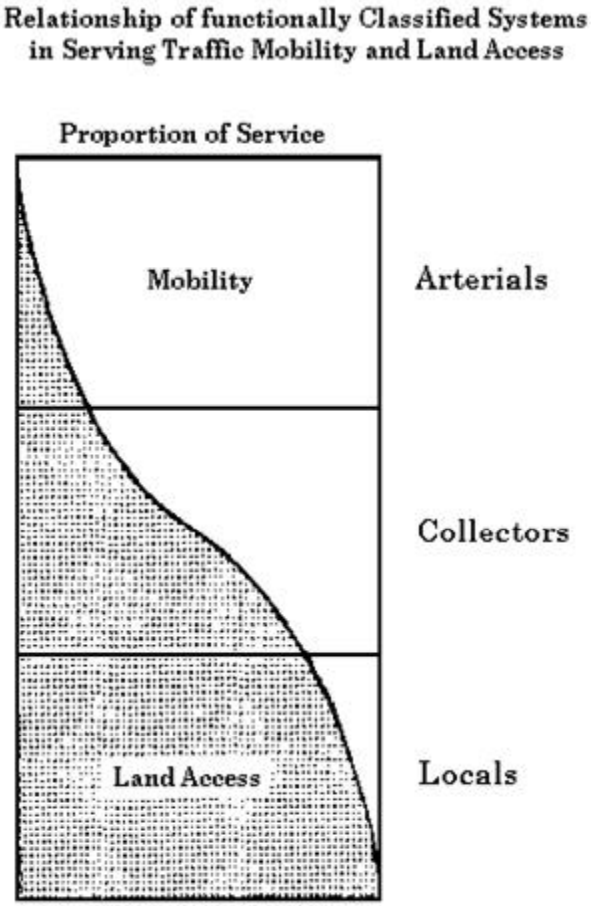
- High volume, multi-lane, signalized facilities that serve major corridor movements.
- AADT of 30,000 or greater.
- Low mid-block friction
- Concentrate on arterials with efficient geometric designs and minimal traffic control devices.
- Validate

Future Work

- Quantifying Quality Remains Problematic
- Appropriate specifications and validation methodology

Fundamental Question

- Where does the VPP data provide value on mobility–accessibility spectrum?
- How do you quantify the effectiveness?



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Arterial Data Quality & Performance Measures

- Probe data (specifically Bluetooth data) increasingly used for arterial evaluation
- Emphasis on planning uses of VPP data
- Performance measures emphasis Map-21

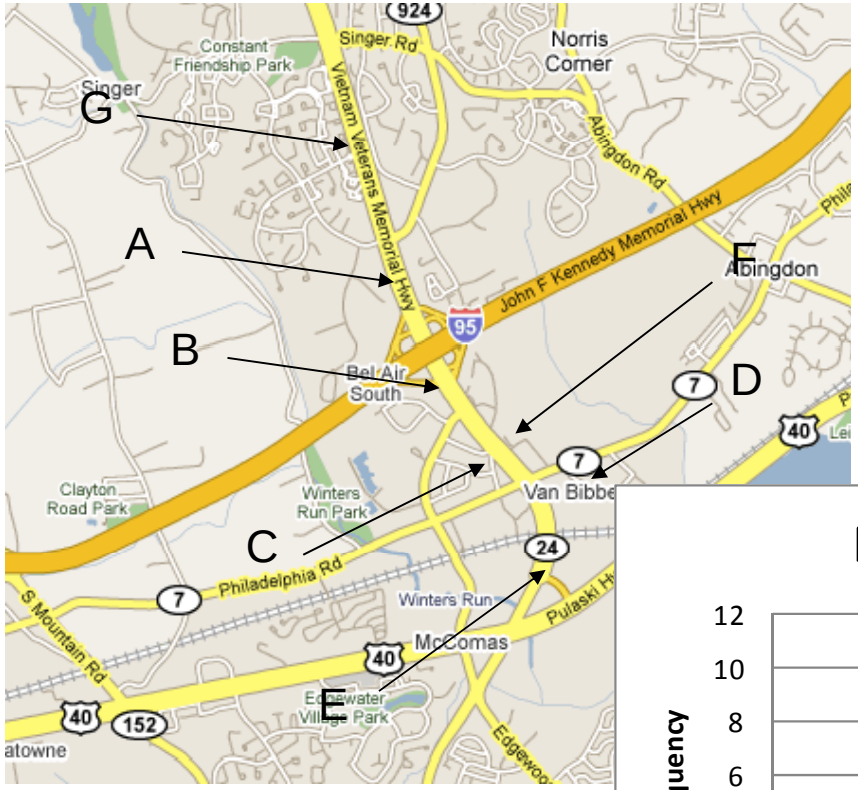
Arterial performance measures & validation are intrinsically linked

Traffic Engineering (NCHRP 3-79)	Operations (Query Ops)	Planning (Query Planning)
Delay	Delay	Delay (> usual travel time)
Travel Speed	Travel Speed	Travel Speed
Stop Rate		
V/C	V/C Volume Splits	Volumes
Bandwidth Efficiency / Cycle Failure Rate / Percent Arrival on Green		
Queue Length	Queue Length	
Travel Time	Travel Time	Travel Time (free flow, usual peak period, 95th %)
Travel Time Reliability	Travel Time Reliability	Travel Time Reliability (PTI)
	Recovery Time	Duration of congestion/period
		Density of lights/driveways

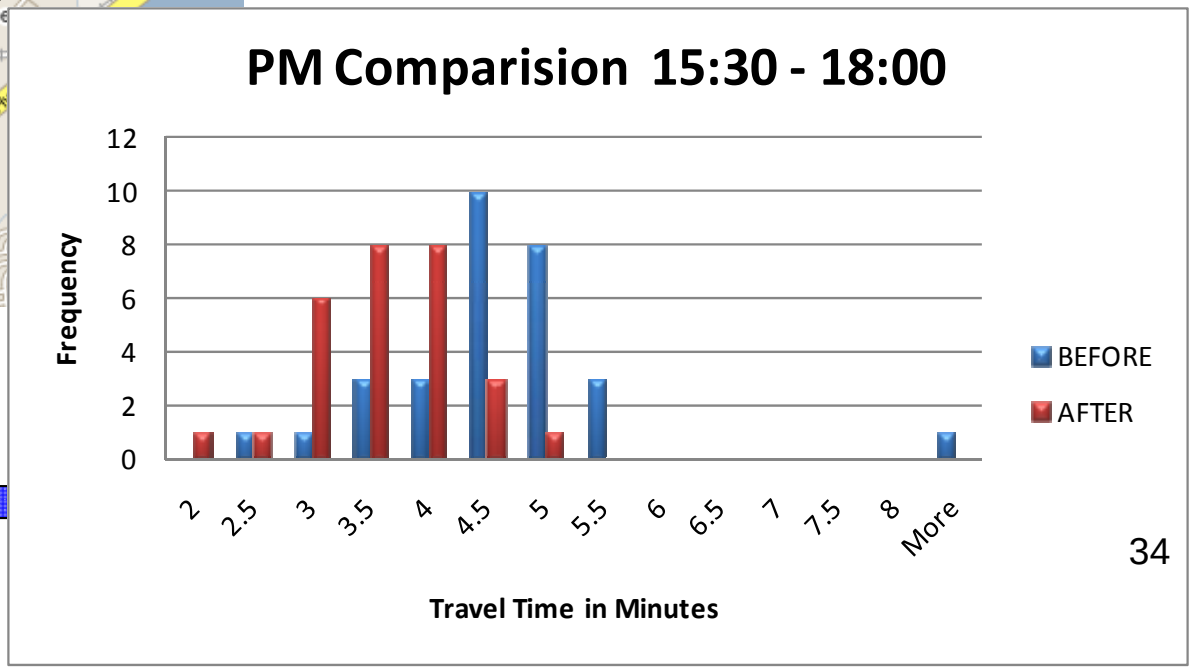
Approach …

- Evolved from Traffic Engineering
- Developed in partnership with Purdue
- Sampled distributions (Histograms & CFDs) form base for Performance Measures and Validation
- Freeway PM can be directly calculated

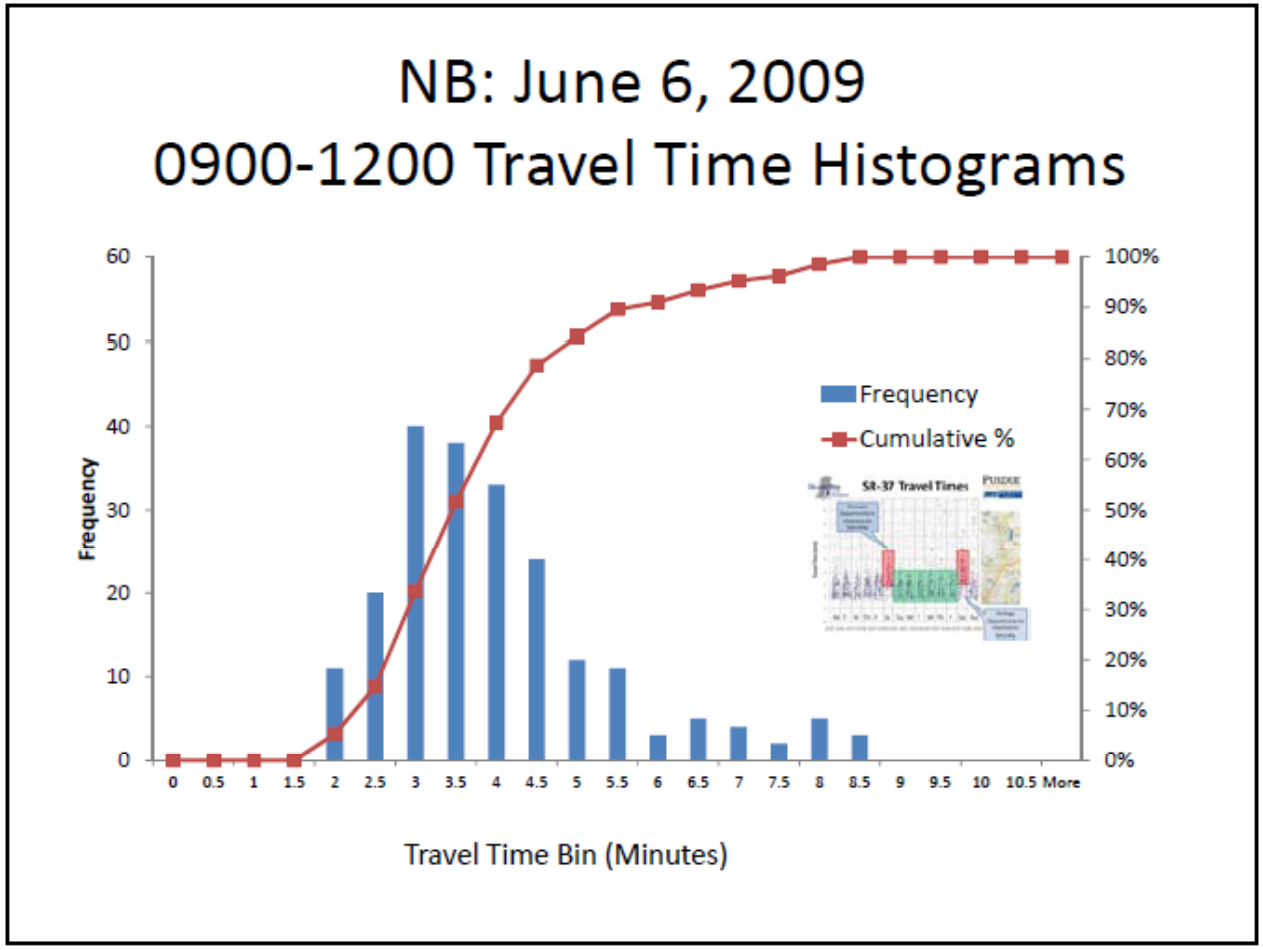
Initial Use of Probe Data on Arterials…



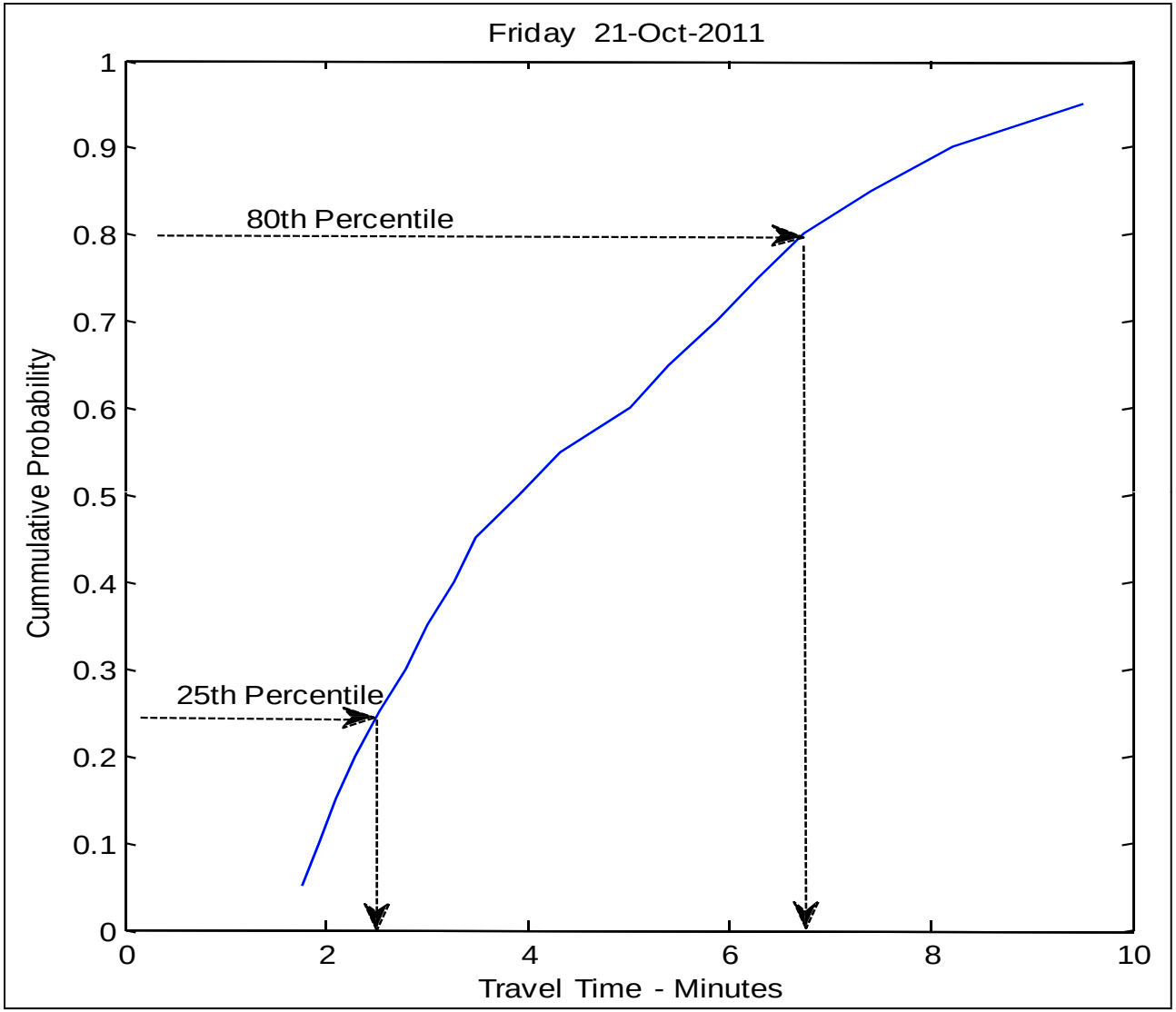
- To verify signal timing
- Based on floating cars
  - Minimal data
  - Expensive
- First use of Bluetooth



Histograms converted to Cumulative Frequency Diagrams



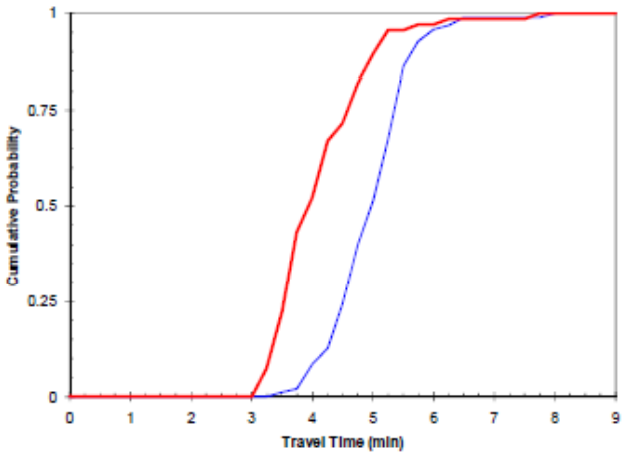
Construction of CFD's



CFD's for Comparative Analysis

Business Case: SR 37 Timing Improvements

(Largest Cost Benefit/Reduction/Avoidance)



0600 -2200 (8,500 veh)

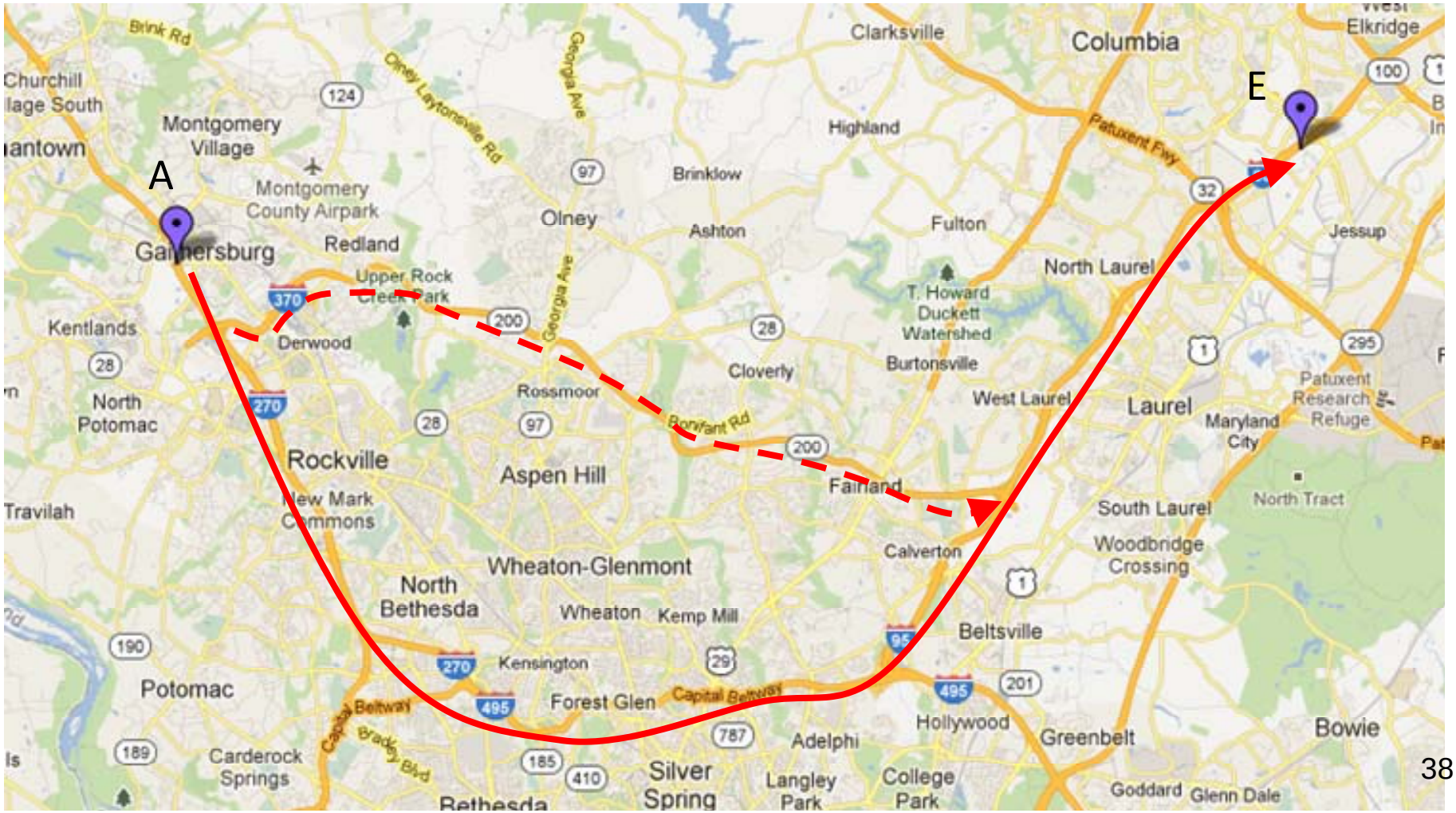
USER SAVINGS

- Travel time tests for SR37 Corridor have improved Northbound Travel Time by ~ 1 Minute.
- **~8,500** Cars per Day Are Effected by this benefit (NB).
- **~0.17 Cents** per minute ($10/hour) saved for each driver in fuel costs and time value.
- **~1.0 Minutes** are assumed saved on average for the intersection over 1-Year with improvements.
- User benefit =

