Vehicle Probe Project II

Arterial Validation Webcast

April 30, 2015

Agenda

Topic		Speaker
1	Welcome	Stan Young, University of Maryland CATT
2	Review of case studies (9 data collections in 2013 & 2014 - NC to NJ)	
3	Summary of Findings	
4	Future Trends	

Webcast & Audio Information

- The call-in phone number is:

  1-712-775-7031 & enter 780245114# at the prompt

- Please keep your phone line muted throughout the webcast; **we request that you ask questions through the "chat box"**

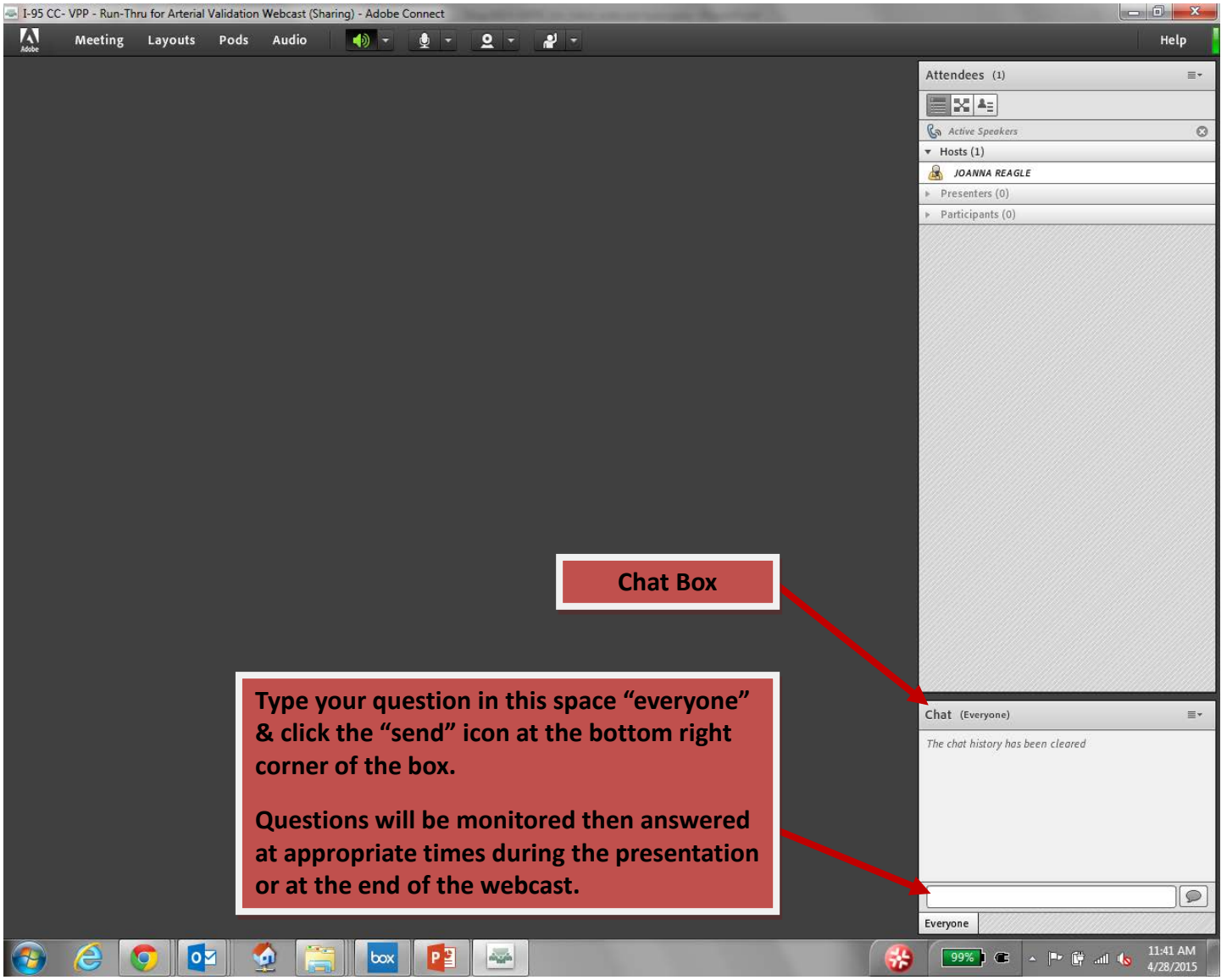
- Please do not place call "on hold" as your hold music may be heard by the group

- Please call 610-662-5569 for difficulties with the web application

Questions

- May be asked throughout the webcast by typing the question in the “chat” box on the webcast screen
- Questions in the “chat” box will be monitored then answered by the speakers at appropriate times during the presentation or at the end of the webcast

Asking Questions



Fidelity of Vehicle Probe Project Data on Arterial Corridors

April 30, 2015
I95 Corridor Coalition Special Webcast

University of Maryland
Center for Advanced Transportation Technology
CATT Works
Stanley E. Young

Outline

- Background on Initiative
- Executive Summary …. '*the short story*'
- Case Studies and Methodology
- *"A tale of three arterials"* …
- Bringing it all together
- Future direction

The Validation Team

- CATT
  - Elham Sharifi, Reuben Juster, Sepideh Eshragh, Masoud Hamedi & Grad Students
- UMD
  - Ali Haghani & Grad Students
- State coordinators for collecting data
- KMJ for tirelessly reviewing reports
- Coalition for consistent support

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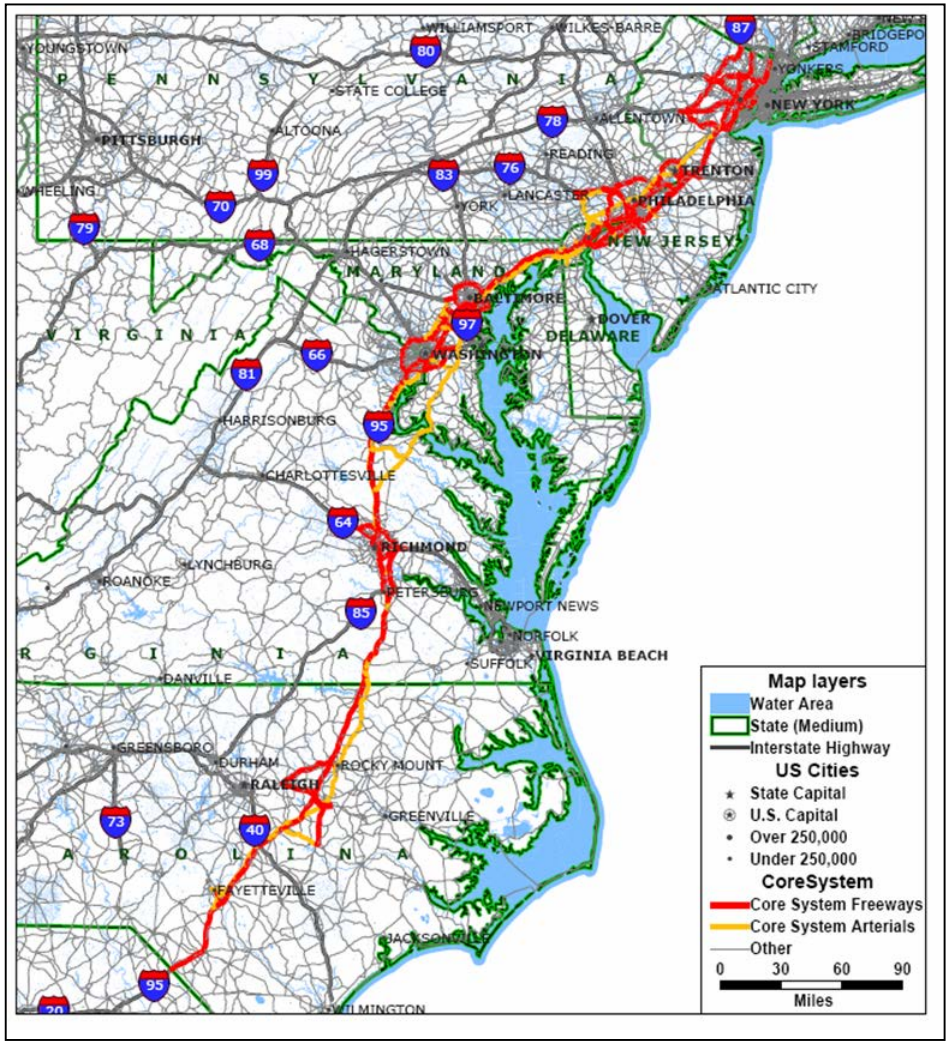
Vehicle Probe Project in 2008