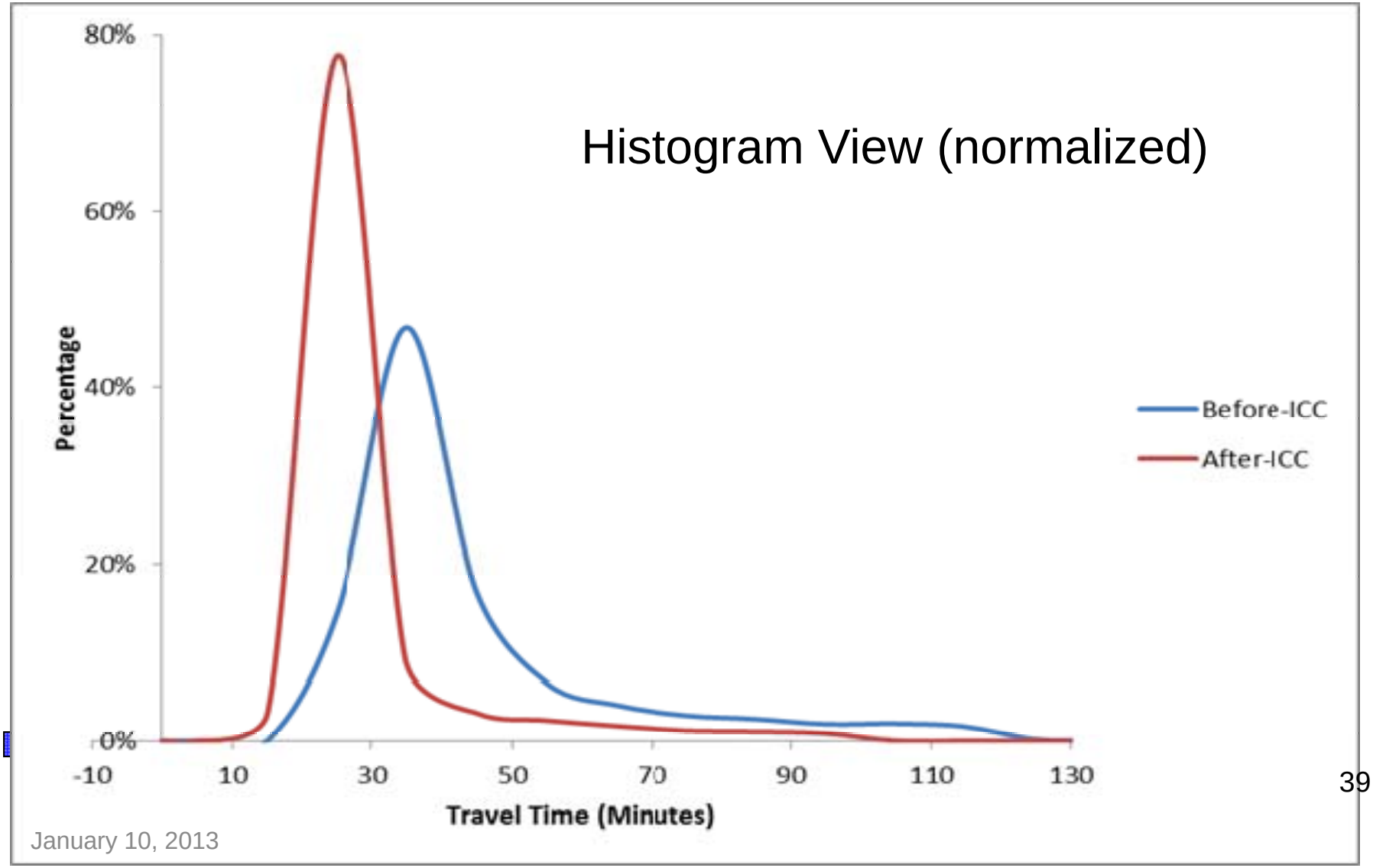
  (8,500 Veh/Day * $0.17/min * 1-min/Veh * 2*52 Days/Year)= **$150,000/year** for a 1.6 mile stretch of roadway is realized.

66

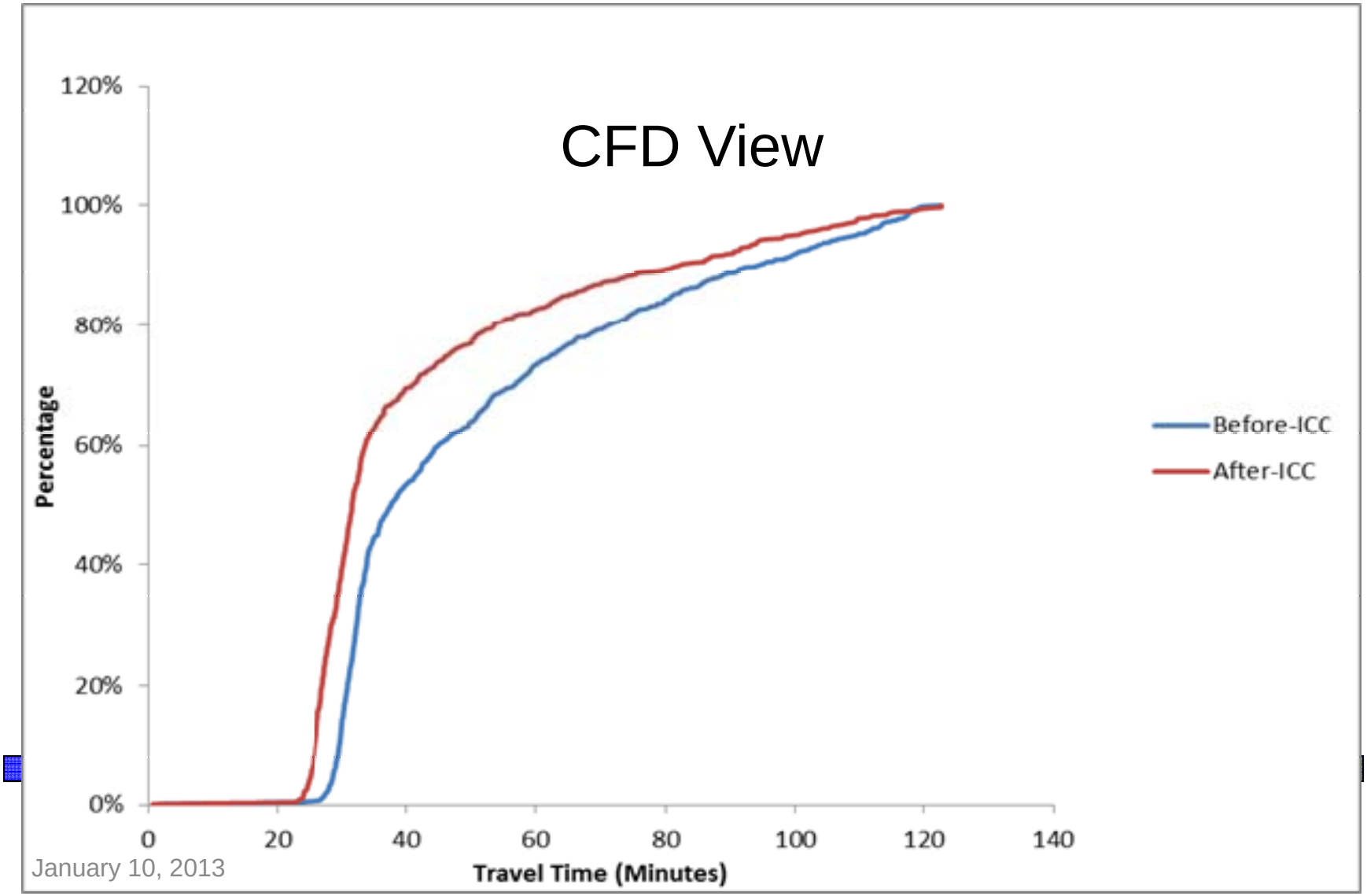
Example from Freeways … Impact of the ICC