Core Coverage

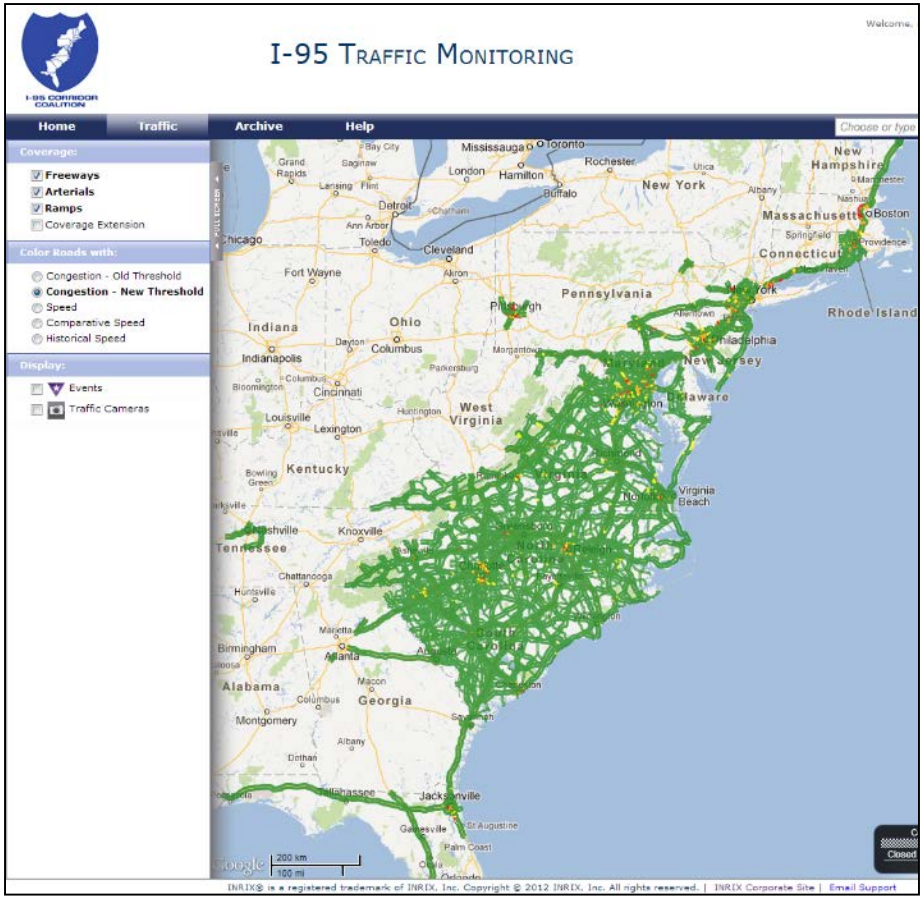
- 1500 Freeway miles
- 1000 Arterial miles
- New Jersey to North Carolina

Roadways

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



VPP as of 2013



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

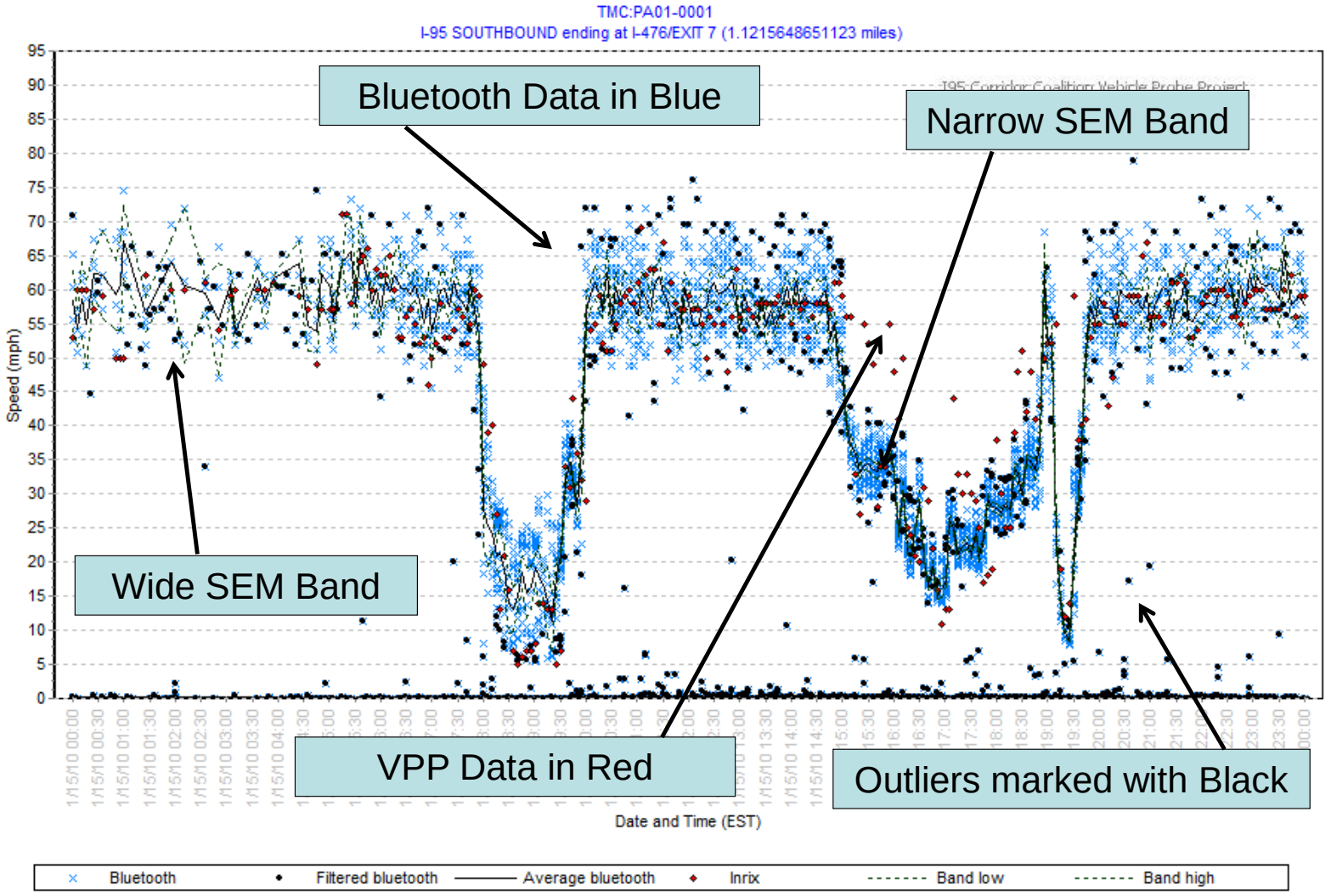
…Try, Try, Again

- **2008-2010 Effort**
  - *Arterials are different, really different!*
- **2011-2012 Initiative**
  - *New tools/methods – Overlays and CFDs*
- **2013-2014 Program**
  - 9 Case Studies form multiple states
  - Variety of arterials (lanes, AADT, # signals)
  - Return of the ‘Slowdown Analysis’

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

Freeway Validation Ex. – Jan 2010



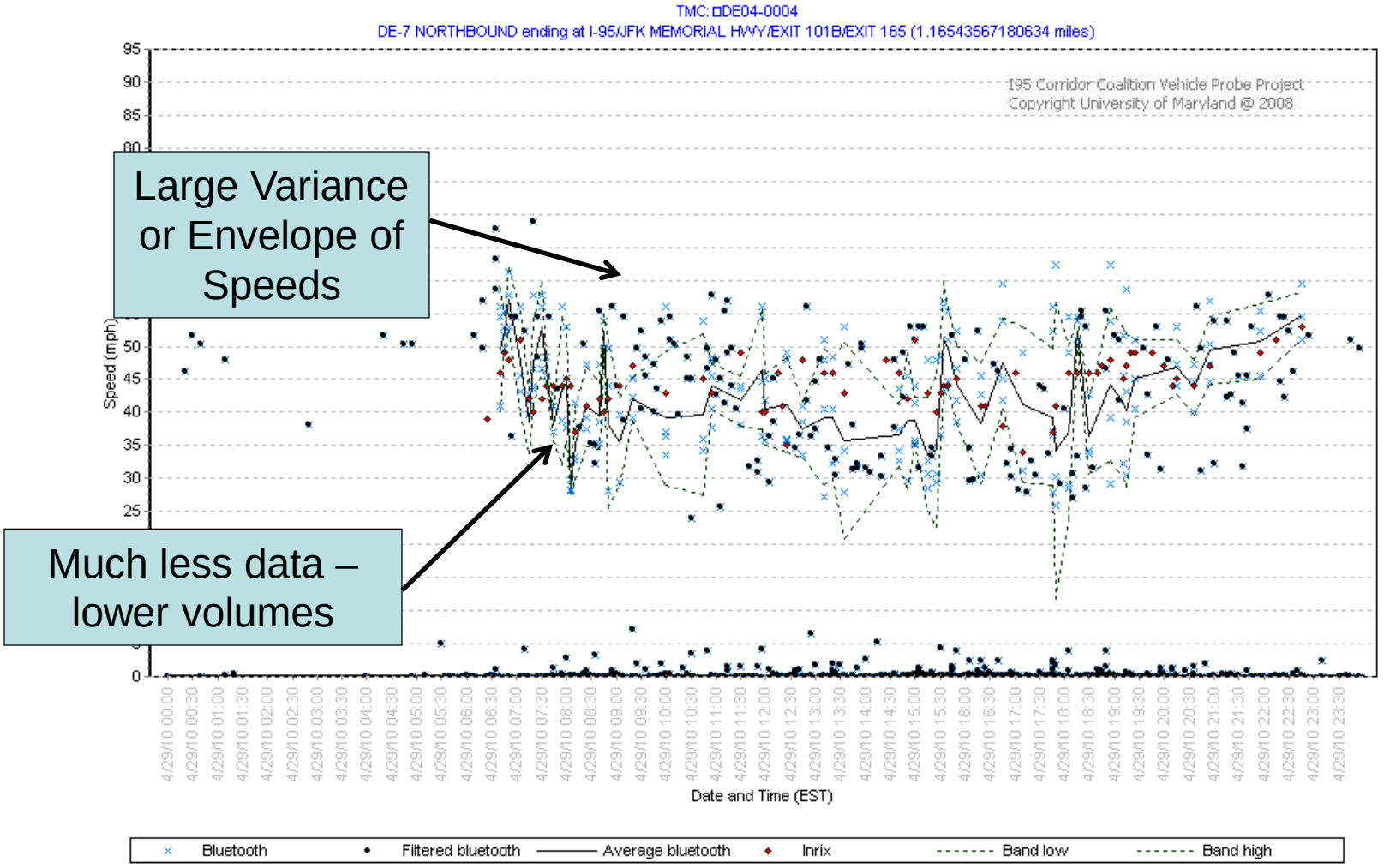
Traditional Validation

- Compares Vendors Data to Bluetooth Reference Data:
  - Average Absolute Speed Error : Measures deviation from ground truth (10 MPH spec)
  - Speed Error Bias : Measures any consistent over or under estimation of reported speed (+/- 5 MPH Max)
- Accuracy is assessed in four flow regimes

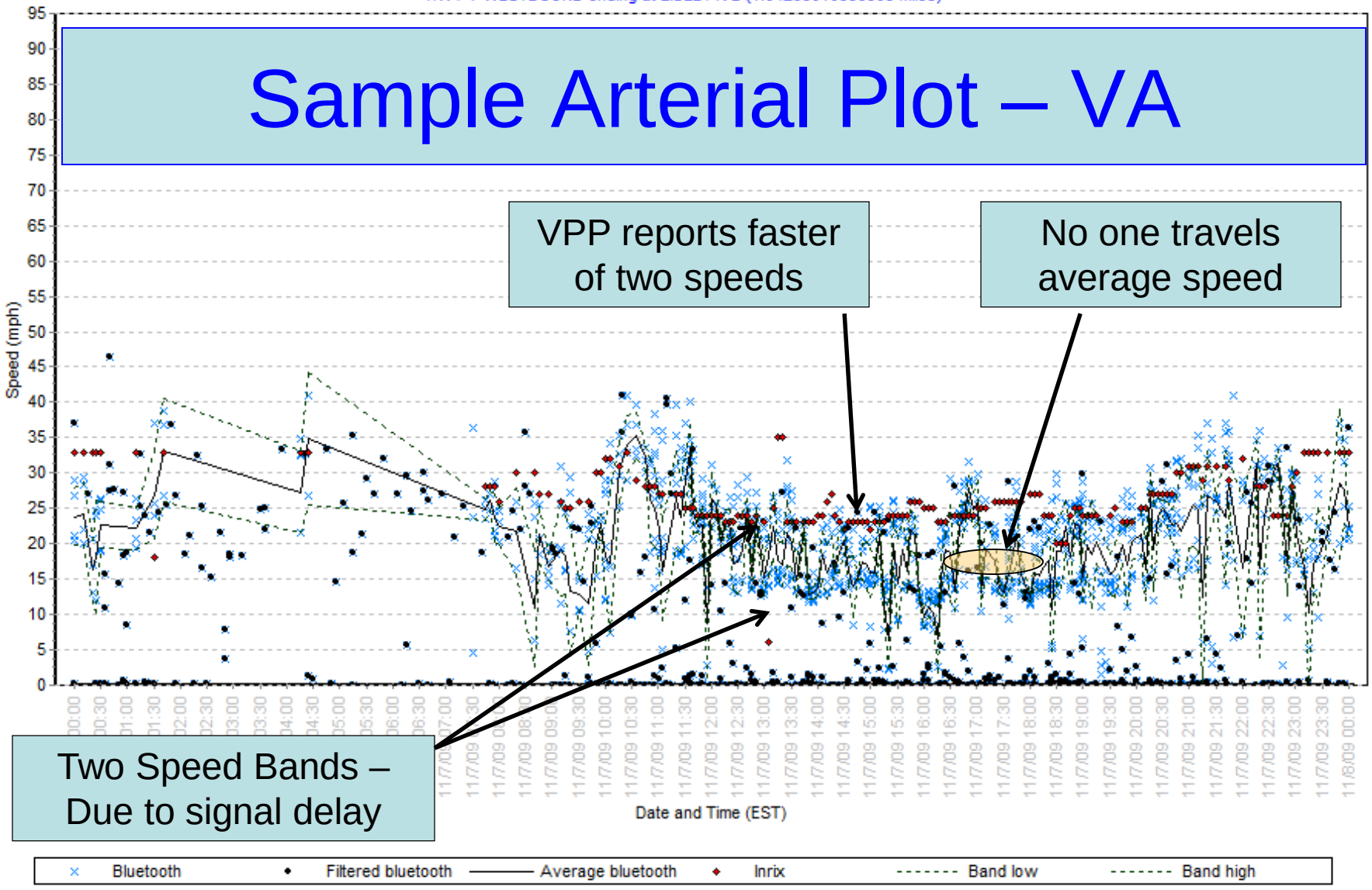
  0 - 30 MPH 30-45 MPH
  45-60 MPH > 60 MPH
- Specs are applied **against Standard Error of the Mean (SEM) band** when flow exceeds 500 vph