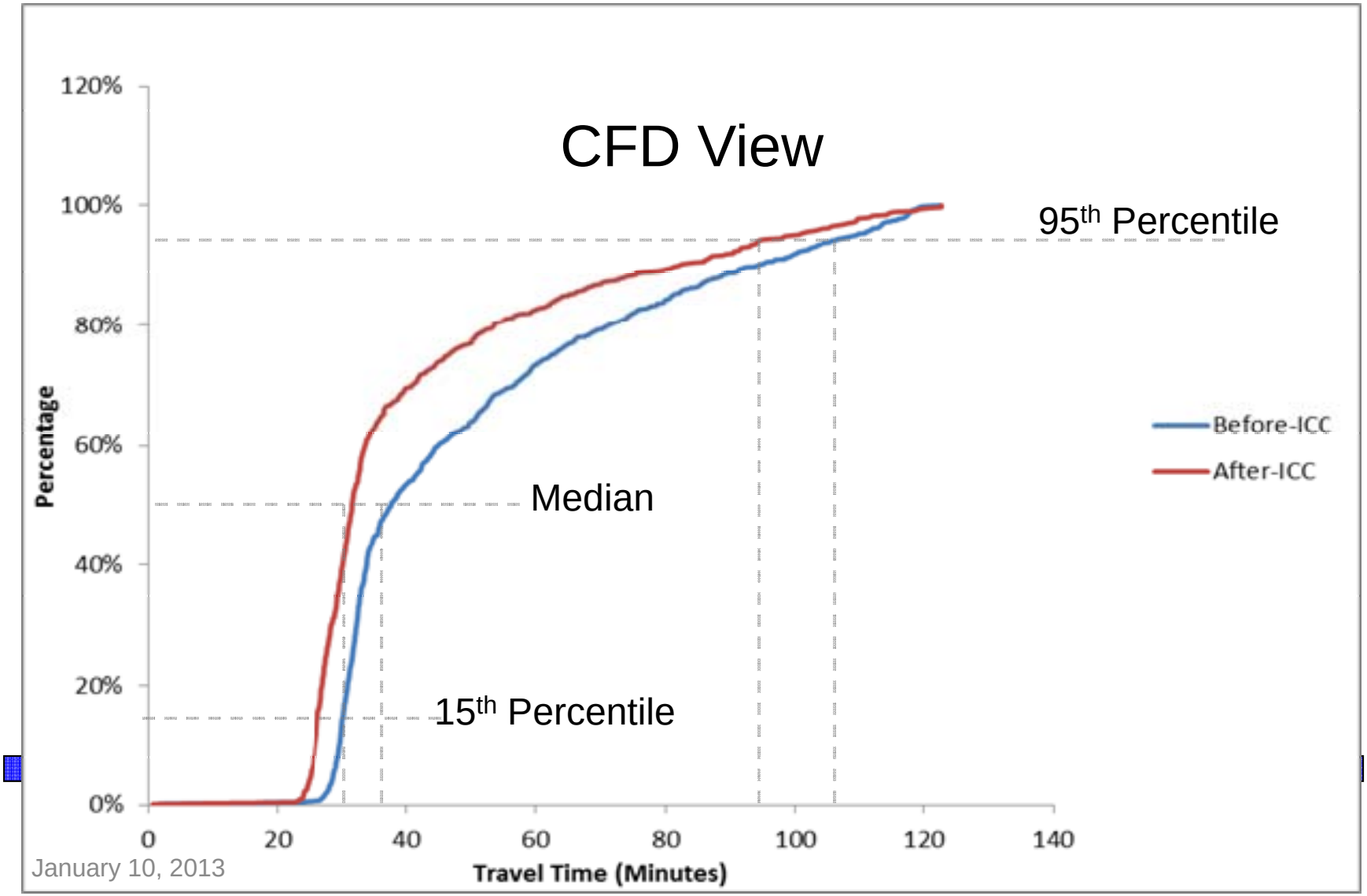
Impact on travel time A -> E



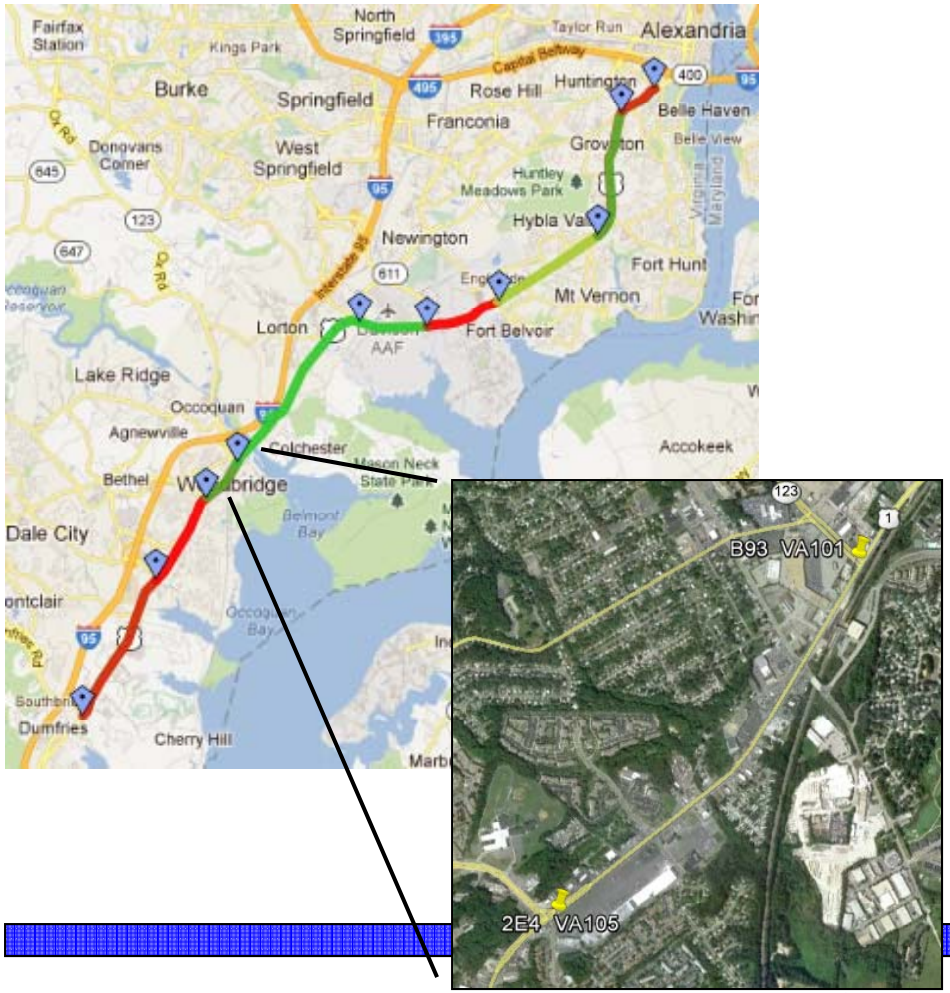
Impact on travel time A -> E



Impact on travel time A -> E

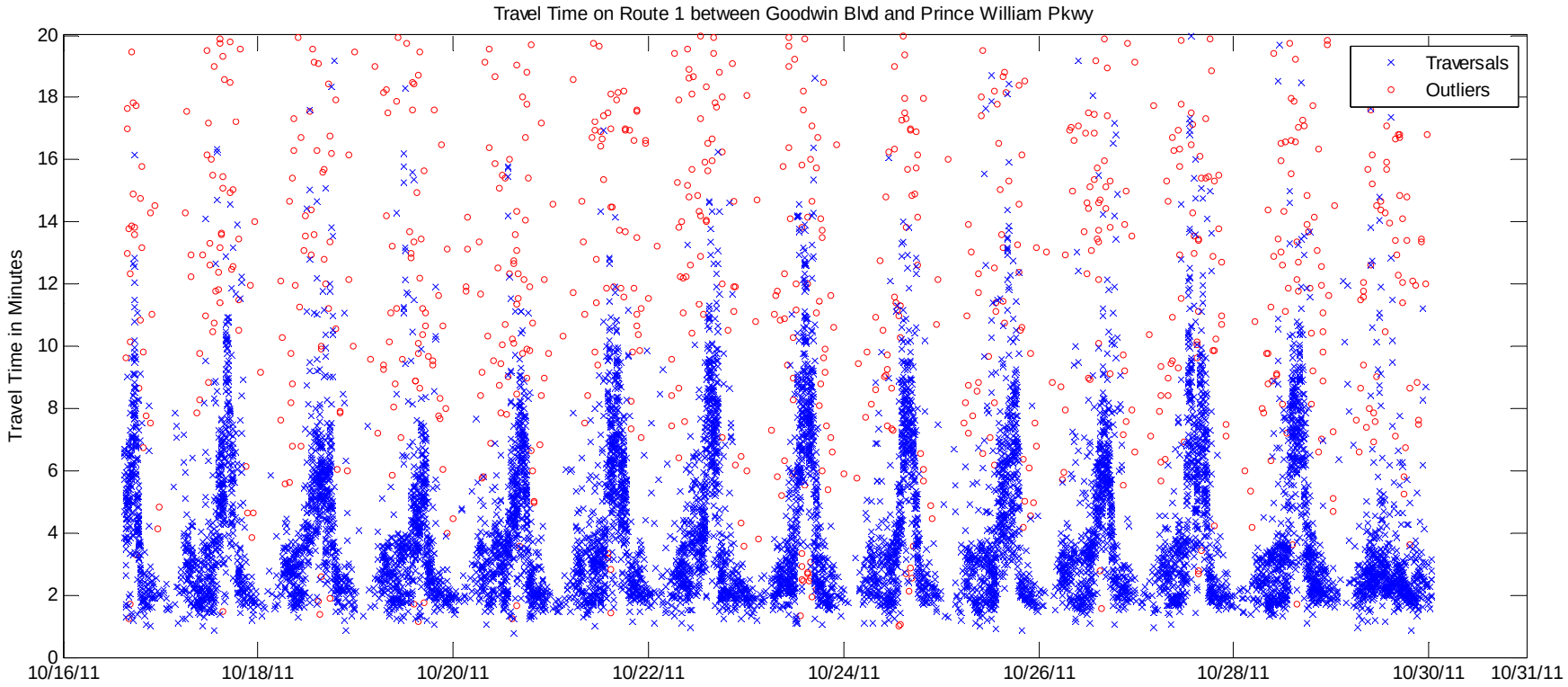


Applied to Route 1 in Virginia …

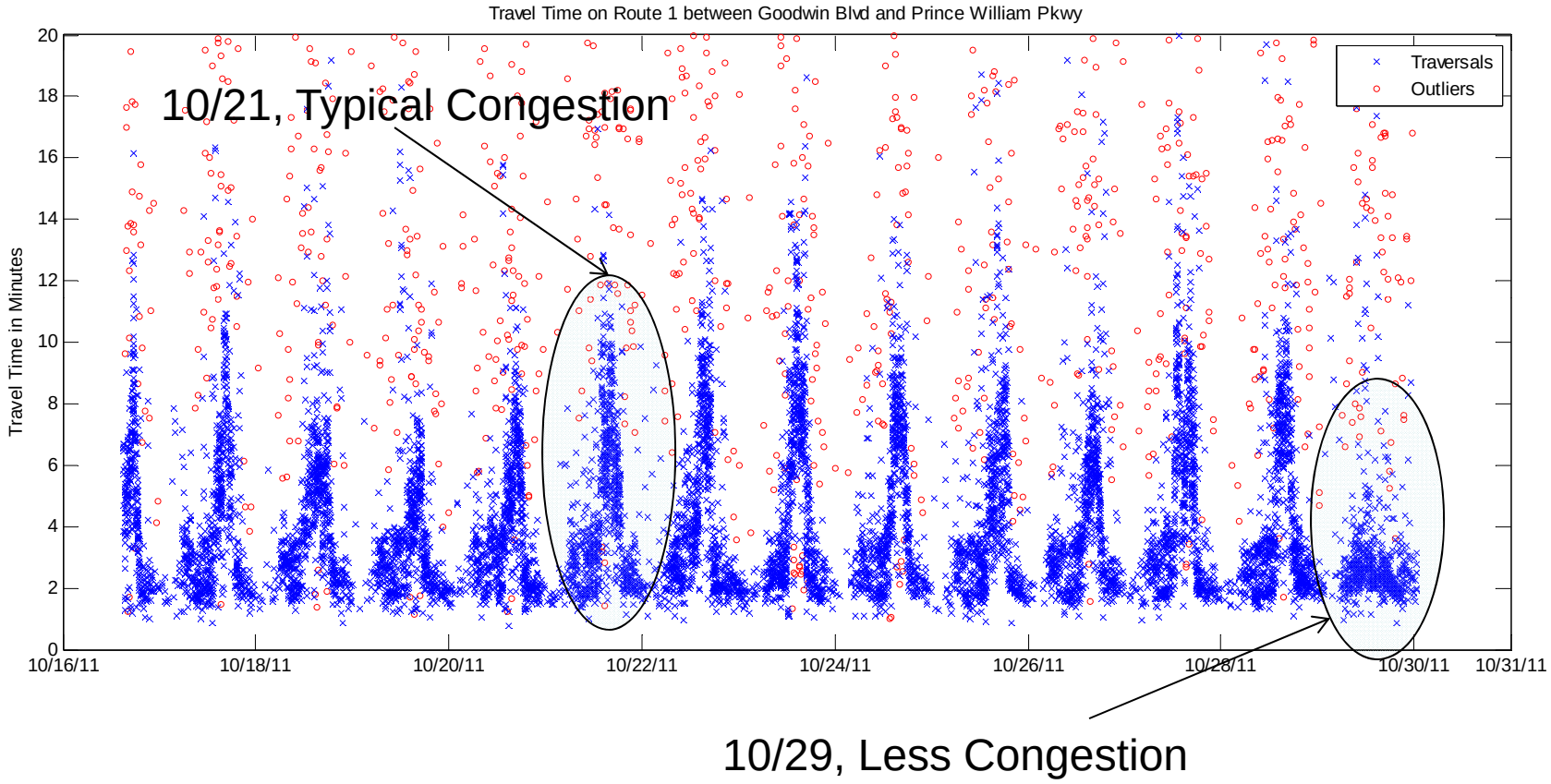


- SBIR deployment 48 BTM Sensors
- 10 Sensors in Rt 1
- > 6 months data
- Real time & archive
- Oct 17 – 29, 2011
- 1.2 miles
- Woodbridge, VA
- Two internal intersections

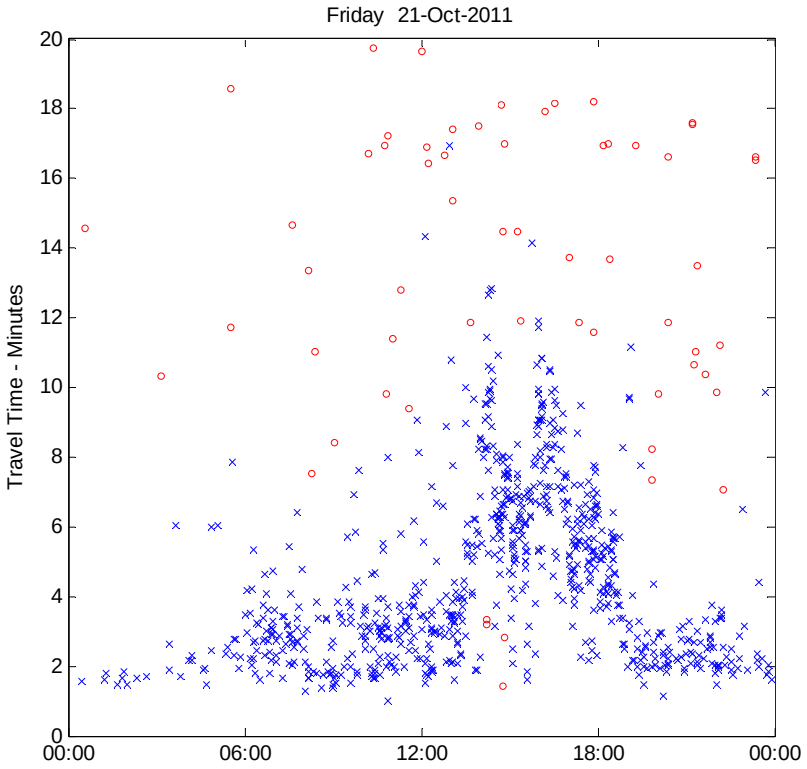
Scatter Plot of BTM Data

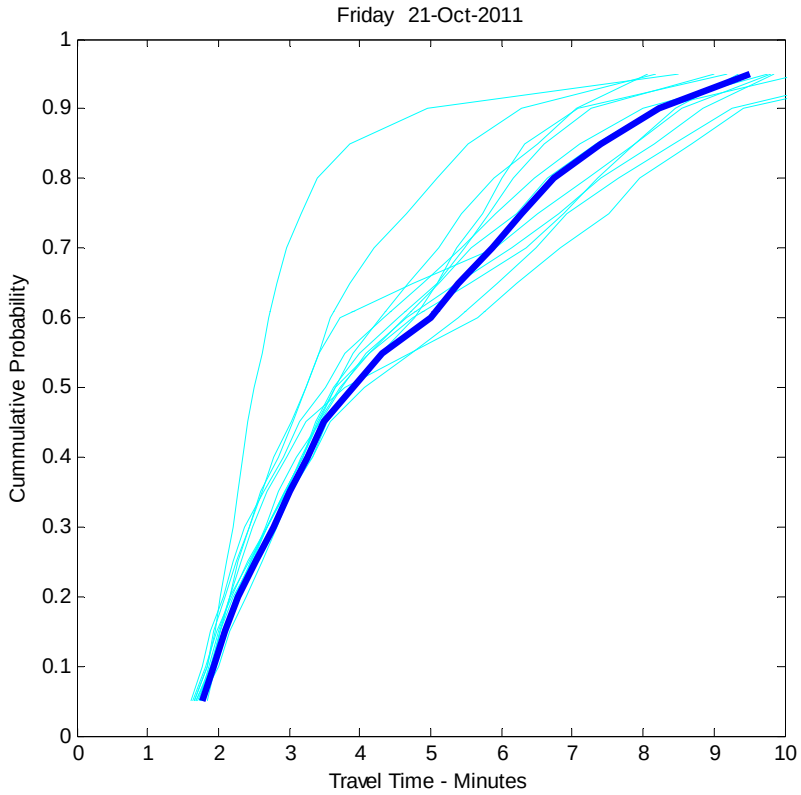


Scatter Plot of BTM Data

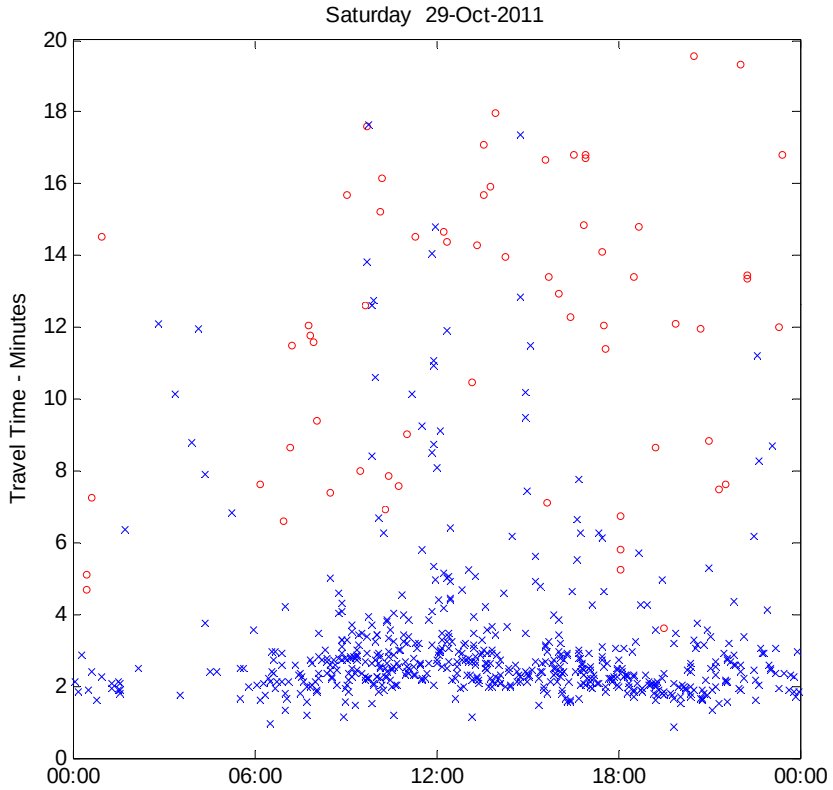


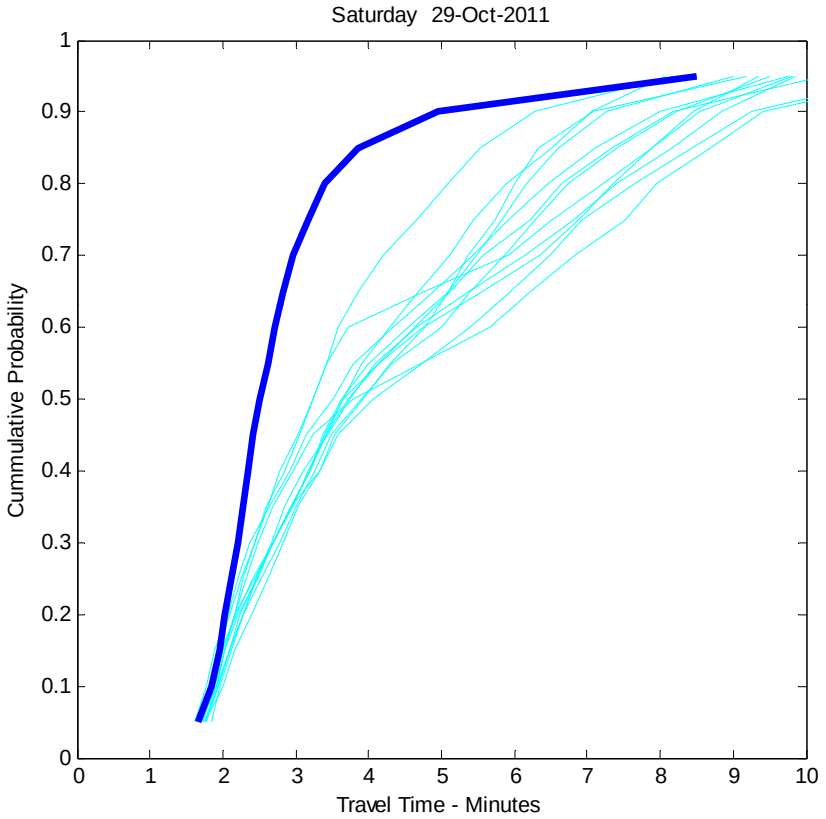
Friday, Oct 21, 2011



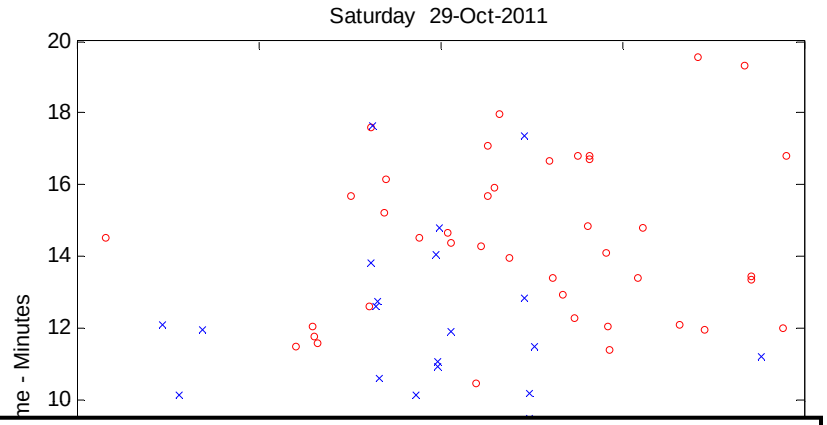


Saturday, Oct 29, 2011



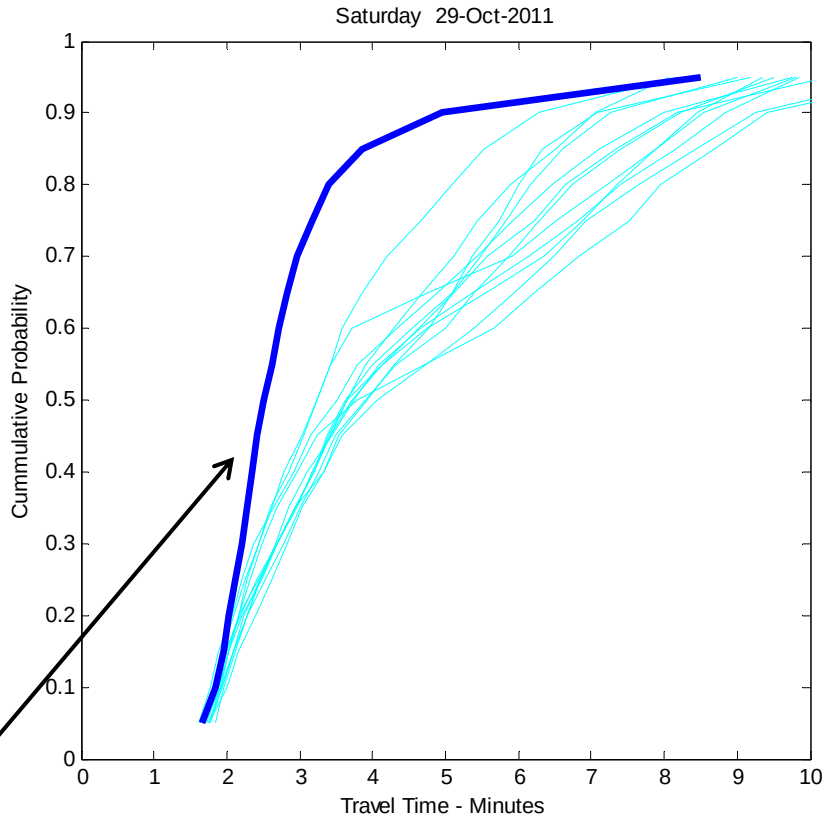


Saturday, Oct 29, 2011



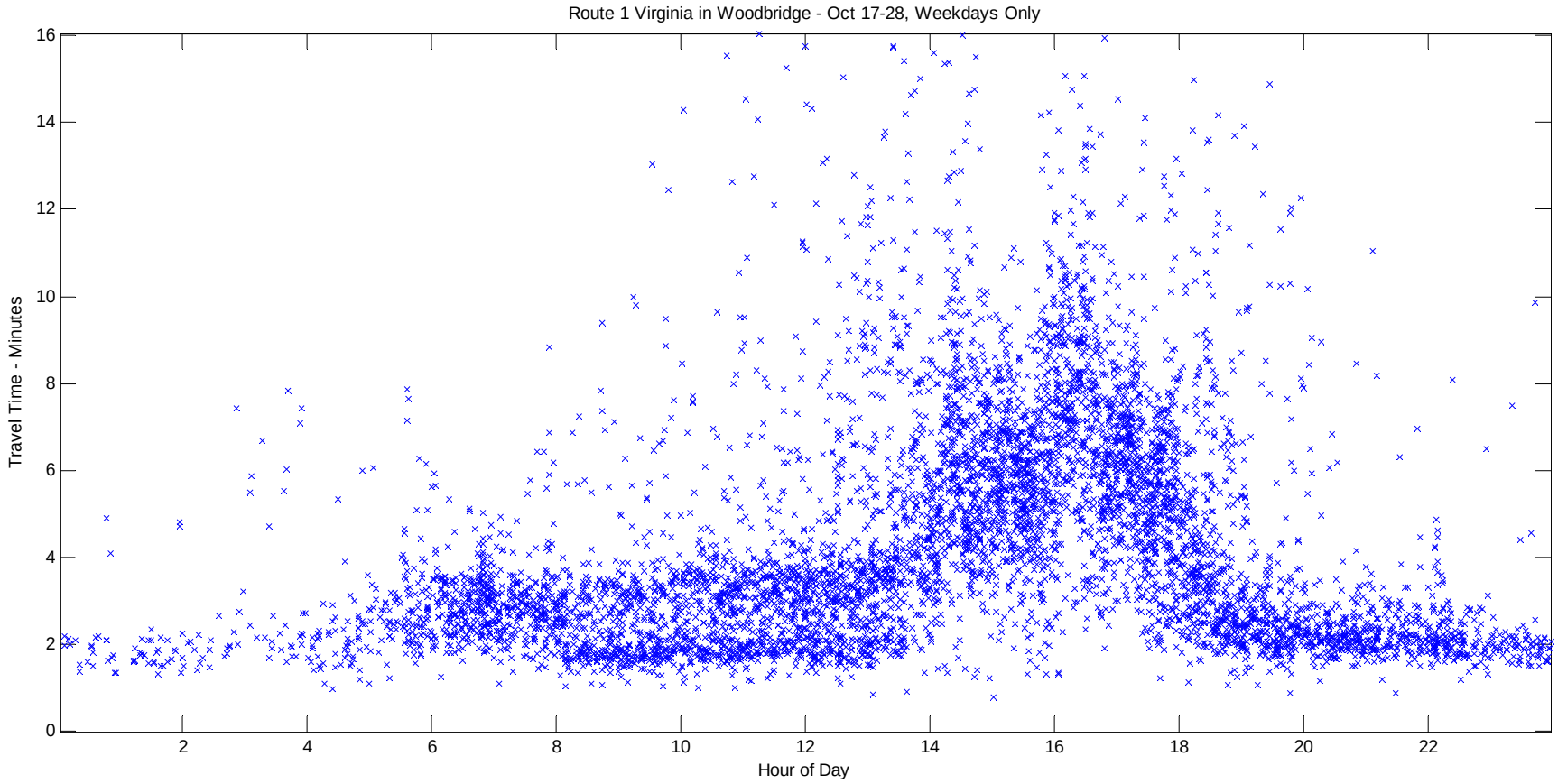
A rare pre-Halloween snow fell on much of the D.C. area early Saturday, coating roofs and cars and dusting trees that have not yet shed their leaves.