Freeway Validation Methods using AASE and SEB do not work well on Arterials

Arterial Data Example



Sample Arterial Plot – VA



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- **Executive Summary …. '*the short story*'**
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- *"A tale of three arterials"* …
- Bringing it all together
- Future direction

Arterial Probe Data Rec's

Likely to have usable probe data	Possibly usable probe data	Likely not usable probe data
• **<= 1 signals per mile** • AADT > 40000 • Fully or Partially captures >75% slowdowns	• **<= 2 signals per mile** • AADT 20K to 40K • May Fail to capture > 25% of slowdowns • Should be tested	• **>=2 signals per mile** • Not recommended

- **Probe data quality most correlated to signal density**
- Increased volume aids quality, but does not overcome issues associated with signalized corridors
- Accuracy is anticipated to improve with increased probe density and better processing

Outline

- Background on Initiative
- Executive Summary …. '*the short story*'
- **Case Studies and Methodology**
- *"A tale of three arterials"* … some examples
- Bringing it all together
- Future direction

Case Study Locations
Validation of Arterials

State / Set ID	Road Number	Road Name	Validation Date Span	# of Segments	# of Through Lanes	AADT Range (in 1000s)	Length* (mile)	# Signals / Density	# of Access Points	Median Barrier	Speed Limit (mph)
NJ-11	US-1	Trenton Fwy, Brunswick Pike	Sep 10 - 24, 2013	10	2-4	33 - 90	14.2	10 / 0.7	112	Yes	55
	NJ-42	Black Horse Pike		8	2	25-54	12.5	23 / 1.8	260	Yes	45-50
	US-130	Burlington Pike		10	3	42	14.3	28 / 2.0	229	Yes	50
NJ-12	NJ-38	Kaighn Ave.	Nov 5-19, 2013	16	2-4	32-80	24.5	44 / 1.8	235	Yes	50
	NJ-73	Palmyra Bridge Rd.		18	2-4	33-74	23.9	41 / 1.7	236	Yes	45-55
PA-05	US-1	Lincoln Highway	Dec 3 - 14, 2013	28	2 - 3+3	21 - 100	30.62	107 / 3.5	178	Yes	40 - 50
	US-322	Conchester Highway		6	1-2	22 - 34	14.28	7 / 0.5	48	No	35 - 45
PA-06	PA-611	Easton Rd	Jan 9 - 22, 2014	10	2-4	18-31	6.7	21/ 3.13	98	NO	40-45
	PA-611	Old York Rd		8	1-2	21-30	7.3	26/ 3.56	105	Partial	15-40
	PA-611	N Broad St		16	2-4						
VA-07	VA-7	Leesburg Pike and Harry Byrd Hwy	April 5-16, 2014	30	2-4						
	US-29	Lee Hwy (S Washington St)		4	2						
VA-08	US-29	Lee Hwy	May 8-19, 2014	26	2-4						
MD-08	MD-140	Reistertown Rd	June 5-14, 2014	12	1 - 3						
		Baltimore Blvd		6	2 - 4						

- 9 Case Studies from 2013-14
- Spans NJ through NC
- Test extent of probe data
  - 15K AADT to 100K
  - 2 – 12 lanes
  - 0.5 to 10+ signals per mile
- Objective: Reference case studies

Detailed Corridor Inventory

Segment NJ-00##	GEOMETRIC DESCRIPTION						TMC CODES		BTM Data		General Description and Notes (All lengths in miles and speeds in MPH)
	Crossroads	Lanes	AADT	Signals					Sensor		
	Starting at	Min	Min	#	Access Points	Med	Begin	Len	Beg	Length	
	Ending at	Max	Max	#/Len	Speed Limit	Maj Junct	End	#	End	% Diff	
US-1 Northbound in New Jersey, commonly known as Trenton Fwy or Brunswick Pike NJ11-0001 to -0007											
03	US-1 Bus/Brunswick Pike	2	33352	1	9	Yes	103P04923	0.75	C	0.74	1/3 in Trenton Fwy, 2/3 in Brunswick Pike, Ends with signalized intersection with Bakers Basin Rd.
	Bakers Basin Rd/Franklin Corner Rd	3	47987	1.3	55	0	103P04924	3	D	-1.2%	
05	I-295/I-95	3	87729	0	11	Yes	103+04926	1.16	Q	1.12	Brunswick Pike, Grade separated intersection with Quakerbridge Rd/US-533
	Quakerbridge Rd	4	89635	0.0	55	0	103P04926	2	I	-3.5%	

- Lanes, AADT, signals, access points, speed limit, median access, major junctions
- Cross reference to existing case study to anticipate performance

Traditional Methodology

Speed Bin	Absolute Speed Error (<10mph)		Speed Error Bias (<5mph)		Number of 5 Minute Samples	Hours of Data Collection
	Comparison with SEM Band	Comparison with Mean	Comparison with SEM Band	Comparison with Mean		
0-15 MPH	**5.7**	9.9	**5.7**	9.6	515	42.9
15-25 MPH	**4.6**	9.6	**4.5**	9.4	4047	337.3
25-35 MPH	**3.3**	7.7	**3.1**	7.0	9725	810.4
>35 MPH	**2.0**	5.9	**-1.1**	-2.6	38954	3246.2
All Speeds	2.0	6.0	-1.0	-2.3	53241	4436.8

- Speed ranges are adjusted for arterials
- High variance masks performance when using SEM band
- Insight gained from
  - Contrasting SEM and Mean, AASE and BIAS