The storm, which accounted for up to 1.5 inches of accumulation in some of the outer D.C. suburbs, resulted in few accidents or power outages and was expected to move past the region by late afternoon. But temperatures around the region were hovering around the freezing mark Saturday afternoon and were expected to remain there into Sunday.

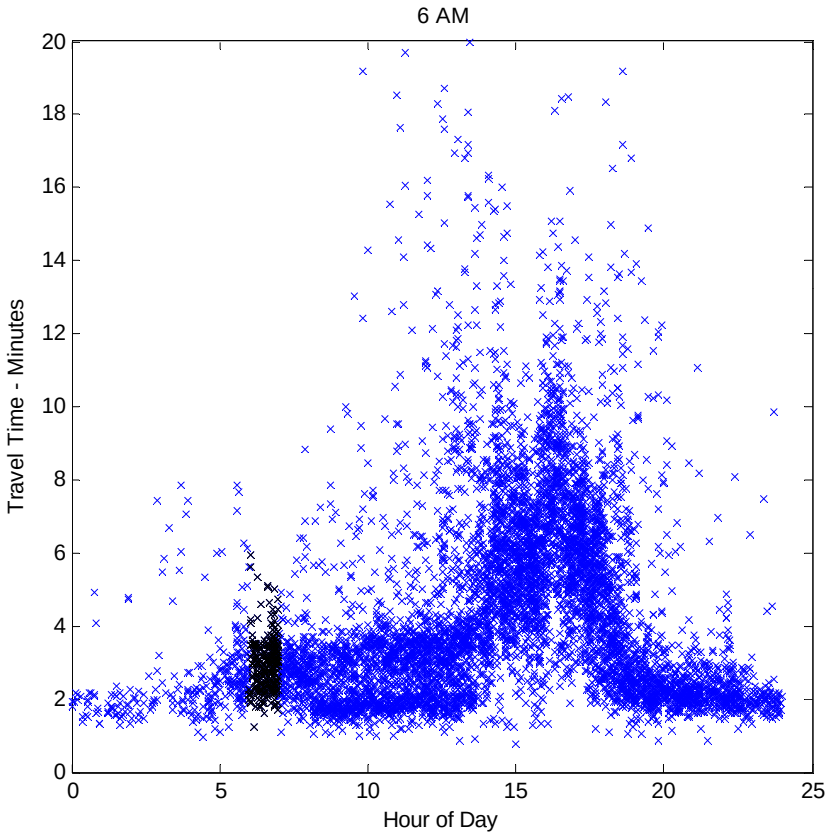


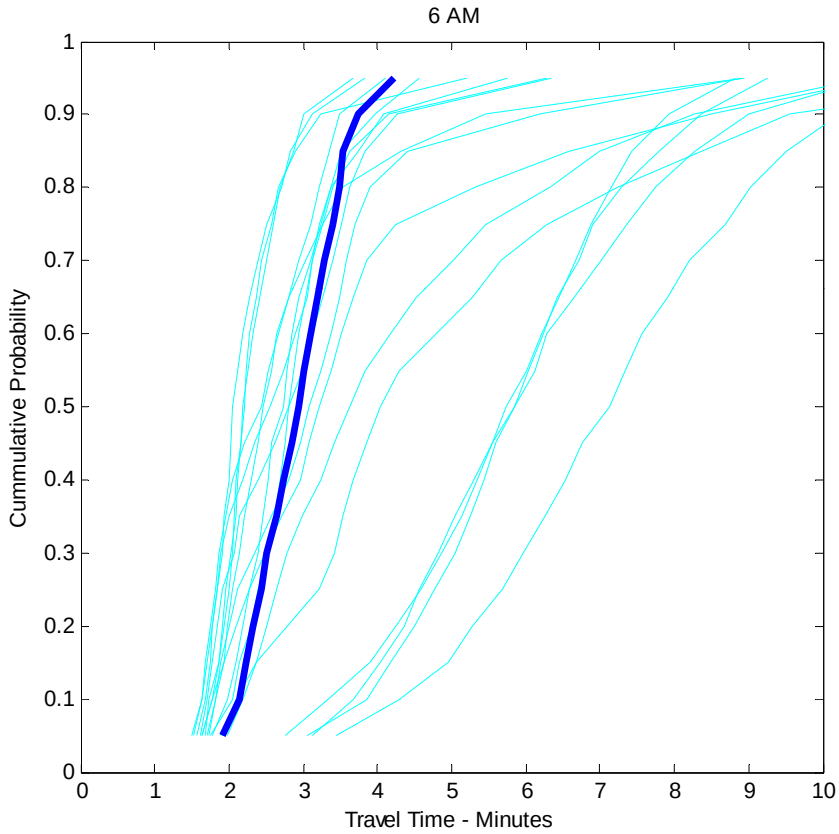
I-95 Corridor Coalition Vehicle Probe Project

Weekday Only

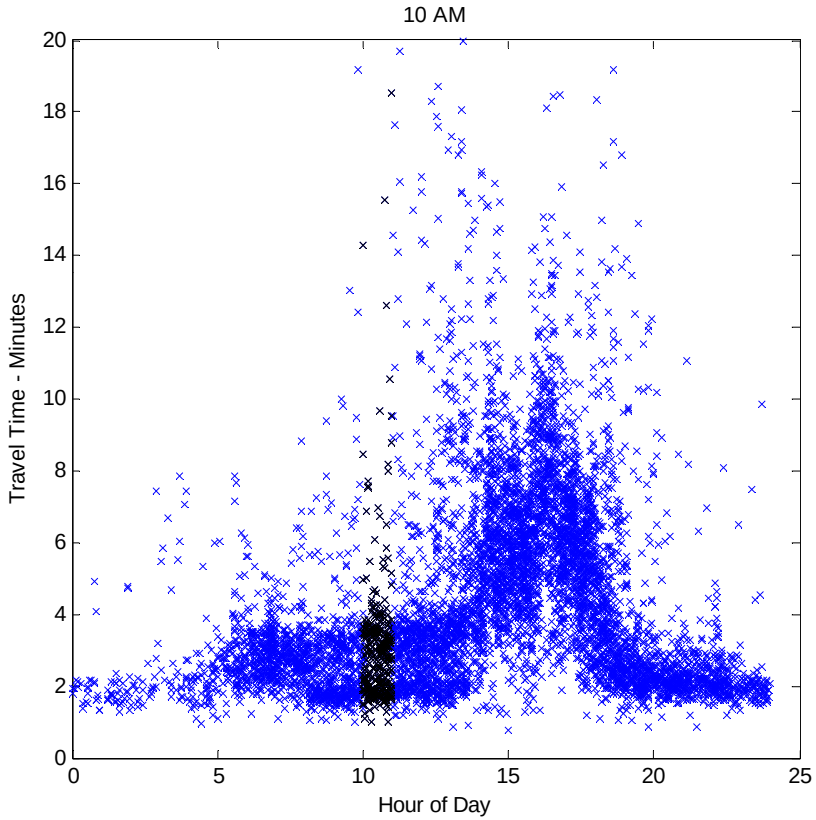


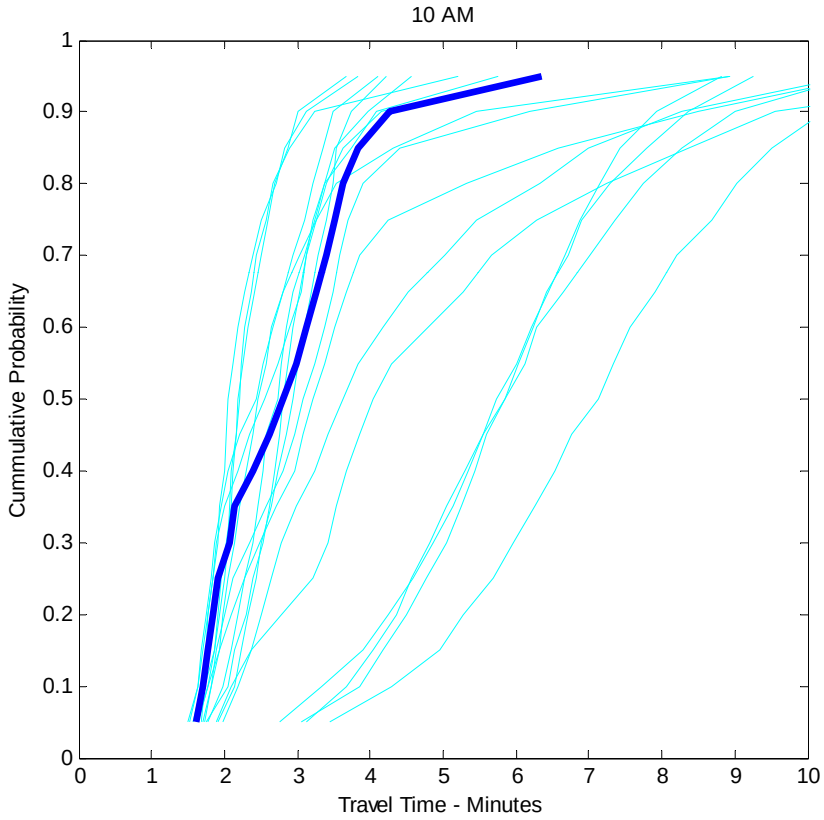
Comparing Hours of Day
6 AM – 7 AM



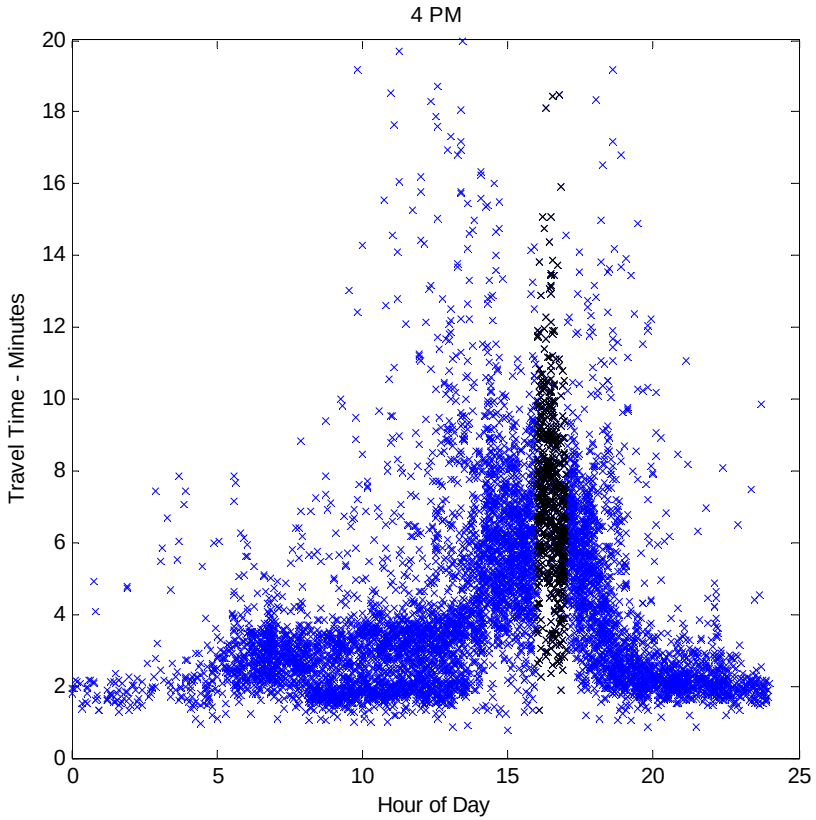


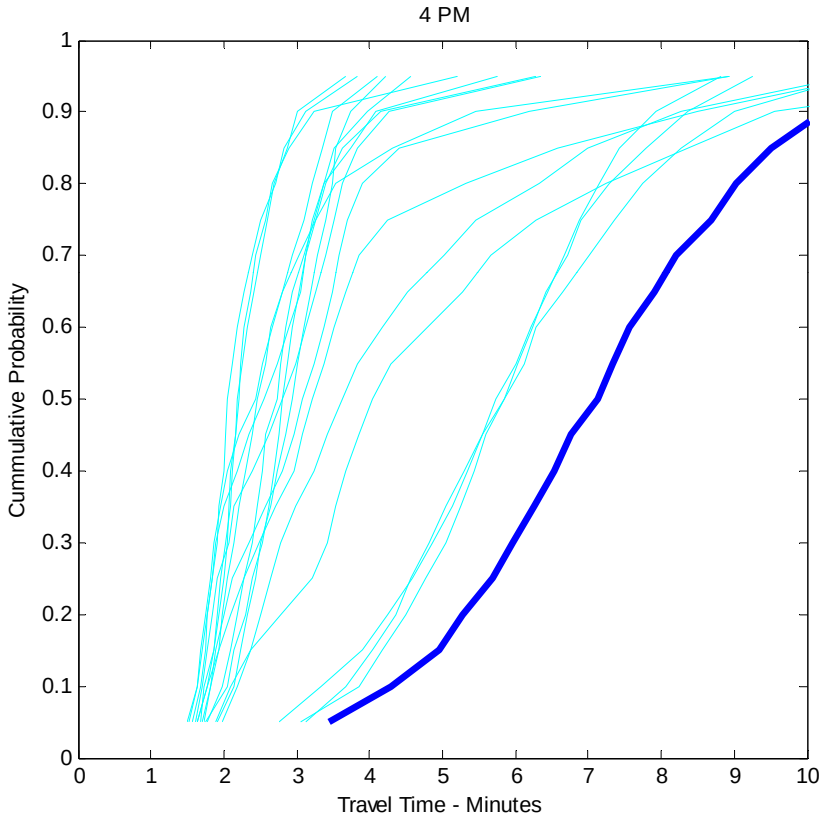
Comparing Hours of Day
10 AM – 11 AM



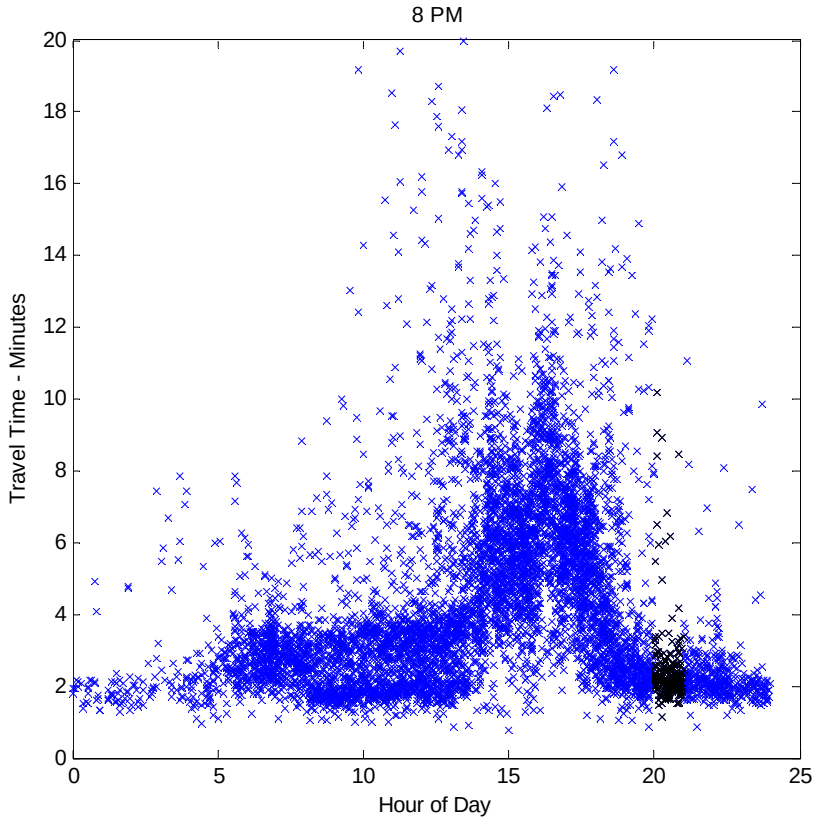


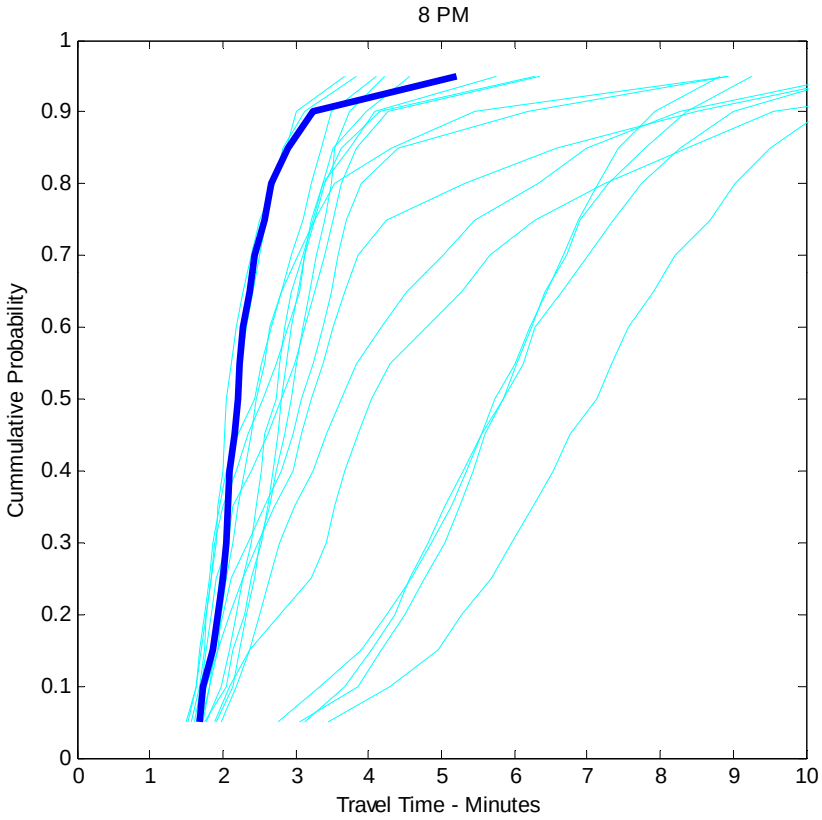
Comparing Hours of Day
4 PM – 5 PM





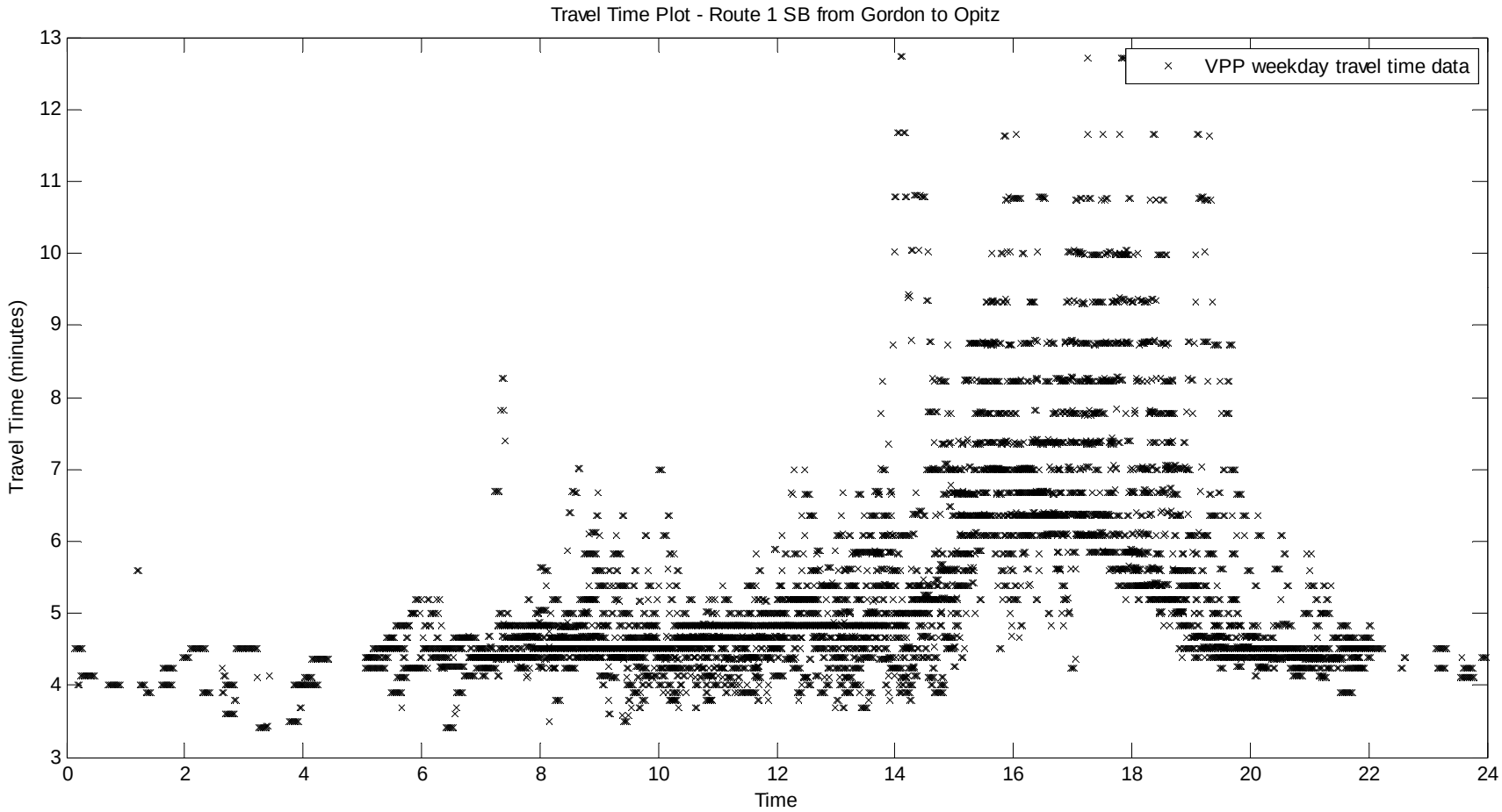
Comparing Hours of Day
8 PM – 9 PM



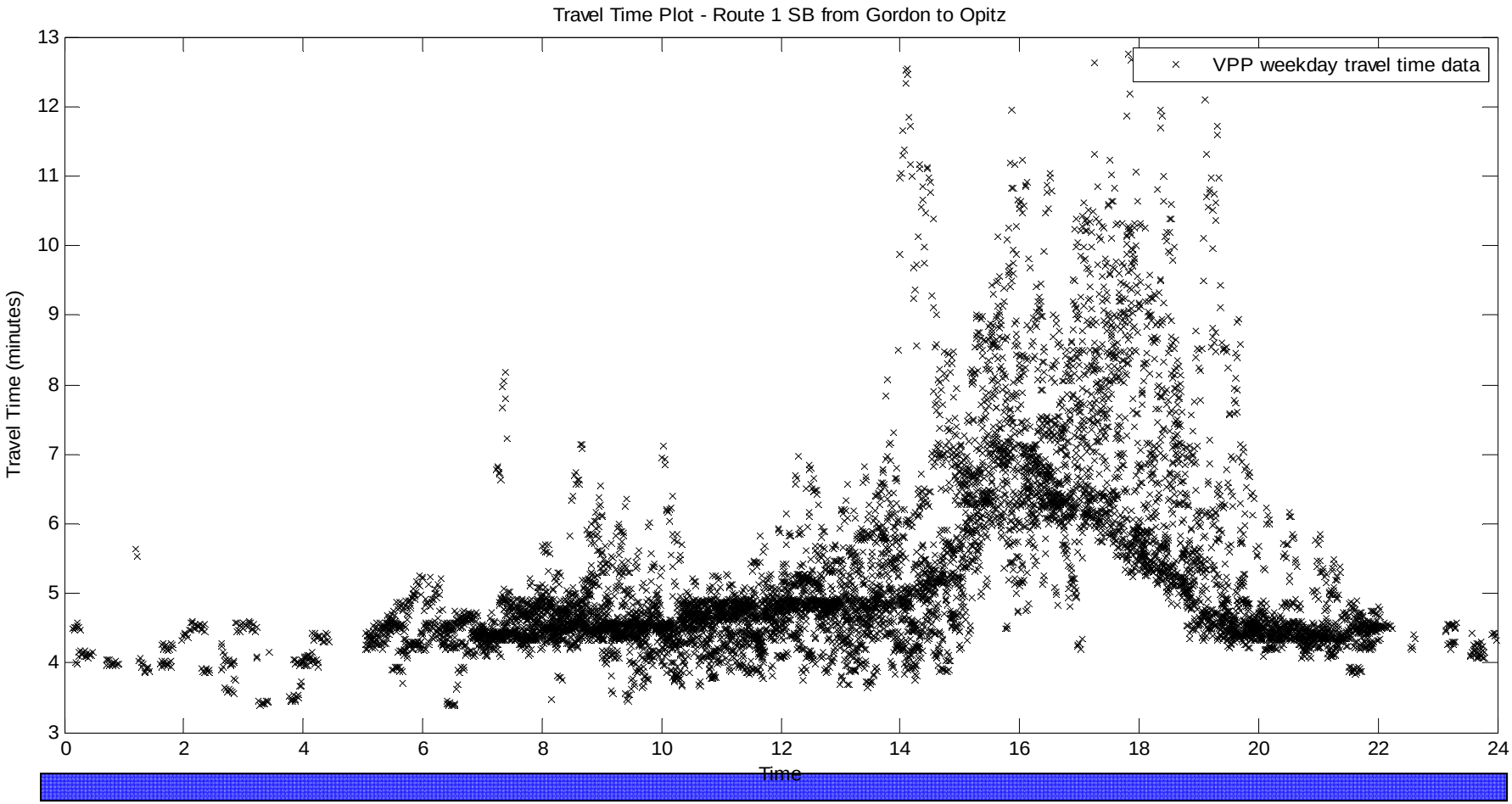


Same methodology can be applied using VPP Data …

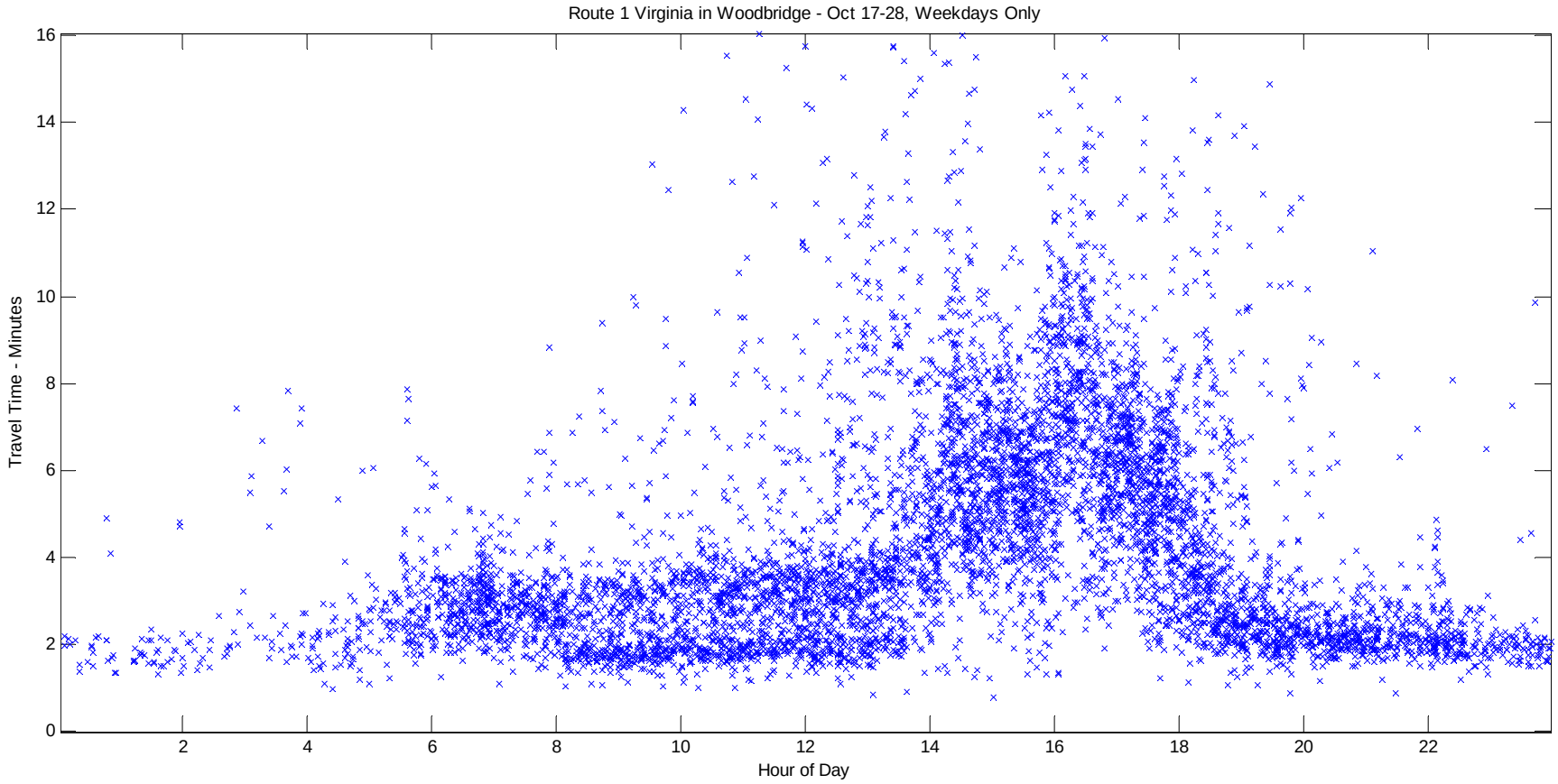
Weekday Only – VPP



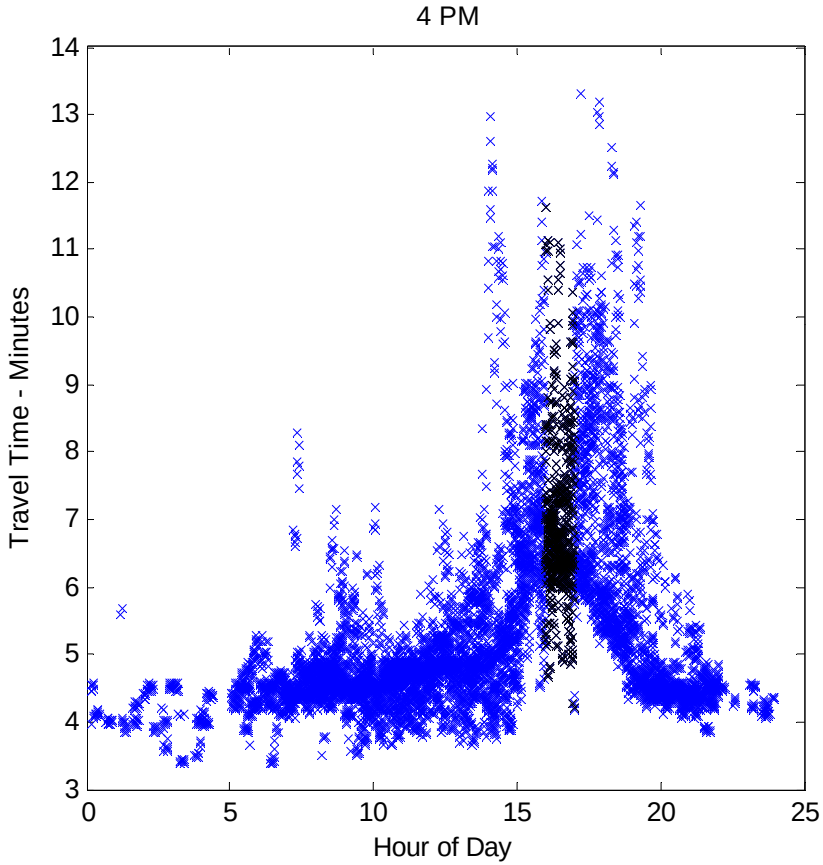
Smooth the data (VPP)…

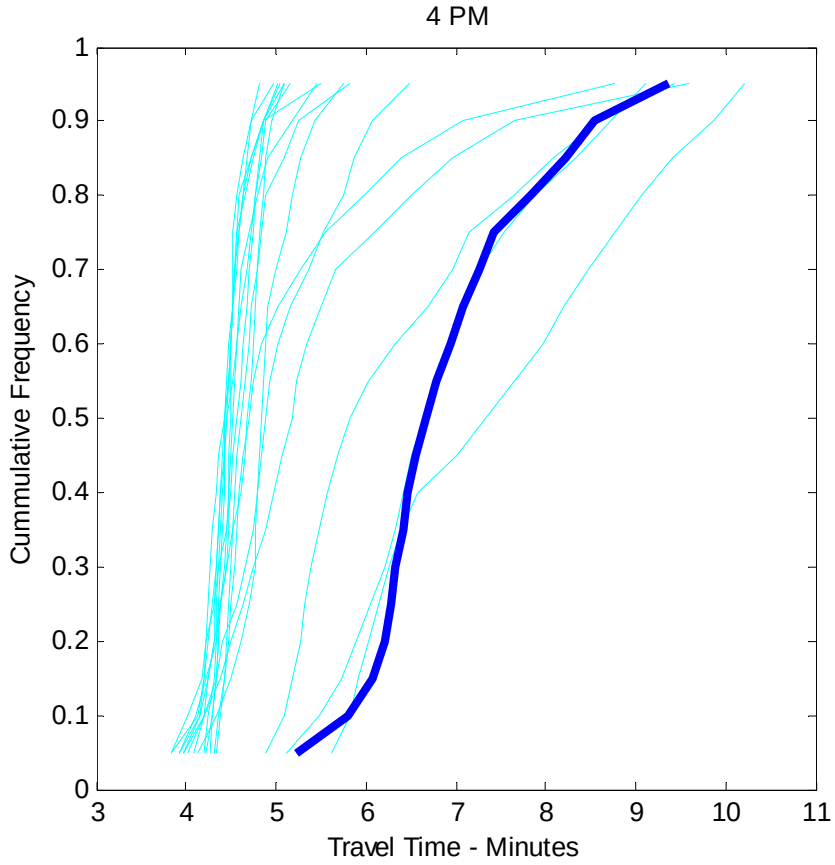


Weekday Only (BTM)