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Slowdown Analysis

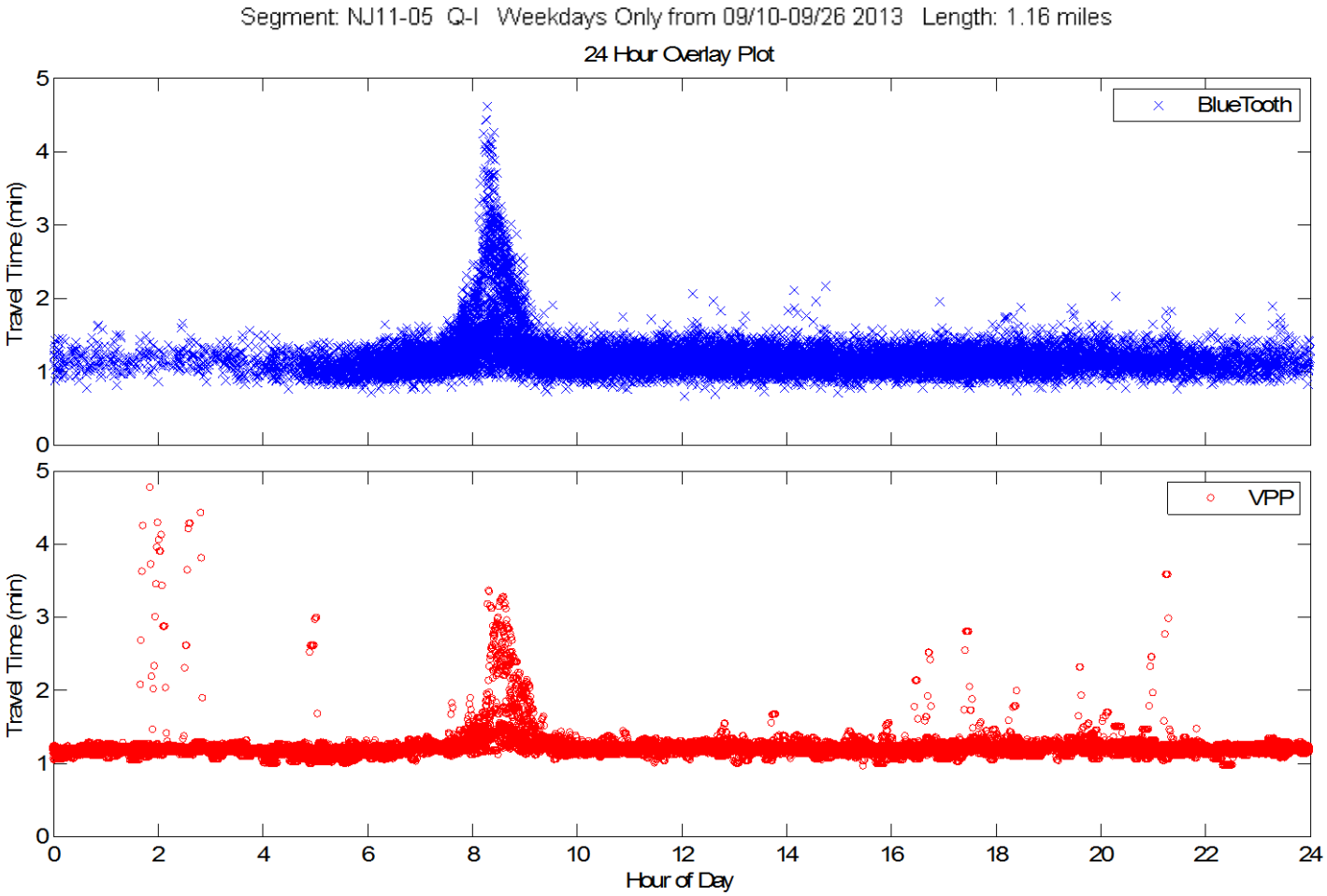
- Slowdowns identified
  - Major : >15 mph in speed, > 1 hour
  - Minor : > 10 mph in speed, > 30 minutes
- For each slowdown rate as:
  - Fully Captured
  - Partially Captured
  - Failed to Capture

	Total	Fully	Partially	Failed
Major	45	11	25	9
Minor	33	11	13	9

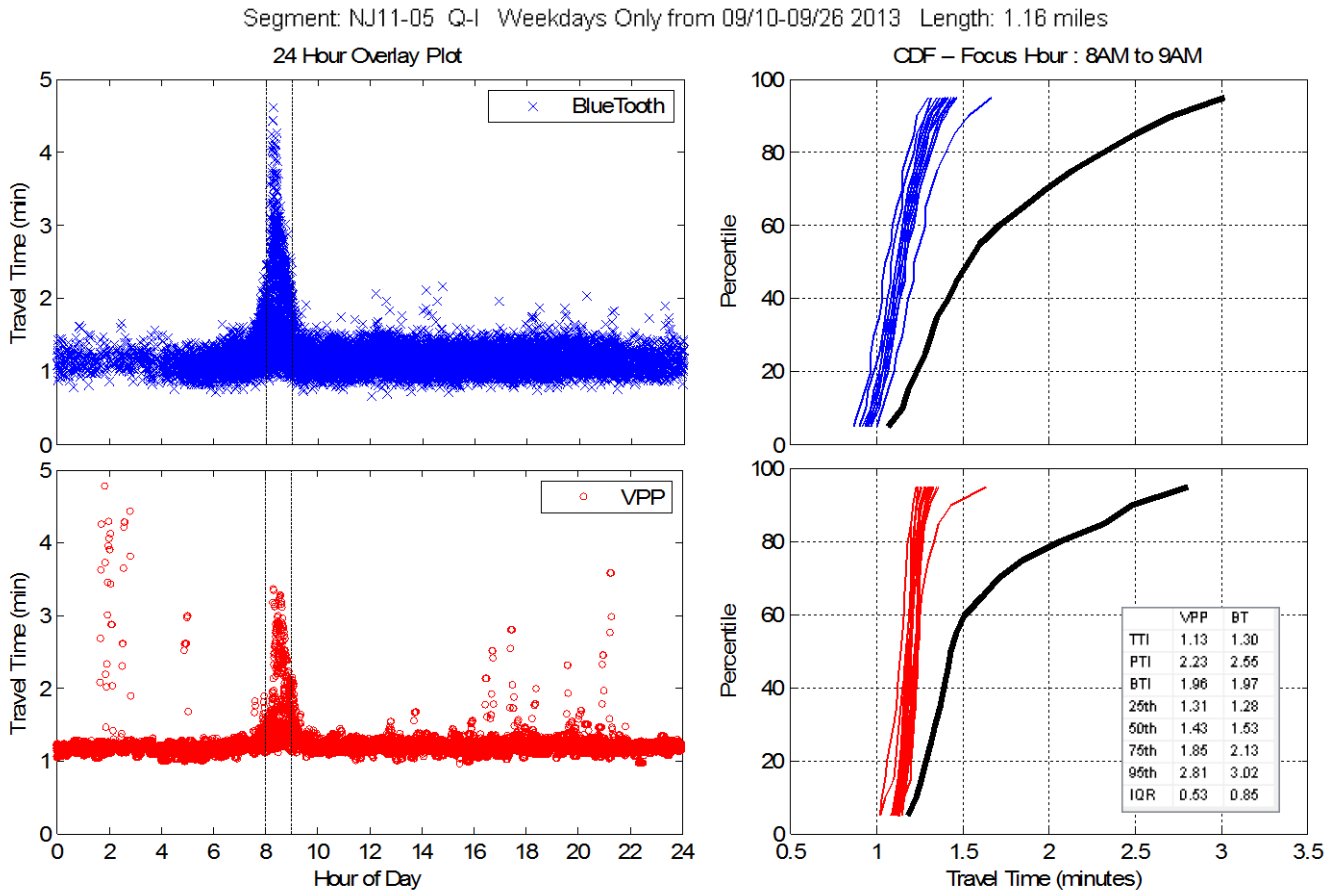
Sampled Distribution Method

- Emphasizes recurrent traffic patterns
  - Data from multiple weekdays are combined to reinforce patterns
  - 24-hour overlay plots reveal impacts of signal timing
  - Cycle failures and platoon progression are easily viewed
- Cumulative Frequency Diagrams (CFDs) display travel time distribution compactly for comparison
- Traditional performance can be calculated from CFDs:
  - TTI, PTI, BTI, Percentiles, IQR, etc.
- **Strengths**
  - Captures REPEATABLE complex flow dynamics
  - Characterizes the nature of variation