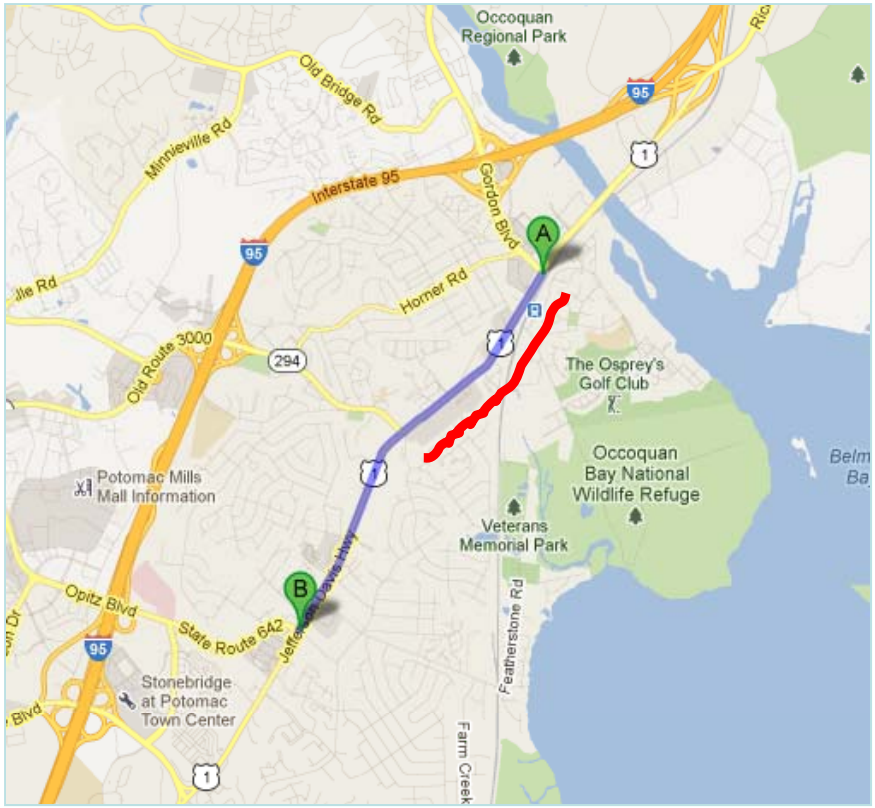
Hourly Comparison
4 PM – 5 PM



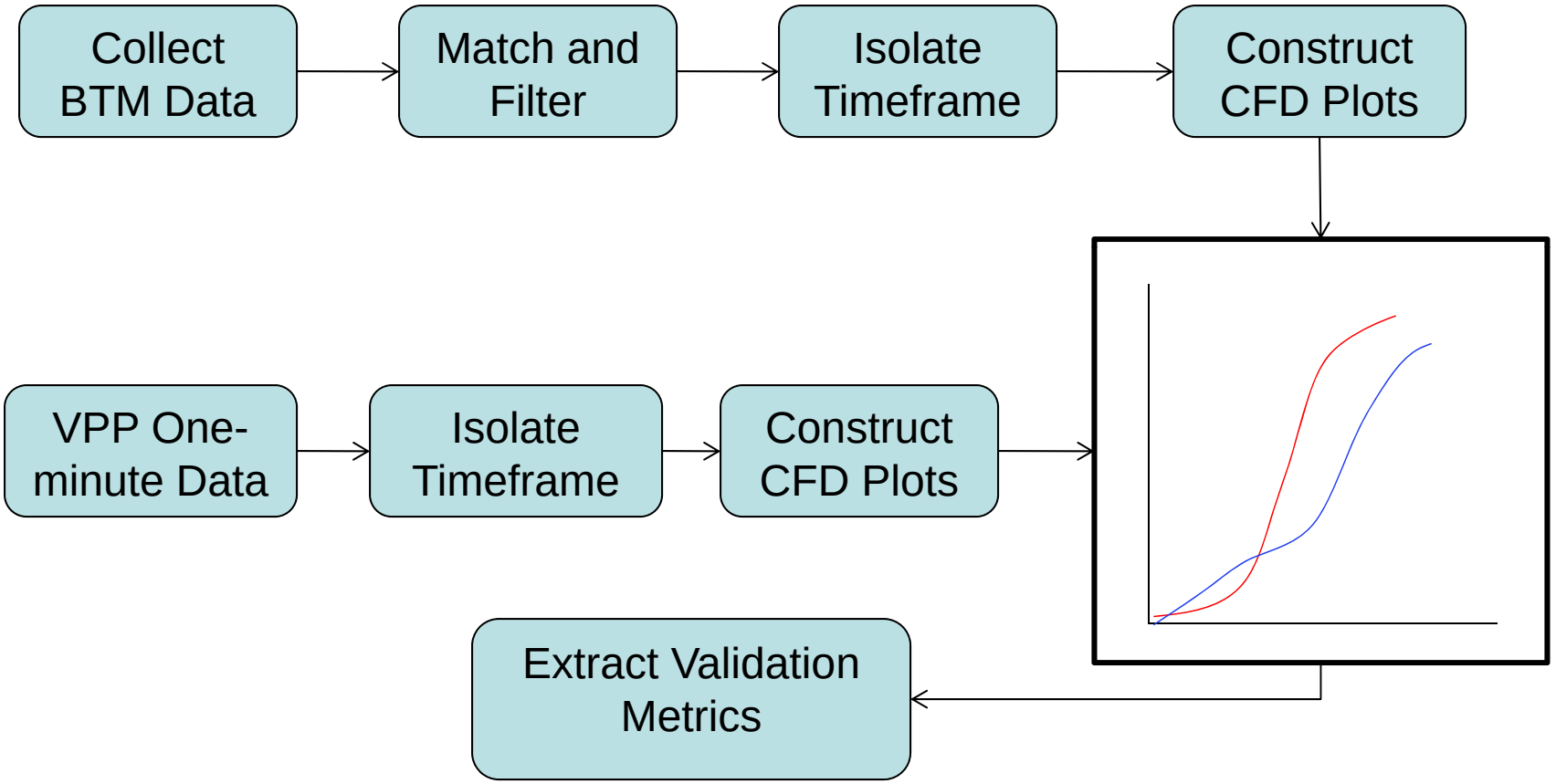


Distribution Analysis with VPP Data

- Base on One-minute VPP data
- Challenges / Issues
  - TMC mis-match
  - No volume data
  - Limited granularity

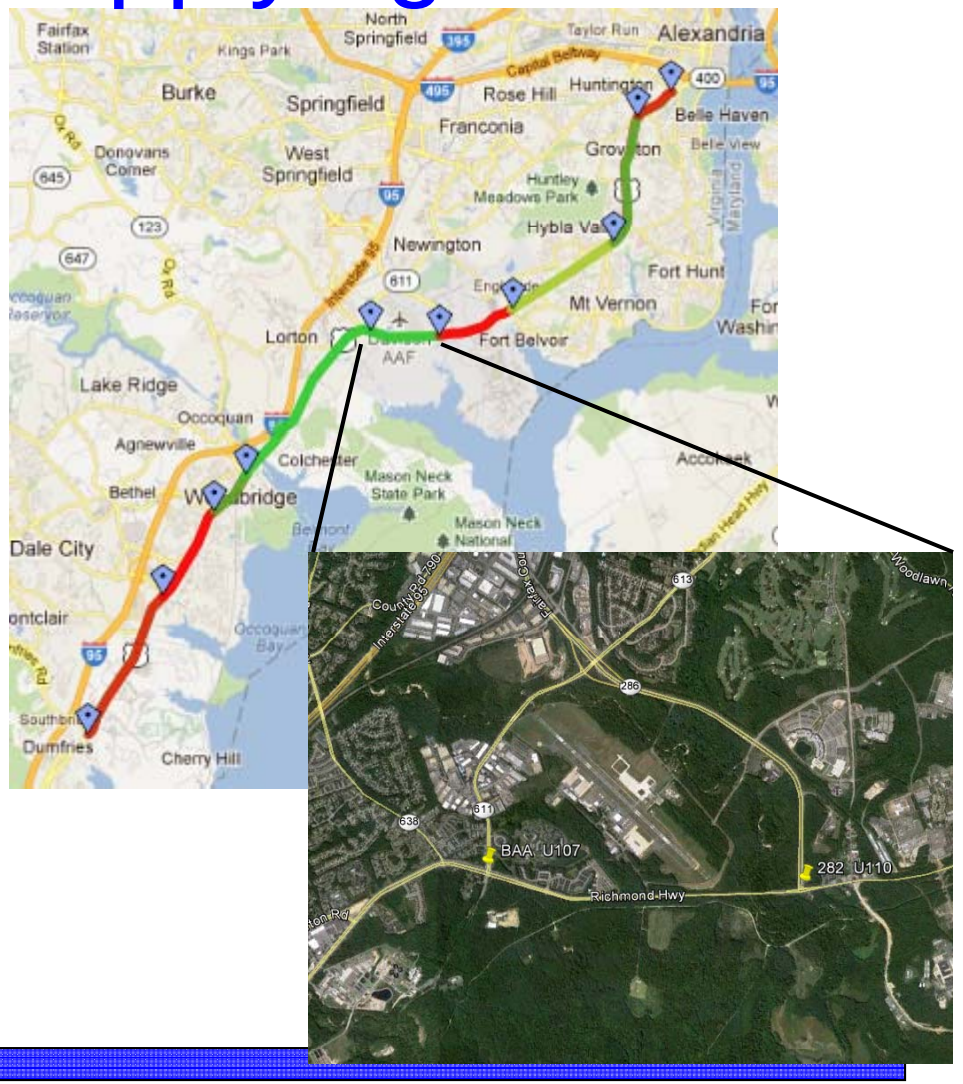


Conceptual Arterial Validation



Case Study – Applying CFDs

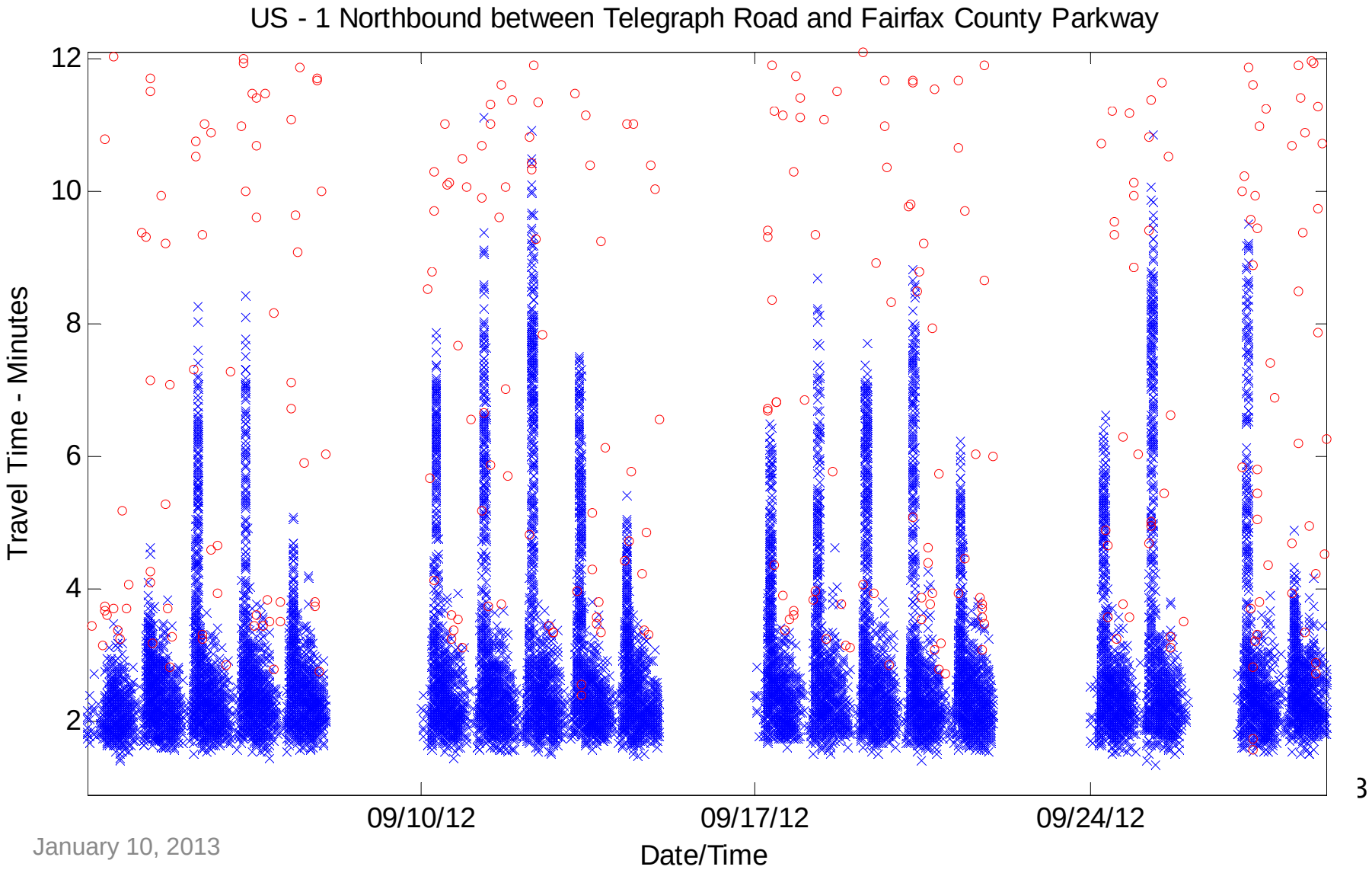
- 1.6 miles
- Route 1
  - Fairfax County Expressway
  - Telegraph Road
- 3 signals
- TMC segments align
- Data
  - Sep 3-30, 2012
  - Weekday only



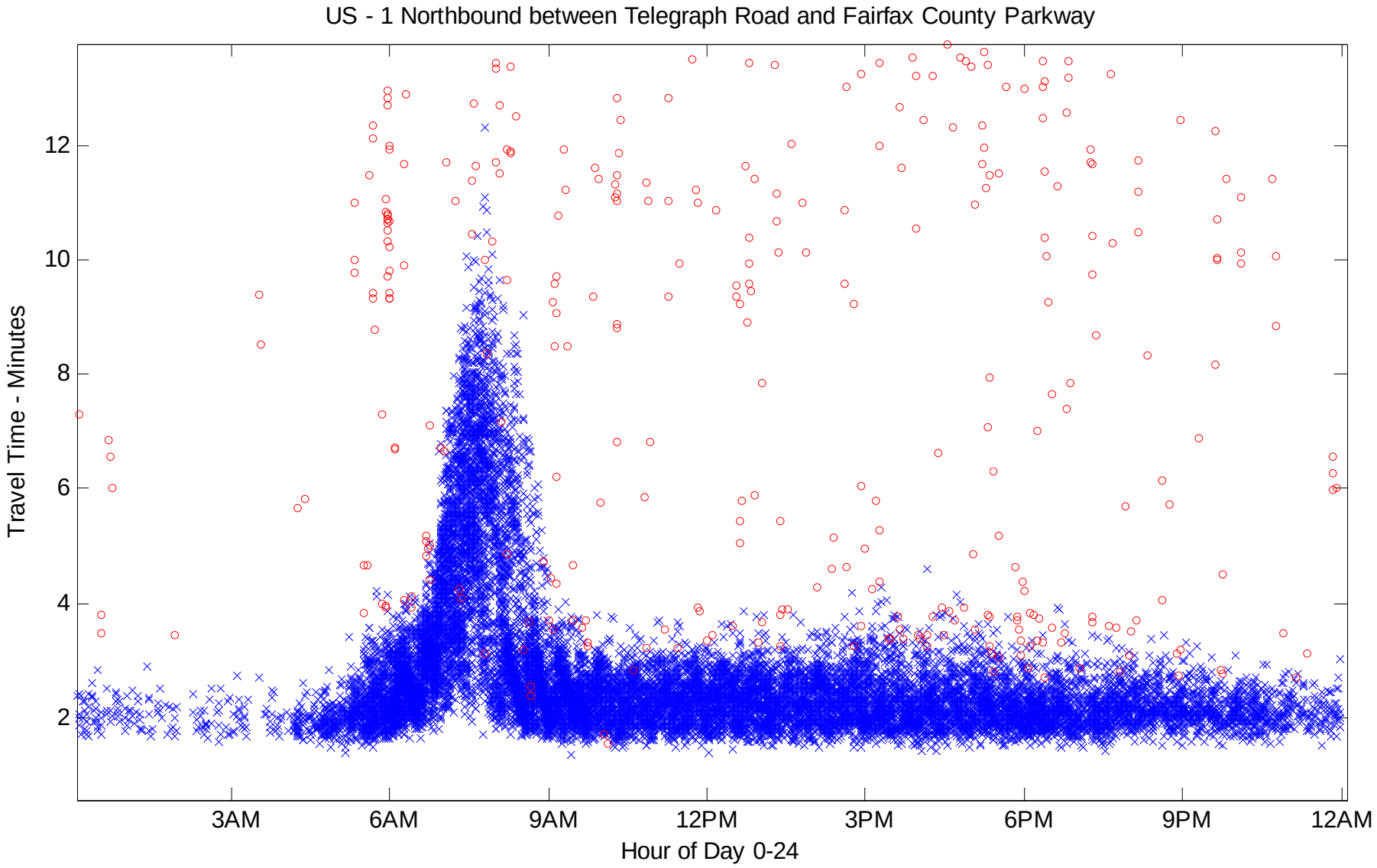
Northbound
US 1, VA

First with Bluetooth Traffic Monitoring

Scatterplot of Weekday BTM Travel Time Data

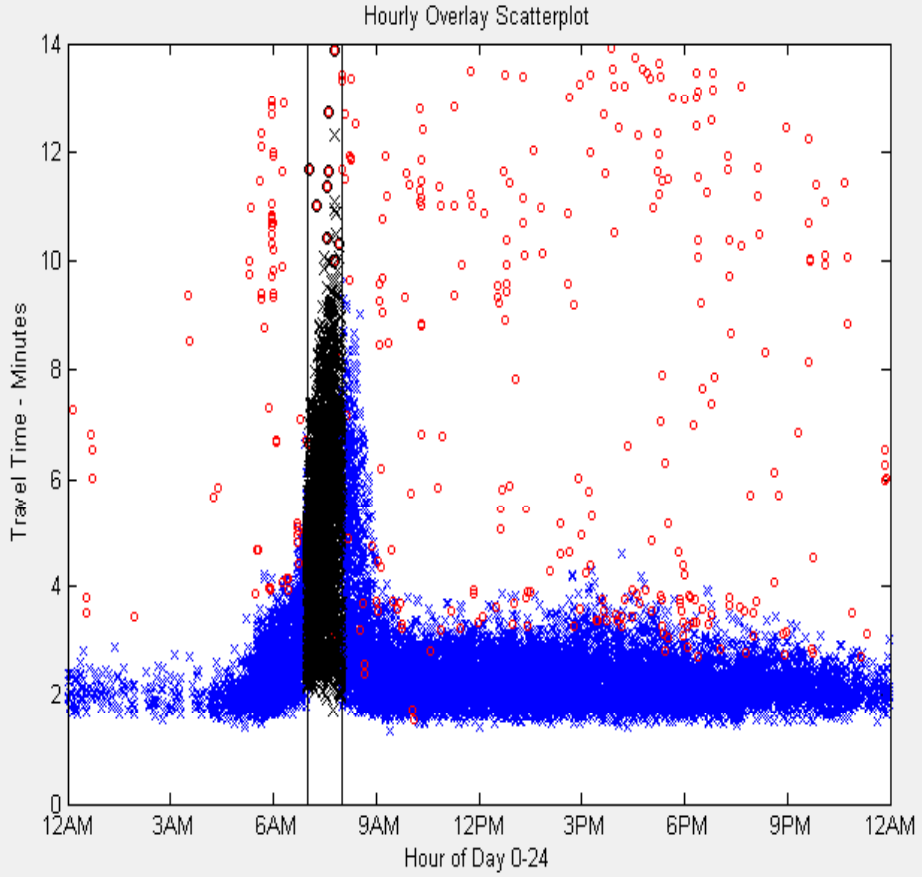


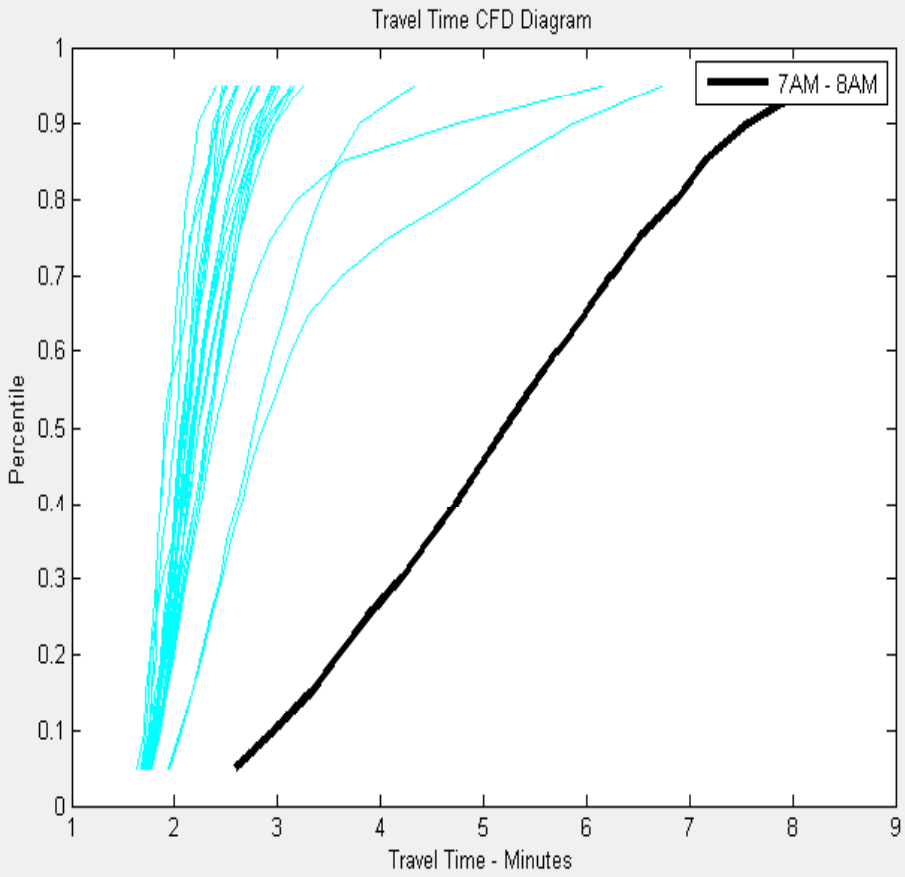
24 Hour Overlay Scatterplot - BTM



January 10, 2013

Family of hourly CFD curves



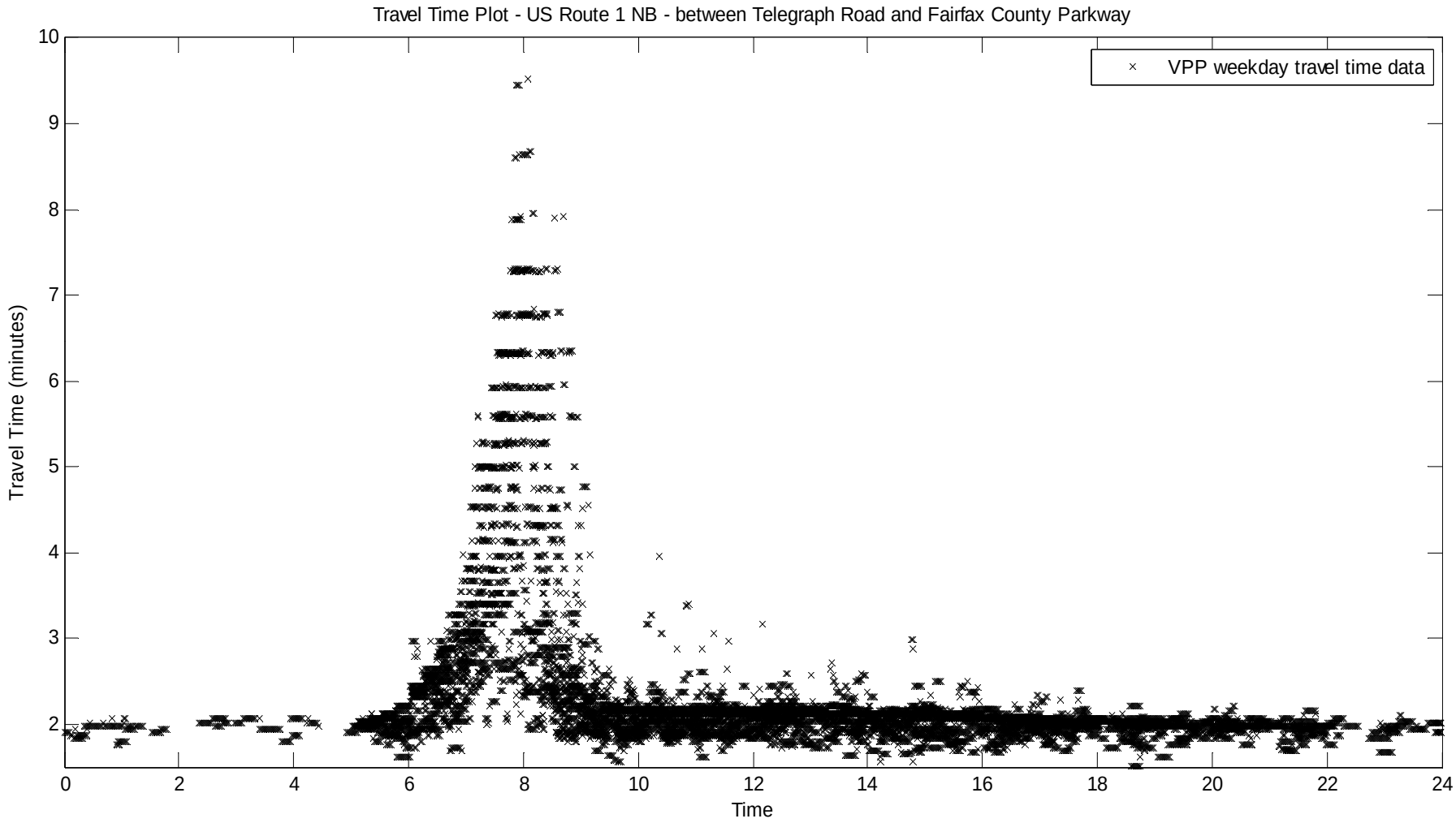


CFD Curve Family - BTM

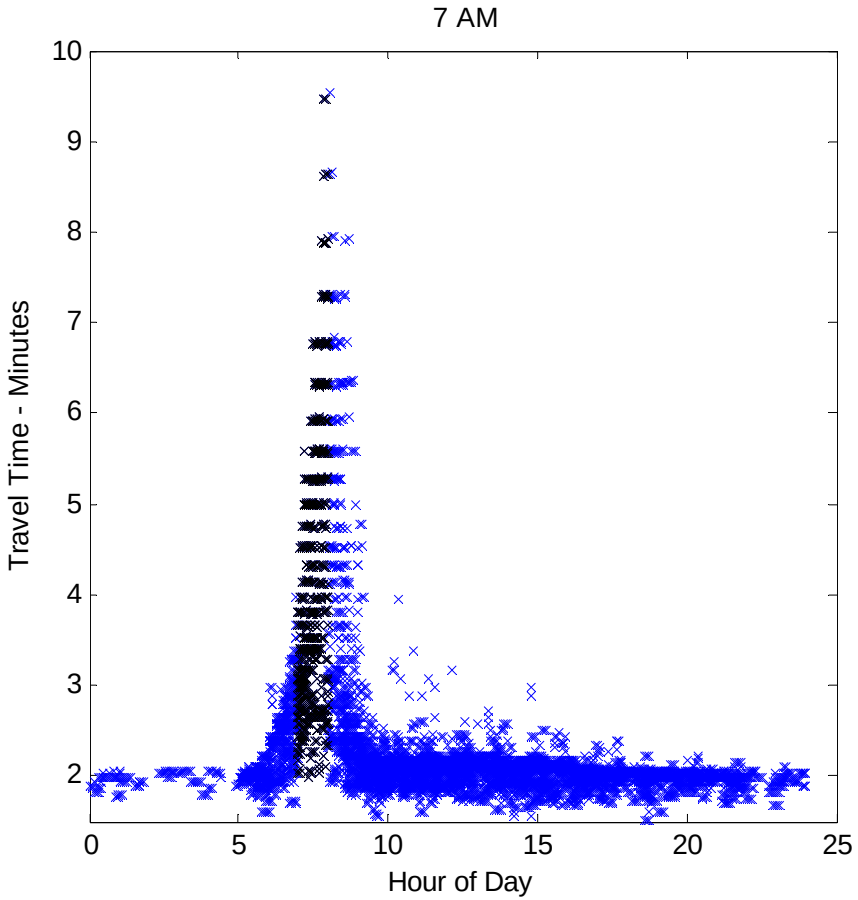
From	To	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
0	1	1.76	1.80	1.84	1.89	1.92	1.93	1.96	1.98	2.02	2.05	2.08	2.12	2.15	2.20	2.30	2.33	2.38	2.42	2.50
1	2	1.75	1.77	1.82	1.85	1.88	1.91	1.95	1.97	2.00	2.03	2.06	2.08	2.12	2.17	2.21	2.25	2.30	2.44	2.57
2	3	1.65	1.72	1.76	1.79	1.82	1.84	1.87	1.89	1.91	1.94	1.97	2.09	2.10	2.14	2.18	2.22	2.31	2.35	2.48
3	4	1.67	1.68	1.78	1.80	1.83	1.87	1.93	1.98	2.03	2.05	2.06	2.07	2.08	2.12	2.15	2.19	2.32	2.40	2.51
4	5	1.68	1.72	1.74	1.77	1.80	1.82	1.84	1.87	1.89	1.93	1.97	1.98	2.01	2.04	2.08	2.11	2.19	2.23	2.42
5	6	1.68	1.77	1.83	1.88	1.93	1.97	2.01	2.06	2.11	2.15	2.20	2.25	2.32	2.40	2.47	2.58	2.70	2.89	3.12
6	7	1.92	2.03	2.12	2.20	2.30	2.38	2.47	2.54	2.64	2.72	2.81	2.92	3.03	3.13	3.24	3.37	3.55	3.78	4.26
7	8	2.11	2.47	2.85	3.25	3.54	3.84	4.19	4.48	4.77	5.03	5.29	5.54	5.83	6.13	6.40	6.75	7.07	7.48	8.10
8	9	1.82	1.93	2.02	2.12	2.23	2.32	2.41	2.52	2.61	2.72	2.85	2.98	3.13	3.37	3.70	4.44	5.06	5.68	6.58
9	10	1.73	1.82	1.87	1.92	1.97	2.01	2.07	2.13	2.19	2.25	2.30	2.37	2.44	2.51	2.58	2.67	2.79	2.93	3.12
10	11	1.70	1.80	1.86	1.91	1.96	2.00	2.05	2.10	2.15	2.22	2.28	2.34	2.41	2.47	2.54	2.63	2.72	2.83	2.99
11	12	1.74	1.82	1.88	1.96	2.03	2.08	2.12	2.18	2.24	2.28	2.33	2.39	2.43	2.50	2.56	2.63	2.72	2.84	3.01
12	13	1.73	1.82	1.89	1.95	2.01	2.07	2.12	2.18	2.23	2.29	2.35	2.41	2.46	2.52	2.58	2.67	2.75	2.84	3.00
13	14	1.73	1.80	1.87	1.92	1.98	2.03	2.08	2.13	2.18	2.23	2.28	2.36	2.42	2.48	2.54	2.63	2.72	2.83	3.02
14	15	1.75	1.85	1.90	1.95	2.00	2.05	2.11	2.17	2.23	2.28	2.33	2.40	2.46	2.53	2.59	2.67	2.76	2.90	3.07
15	16	1.73	1.81	1.87	1.92	1.96	2.00	2.05	2.09	2.13	2.18	2.23	2.29	2.36	2.43	2.54	2.65	2.78	2.96	3.18
16	17	1.71	1.78	1.84	1.89	1.95	2.00	2.03	2.08	2.12	2.17	2.23	2.28	2.34	2.42	2.49	2.60	2.72	2.85	3.13
17	18	1.75	1.82	1.88	1.92	1.97	2.00	2.04	2.09	2.14	2.18	2.22	2.27	2.32	2.37	2.44	2.52	2.63	2.75	2.97
18	19	1.72	1.78	1.83	1.87	1.91	1.95	1.98	2.02	2.06	2.10	2.14	2.18	2.23	2.28	2.32	2.40	2.47	2.61	2.82
19	20	1.70	1.78	1.84	1.88	1.91	1.96	2.00	2.04	2.08	2.13	2.17	2.21	2.24	2.29	2.35	2.41	2.49	2.61	2.78
20	21	1.78	1.84	1.90	1.94	1.99	2.04	2.08	2.11	2.16	2.20	2.23	2.26	2.31	2.37	2.43	2.50	2.58	2.67	2.80
21	22	1.73	1.82	1.89	1.92	1.95	1.98	2.01	2.04	2.06	2.10	2.13	2.17	2.20	2.27	2.32	2.39	2.45	2.52	2.68
22	23	1.72	1.79	1.85	1.90	1.93	1.96	1.99	2.02	2.04	2.07	2.11	2.14	2.19	2.23	2.29	2.37	2.43	2.50	2.61
23	24	1.78	1.82	1.88	1.93	1.95	1.99	2.03	2.05	2.08	2.12	2.15	2.19	2.22	2.25	2.30	2.35	2.42	2.49	2.61

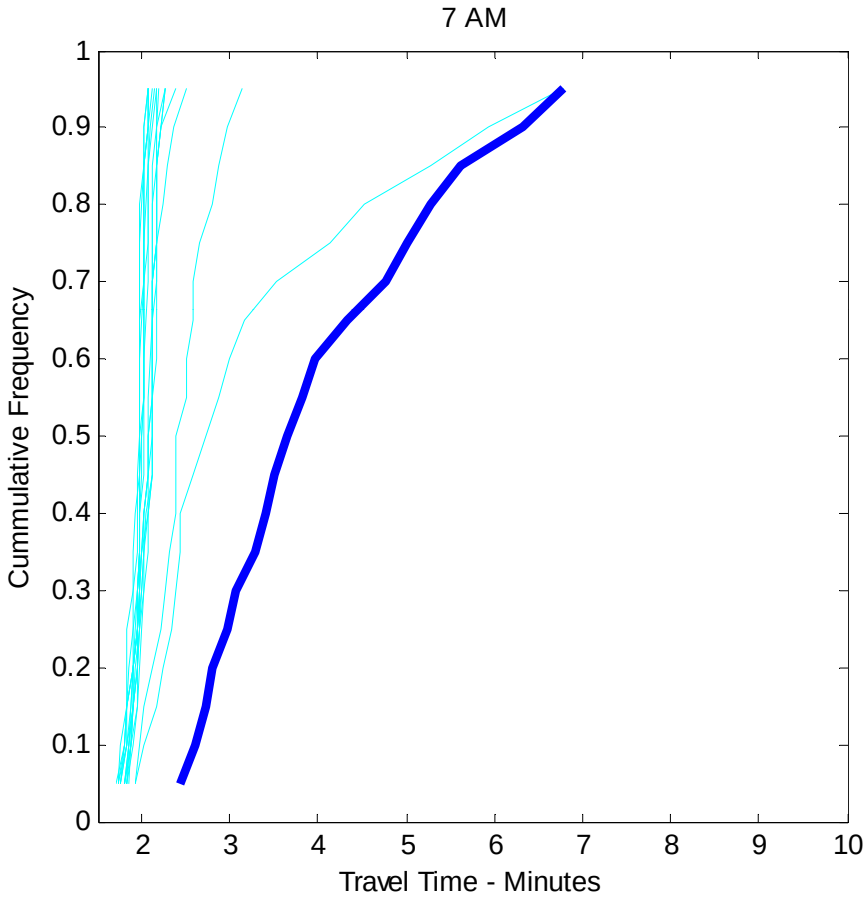
Next, Repeat with VPP Data

NB – BTM Weekday 24 Hour Scatterplot



Family of hourly CFD curves - VPP





CFD Curve Family - VPP

From	To	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
0	1	1.79	1.83	1.83	1.83	1.86	1.86	1.86	1.90	1.90	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98
1	2	1.79	1.79	1.90	1.90	1.90	1.94	1.94	1.94	1.94	1.94	1.94	1.94	1.98	1.98	1.98	1.98	1.98	1.98	2.02
2	3	1.98	1.98	1.98	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.07	2.07	2.07	2.07	2.07	2.07
3	4	1.79	1.79	1.79	1.86	1.94	1.94	1.94	1.94	1.94	1.94	1.94	2.02	2.02	2.04	2.07	2.07	2.07	2.07	2.07
4	5	1.86	1.86	1.86	1.88	1.90	1.90	1.90	2.00	2.02	2.02	2.02	2.02	2.02	2.02	2.07	2.07	2.07	2.07	2.07
5	6	1.79	1.86	1.87	1.90	1.94	1.98	1.98	1.98	1.98	1.98	2.02	2.02	2.03	2.03	2.07	2.07	2.07	2.11	2.16
6	7	1.94	1.98	2.03	2.12	2.21	2.26	2.32	2.38	2.38	2.39	2.50	2.51	2.57	2.58	2.65	2.79	2.88	2.97	3.13
7	8	2.44	2.60	2.72	2.80	2.98	3.07	3.28	3.39	3.50	3.66	3.81	3.97	4.33	4.76	5.00	5.29	5.61	6.32	6.77
8	9	1.93	2.02	2.17	2.24	2.33	2.38	2.43	2.44	2.58	2.72	2.88	2.99	3.16	3.52	4.13	4.52	5.28	5.94	6.78
9	10	1.83	1.87	1.90	1.91	1.94	1.98	1.99	2.03	2.07	2.11	2.12	2.16	2.17	2.17	2.18	2.23	2.29	2.37	2.51
10	11	1.86	1.87	1.90	1.94	1.95	1.99	2.02	2.03	2.07	2.08	2.12	2.12	2.12	2.12	2.16	2.17	2.17	2.22	2.38
11	12	1.83	1.86	1.90	1.94	1.98	1.99	2.03	2.04	2.11	2.12	2.12	2.12	2.12	2.13	2.16	2.17	2.17	2.18	2.26
12	13	1.79	1.87	1.94	1.98	1.99	2.03	2.07	2.08	2.11	2.12	2.12	2.12	2.13	2.17	2.17	2.17	2.17	2.21	2.27
13	14	1.79	1.84	1.90	1.94	1.99	2.02	2.03	2.07	2.11	2.12	2.12	2.12	2.12	2.12	2.17	2.17	2.17	2.22	2.27
14	15	1.73	1.83	1.87	1.91	1.95	1.98	1.99	2.03	2.07	2.07	2.11	2.12	2.12	2.12	2.12	2.12	2.16	2.16	2.17
15	16	1.76	1.80	1.84	1.91	1.93	1.95	2.00	2.07	2.07	2.07	2.07	2.11	2.11	2.12	2.12	2.12	2.13	2.16	2.18
16	17	1.76	1.83	1.90	1.90	1.94	1.94	1.98	1.98	2.02	2.02	2.02	2.03	2.04	2.07	2.07	2.07	2.08	2.09	2.14
17	18	1.79	1.87	1.90	1.94	1.98	1.98	1.98	1.98	1.99	1.99	2.02	2.02	2.02	2.03	2.03	2.04	2.07	2.07	2.11
18	19	1.73	1.79	1.83	1.90	1.94	1.95	1.98	1.98	1.98	1.99	2.02	2.02	2.02	2.02	2.03	2.03	2.03	2.07	2.07
19	20	1.76	1.83	1.84	1.90	1.90	1.94	1.98	1.98	1.98	1.98	1.98	1.98	1.99	2.02	2.02	2.02	2.03	2.07	2.07
20	21	1.83	1.90	1.94	1.94	1.94	1.94	1.98	1.98	1.98	1.98	1.98	1.98	1.98	2.02	2.02	2.02	2.03	2.07	2.07
21	22	1.70	1.79	1.83	1.86	1.90	1.91	1.94	1.94	1.94	1.98	1.98	1.98	1.98	1.98	1.98	1.98	2.02	2.02	2.07
22	23	1.74	1.76	1.83	1.83	1.83	1.90	1.90	1.92	1.98	1.98	1.98	1.98	1.98	1.98	1.98	2.00	2.02	2.02	2.07
23	24	1.67	1.90	1.90	1.90	1.90	1.94	1.94	1.94	1.94	1.94	1.98	1.98	1.98	1.98	2.02	2.02	2.02	2.02	2.02