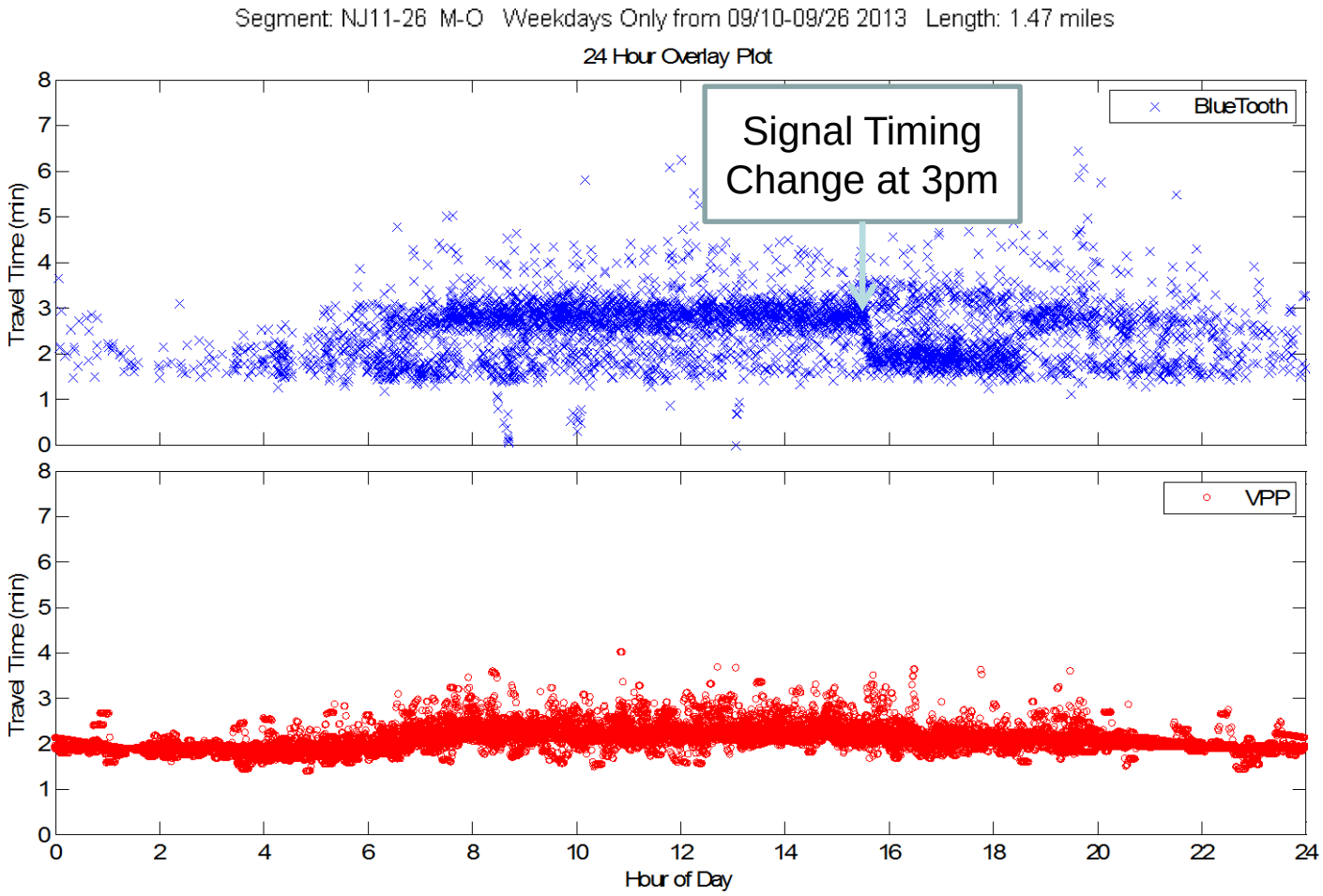
Sample of 24-Hour Overlay Plot Simple Distribution



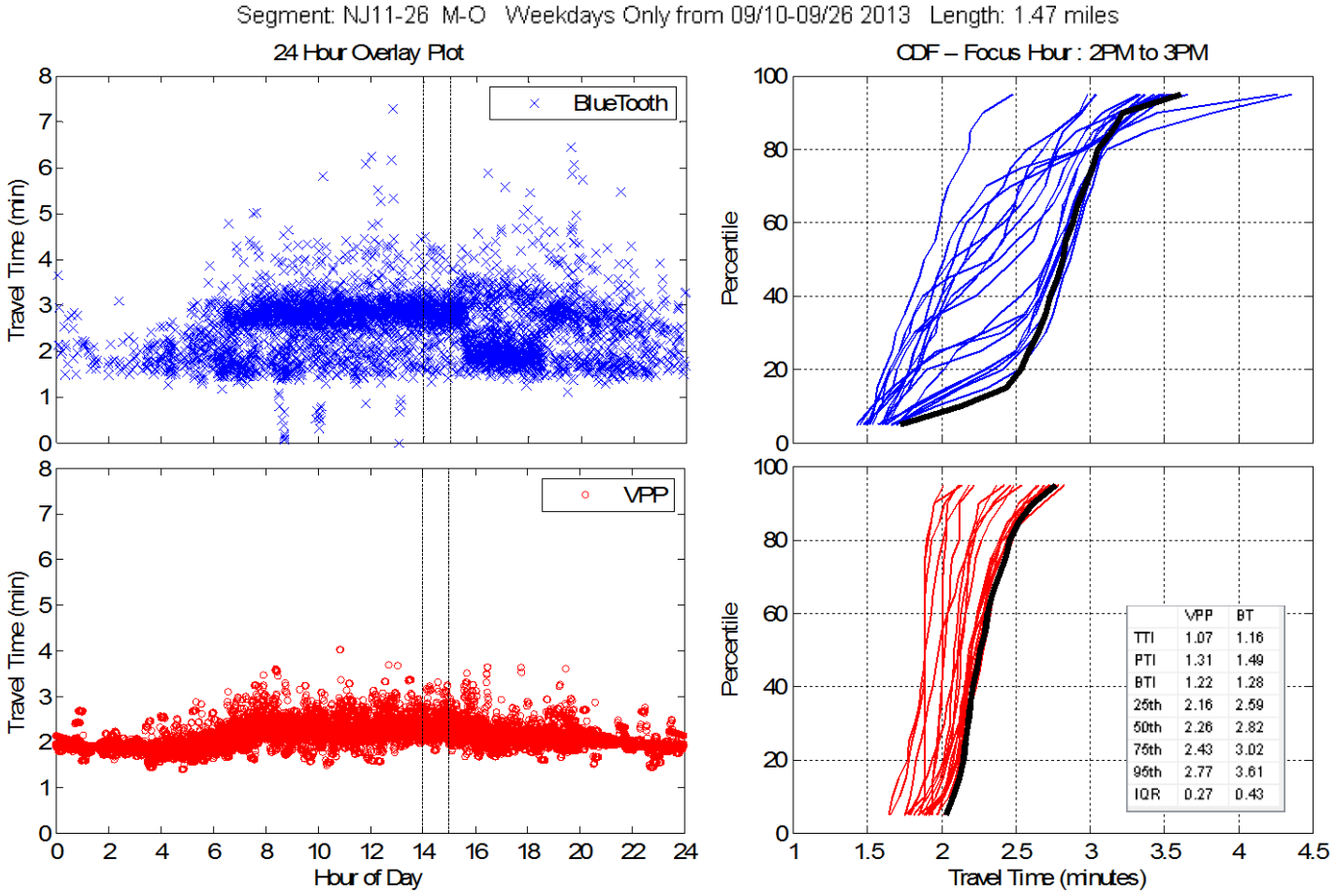
Sample of Overlay and CFD Plot Simple Distribution



Sample of 24 Hour Overlay Plot Complex Distribution



Sample of Overlay and CFD Plot Complex Distribution



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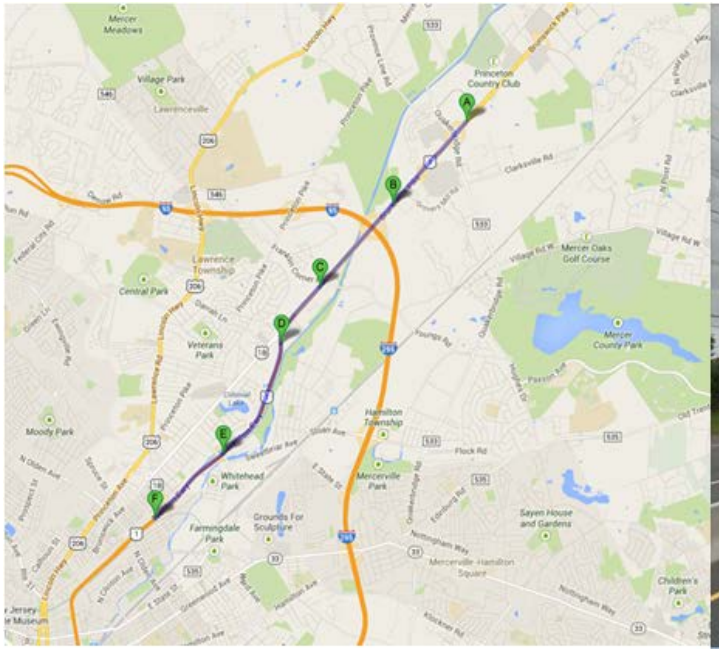
Sample of Well Performing Arterial New Jersey US-1



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NJ-11	US-1	Trenton Fwy, Brunswick Pike	Sep 10 - 24, 2013	10	2-4	33 - 90	14.2	10 / 0.7	112	Yes	55

Traditional Analysis
NJ US-1

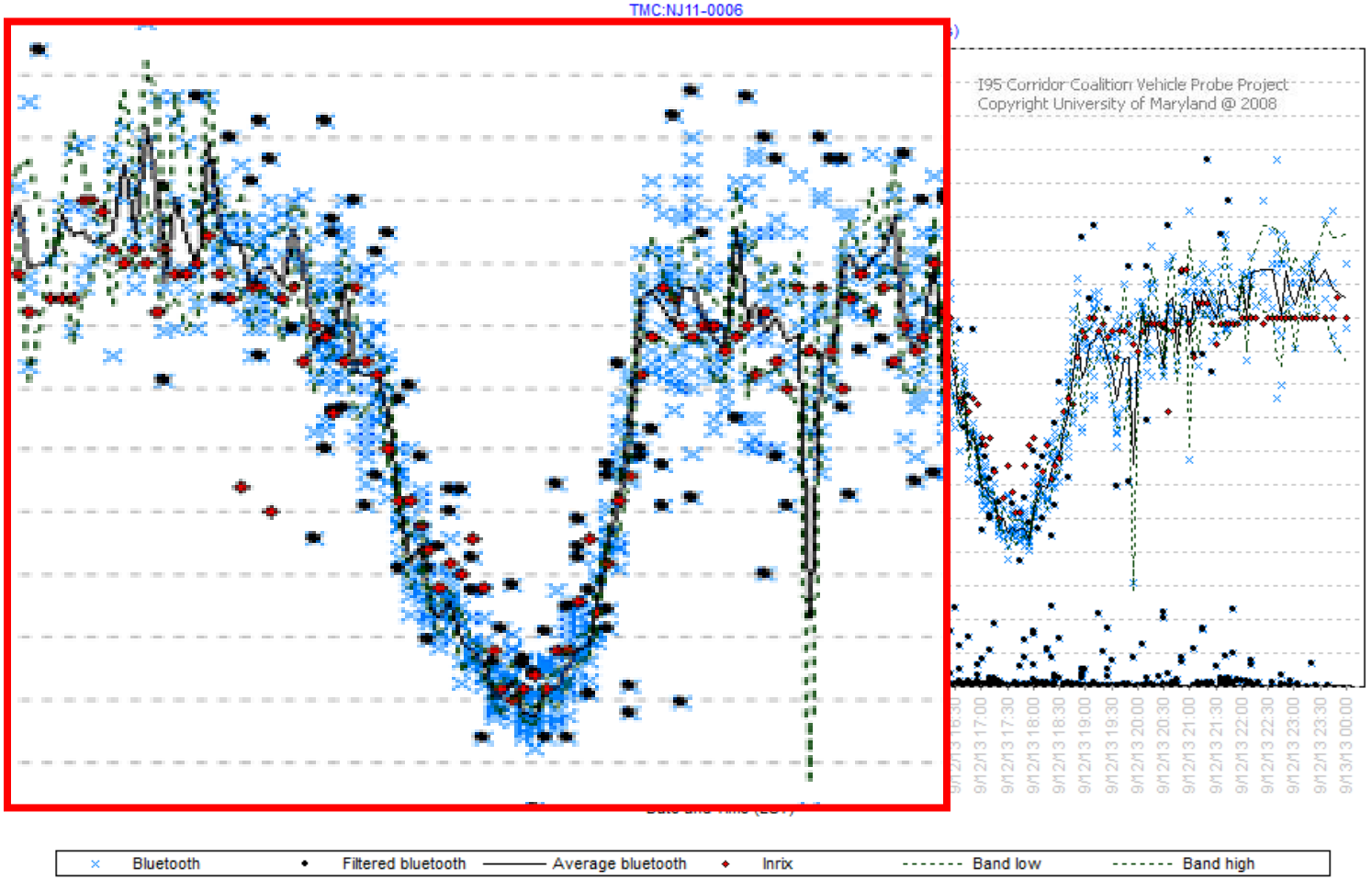
Table CS3-2-2 US-1 Evaluation Summary

Speed Bin	Absolute Speed Error (<10mph)		Speed Error Bias (<5mph)		Number of 5 Minute Samples	Hours of Data Collection
	Comparison with SEM Band	Comparison with Mean	Comparison with SEM Band	Comparison with Mean		
0-15 MPH	2.9	4.4	2.8	3.8	224	18.7
15-25 MPH	5.3	7.3	5.2	6.9	1742	145.2
25-35 MPH	5.4	9.6	5.2	8.8	3155	262.9
>35 MPH	2.3	6.5	-1.3	-2.9	21276	1773.0
All Speeds	2.9	6.9	-0.1	-0.8	26397	2199.8