Calculation of PM from CFDs

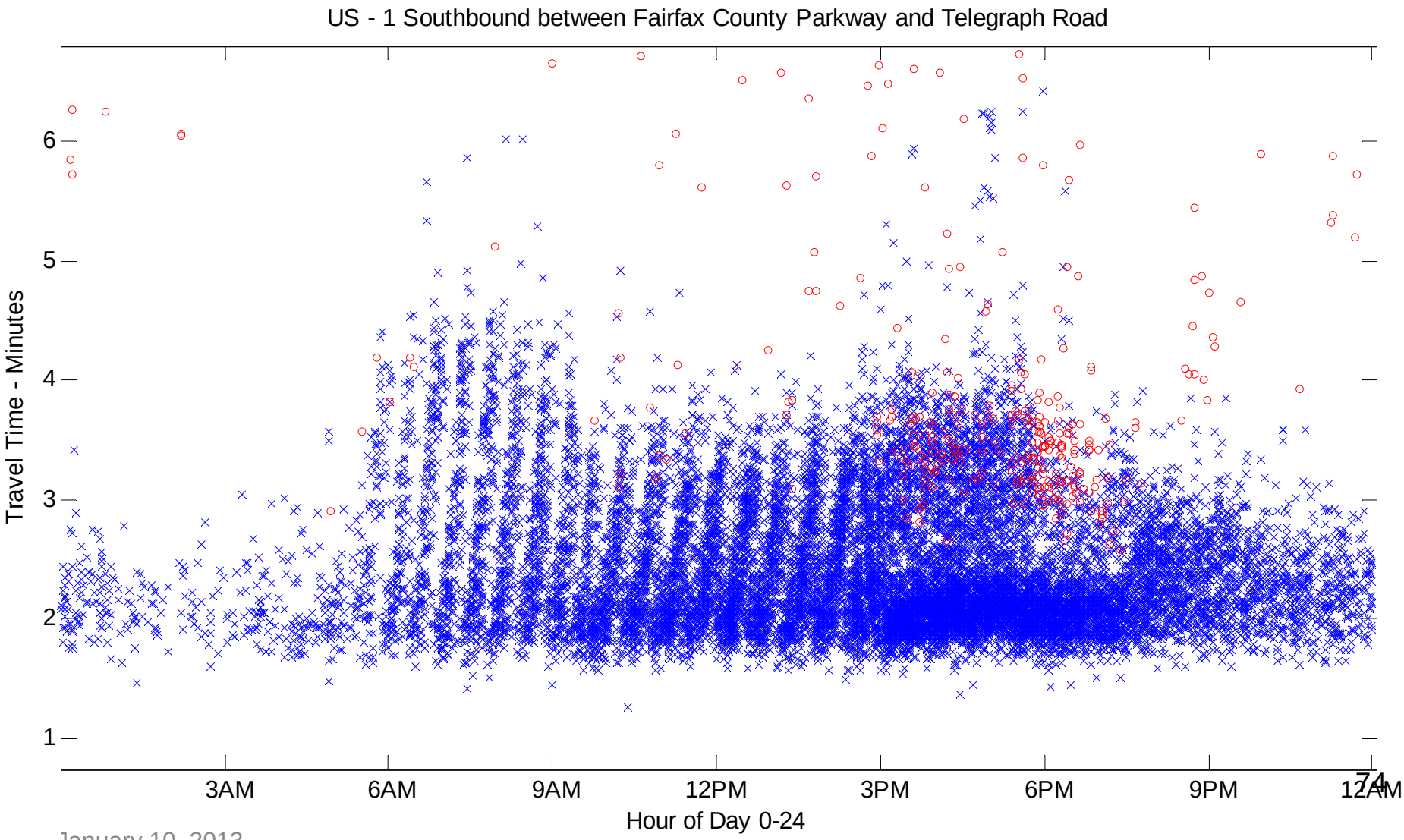
- Travel Time Index
  - Average / Freeflow P50 / P15
- Planning Time Index
  - 95th PCT / Freeflow P95 / P15
- Buffer Index
  - Extra time above average (P95 – P50)/P50
- Inter-Quartile Range
  - 75th PCT – 25th PCT P75 – P25

Direct Comparison of PM - NB

From	To	Travel Time Index		Planning Time Index		Buffer Index		Inter Quartile Range	
		VPP	BTM	VPP	BTM	VPP	BTM	VPP	BTM
6	7	1.18	1.29	1.54	2.01	0.31	0.56	0.44	0.94
7	8	1.34	1.77	2.49	2.84	0.85	0.61	2.02	2.86
8	9	1.25	1.34	3.13	3.25	1.49	1.42	1.80	1.47
9	10	1.11	1.21	1.32	1.67	0.19	0.39	0.23	0.61
10	11	1.09	1.19	1.25	1.61	0.14	0.35	0.22	0.58
11	12	1.11	1.21	1.19	1.60	0.07	0.32	0.19	0.53
12	13	1.09	1.21	1.17	1.58	0.07	0.31	0.17	0.57
13	14	1.11	1.20	1.19	1.62	0.07	0.35	0.18	0.56
14	15	1.11	1.20	1.16	1.62	0.05	0.35	0.17	0.59
15	16	1.13	1.16	1.19	1.70	0.05	0.46	0.19	0.58
16	17	1.07	1.18	1.13	1.70	0.06	0.44	0.13	0.54
17	18	1.05	1.16	1.11	1.58	0.06	0.36	0.06	0.47
18	19	1.09	1.15	1.13	1.54	0.04	0.34	0.09	0.42
19	20	1.08	1.16	1.12	1.51	0.04	0.31	0.12	0.44
0	24	1.09	1.21	2.08	2.96	0.91	1.44	0.19	0.77

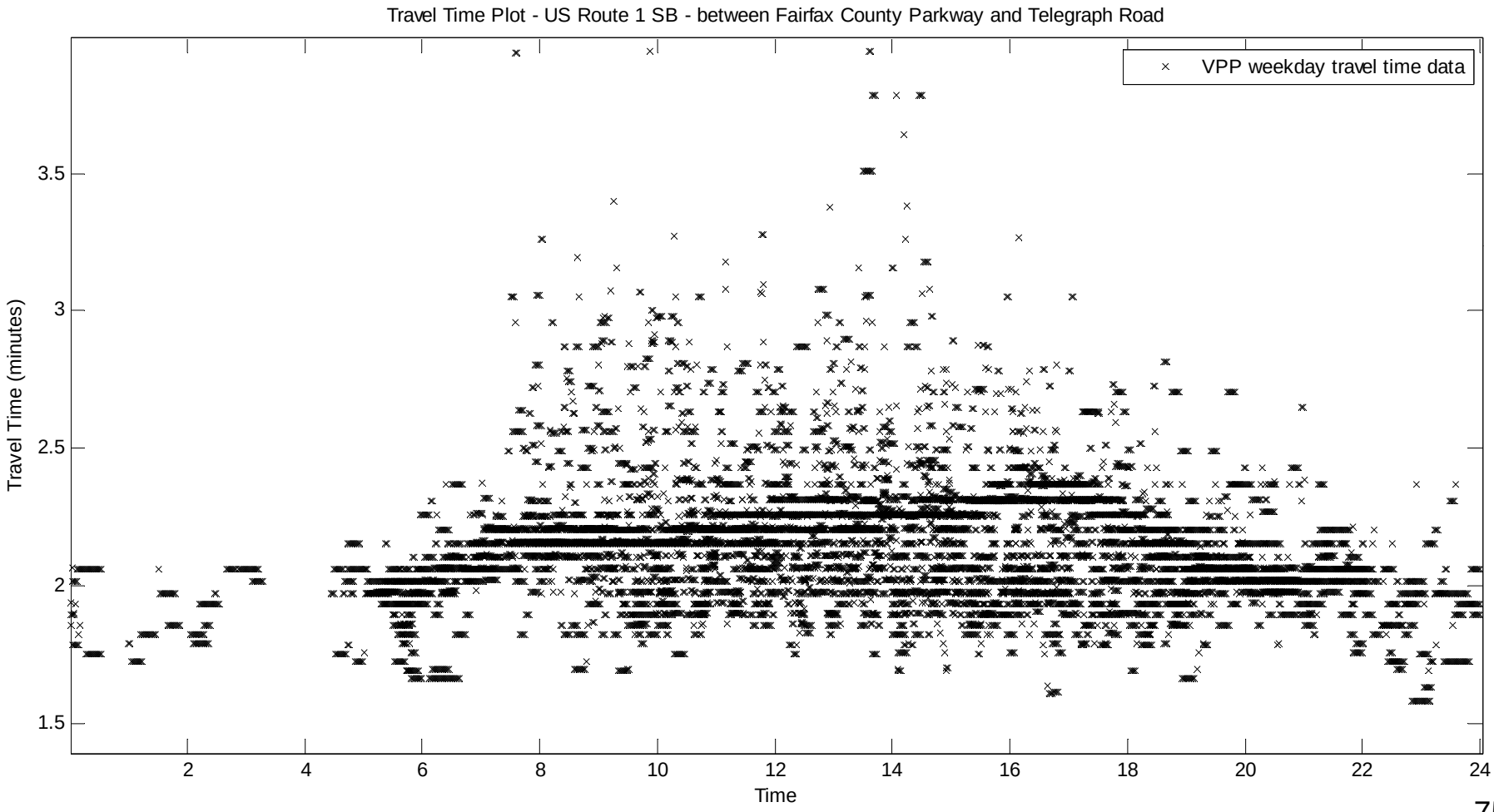
Southbound
US 1, VA

24 Hour Overlay Scatterplot - BTM

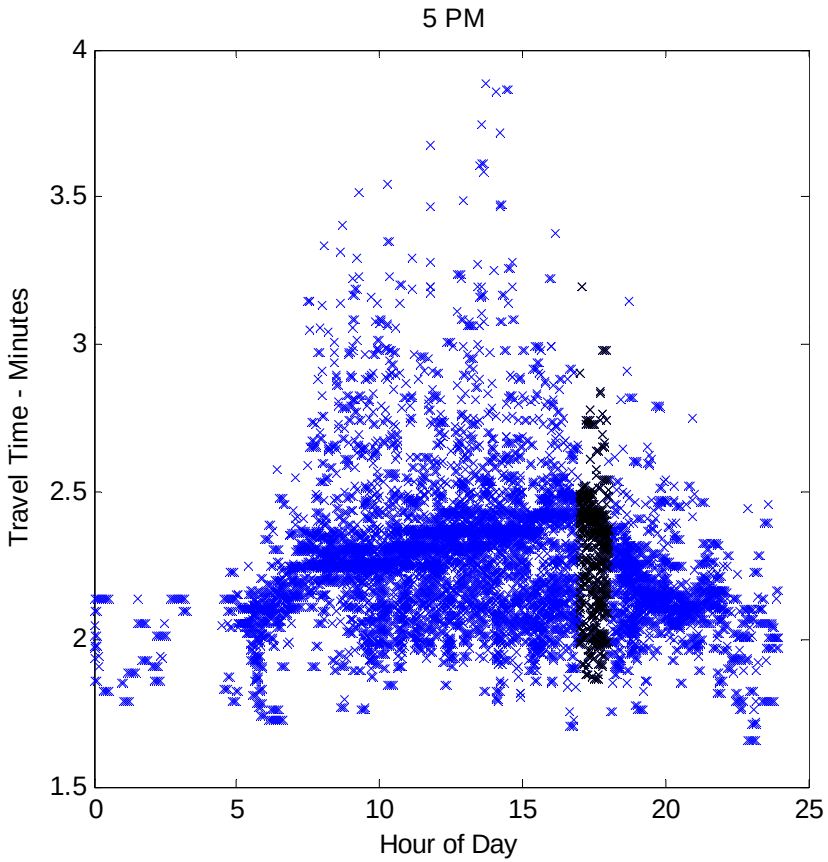


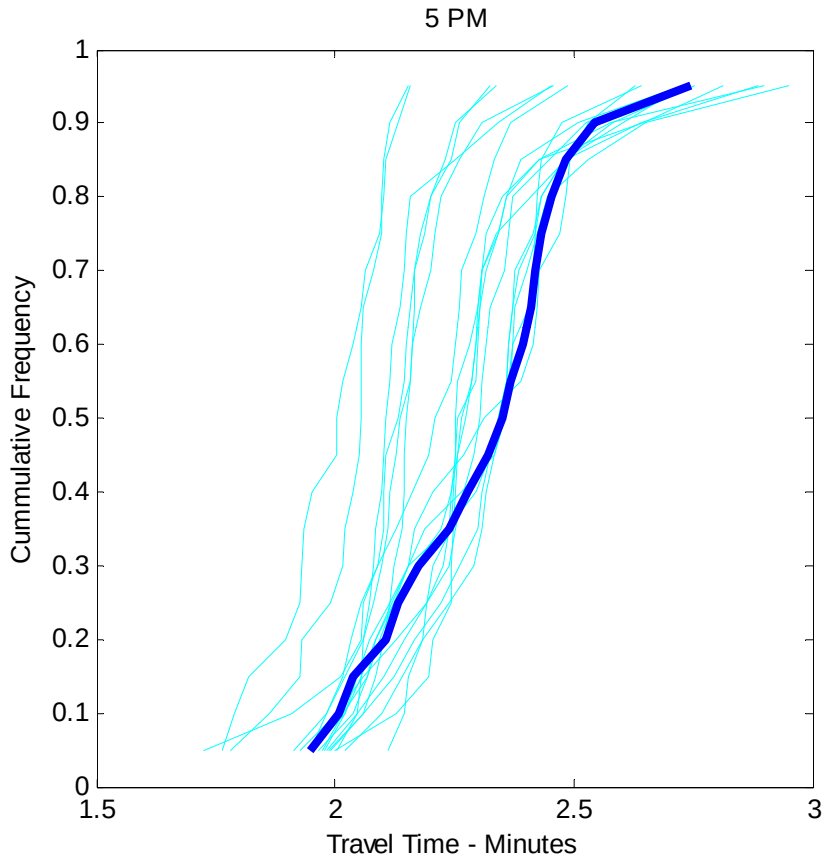
January 10, 2013

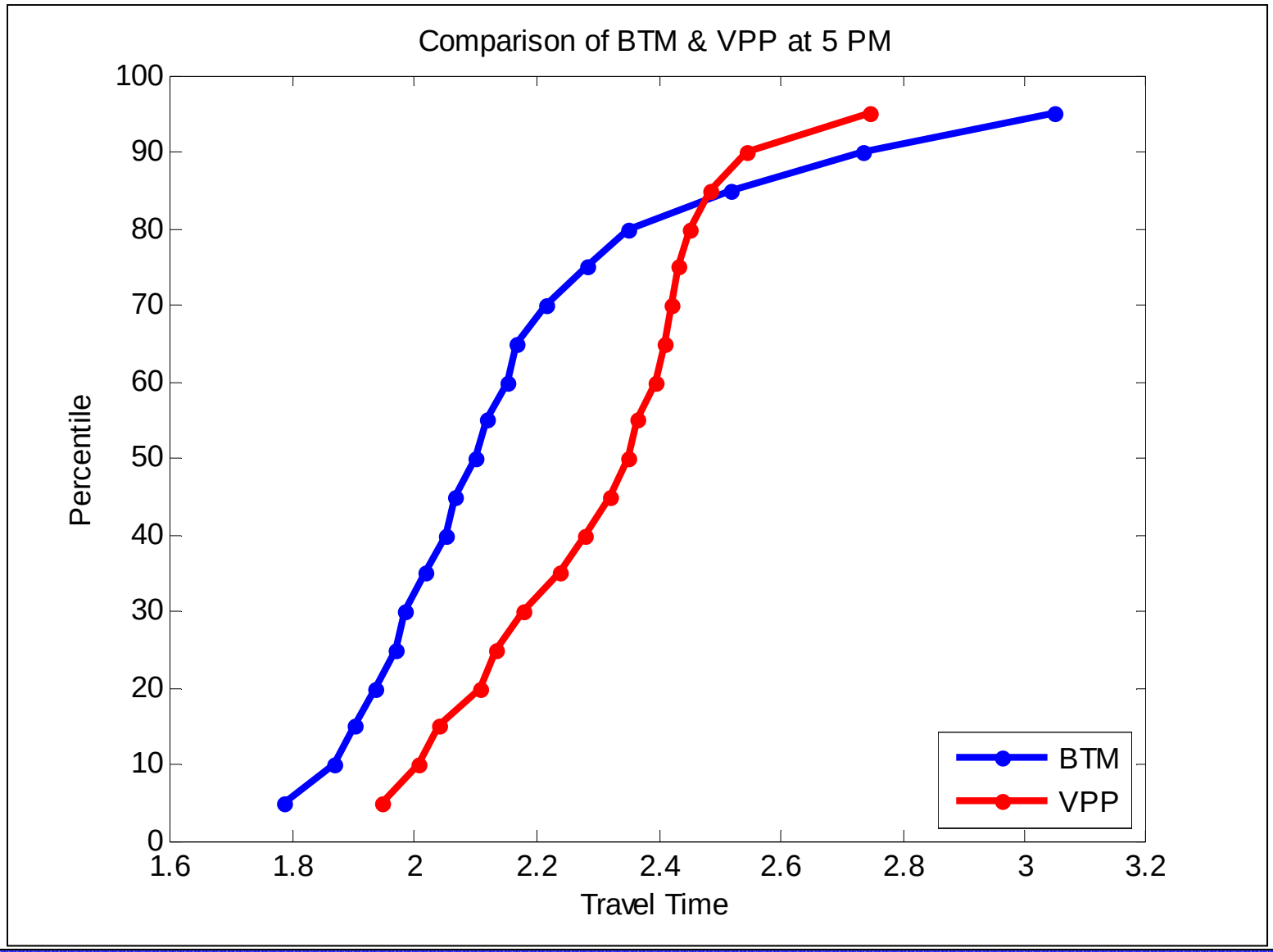
24 Hour Overlay Scatterplot – VPP



Family of hourly CFD curves - VPP






Comparison of BTM & VPP at 5 PM
Percentile
Travel Time
100
90
80
70
60
50
40
30
20
10
0
1.6
1.8
2
2.2
2.4
2.6
2.8
3
3.2
BTM
VPP

Direct Comparison of PM - SB

From	To	Travel Time Index		Planning Time Index		Buffer Index		Inter Quartile Range	
		VPP	BTM	VPP	BTM	VPP	BTM	VPP	BTM
5	6	1.08	1.19	1.13	1.99	0.04	0.68	0.12	0.78
6	7	1.06	1.24	1.17	2.16	0.10	0.74	0.13	1.15
7	8	1.05	1.23	1.25	2.17	0.20	0.77	0.10	1.08
8	9	1.03	1.25	1.26	2.05	0.23	0.64	0.08	0.97
9	10	1.09	1.18	1.42	1.90	0.30	0.62	0.14	0.82
10	11	1.11	1.19	1.43	1.74	0.29	0.46	0.19	0.72
11	12	1.11	1.20	1.33	1.71	0.19	0.43	0.17	0.75
12	13	1.12	1.18	1.30	1.73	0.17	0.46	0.20	0.73
13	14	1.12	1.22	1.34	1.74	0.20	0.43	0.20	0.78
14	15	1.14	1.21	1.33	1.77	0.17	0.46	0.26	0.80
15	16	1.17	1.15	1.31	1.85	0.13	0.61	0.30	0.80
16	17	1.12	1.14	1.26	1.82	0.13	0.60	0.38	0.77
17	18	1.17	1.12	1.36	1.91	0.17	0.71	0.29	0.70
18	19	1.09	1.11	1.23	1.62	0.12	0.46	0.27	0.37
19	20	1.02	1.15	1.16	1.63	0.13	0.42	0.09	0.53

Summary

- Arterial performance measures / validation are intrinsically linked
- Sampled distributions (Histograms and CFDs) form basis of analysis
- Incorporates and extends Freeway PM using functions over CFD
- Provides path to quantify effectiveness of VPP for arterial PM

Moving Forward

- Complete Case Studies with CFD analysis
- Develop distribution analysis tools for use with VPP Archive data
- Target and emphasize additional arterial validation
- Extend to real-time PM / Validation

- Overview & History of VPP Arterial Validation
- Phase 1 – Initial Investigation
- Phase 2 – Case Studies
- Phase 3 – Quantifying Effectiveness
- **Questions and Discussions**

REMINDER
Upcoming Meeting

February 13, 2013 –

VPP Team Webcast

Thank You

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