- Performance consistent with freeways

New Jersey US-1 Segment 06

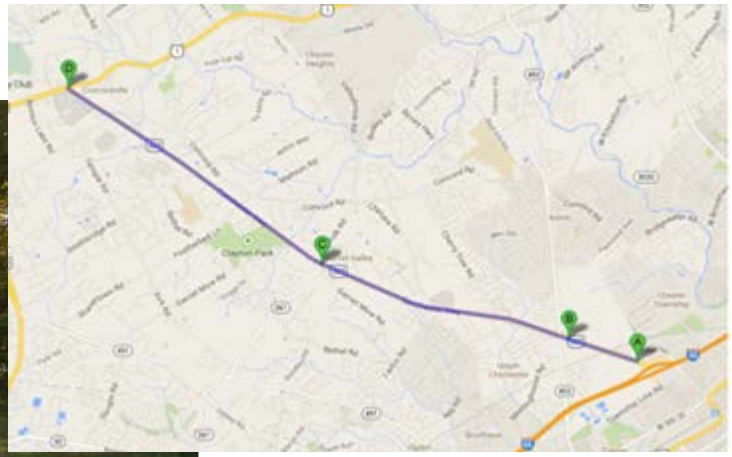
9/12/2013



NJ US-1
Slowdown Analysis

	Total	Fully	Partially	Failed
Major Slowdowns	101	64	37	0
	100%	63%	37%	0%

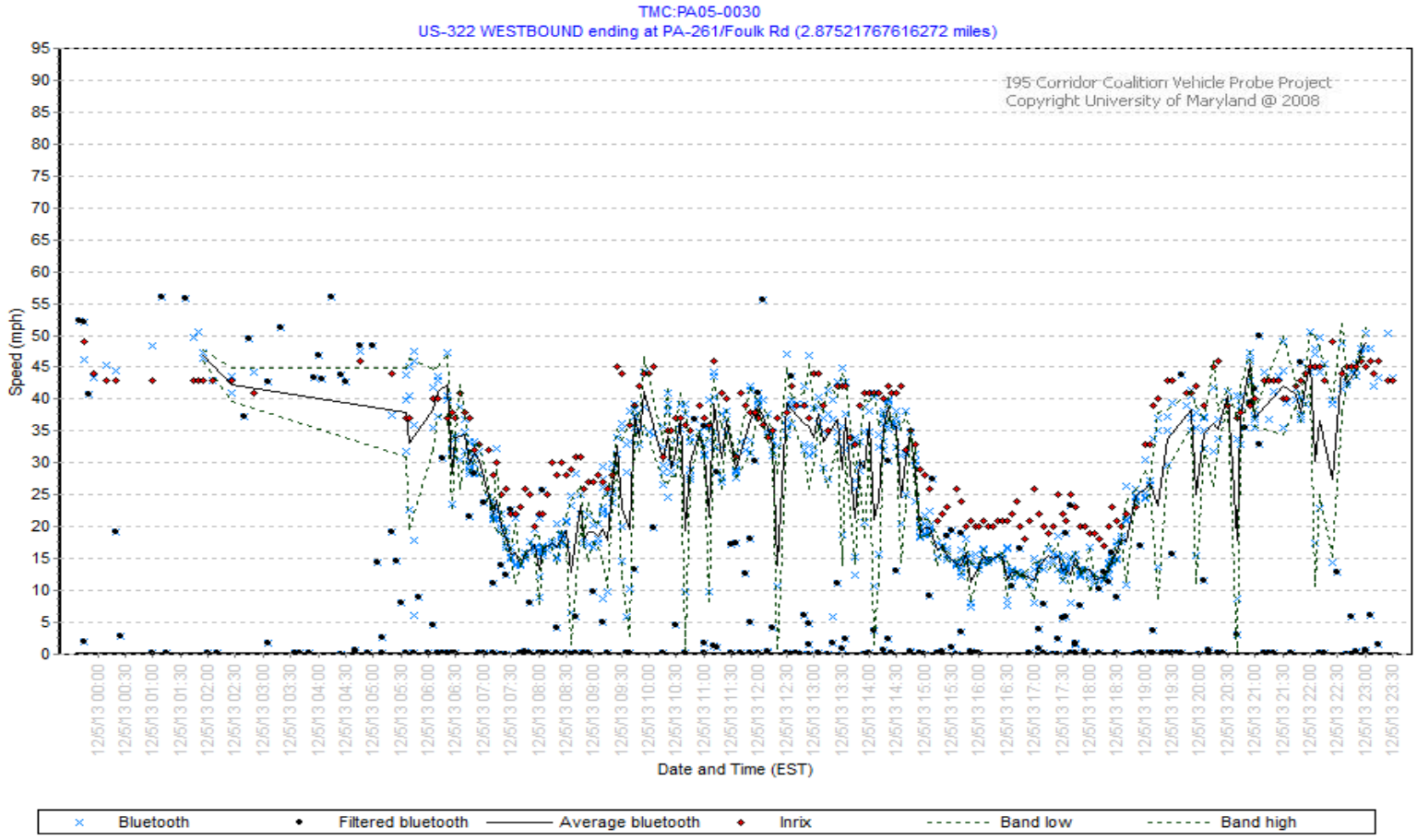
Sample of Well Performing Arterial Pennsylvania US-322



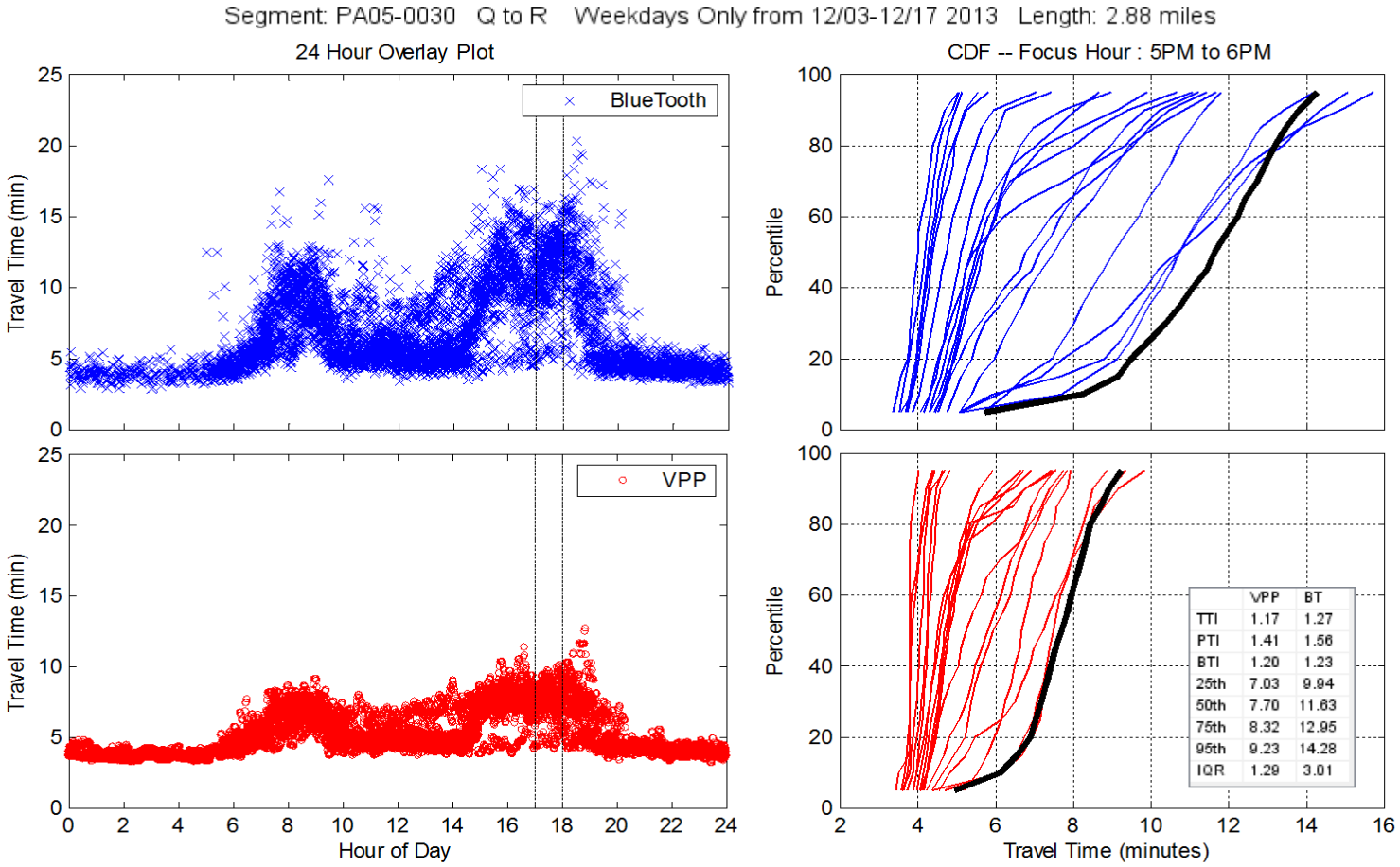
PA-US-322									
Route	Location	Lanes (Per Direction)	AADT (min/max)		Signals / Density		Access Pts	Speed Limit	Length
US-322	US-1 to I-95	1-2	21637	33764	7	0.49	48	35-45	14.28

Pennsylvania US-322

Segment 30 12/05/2013



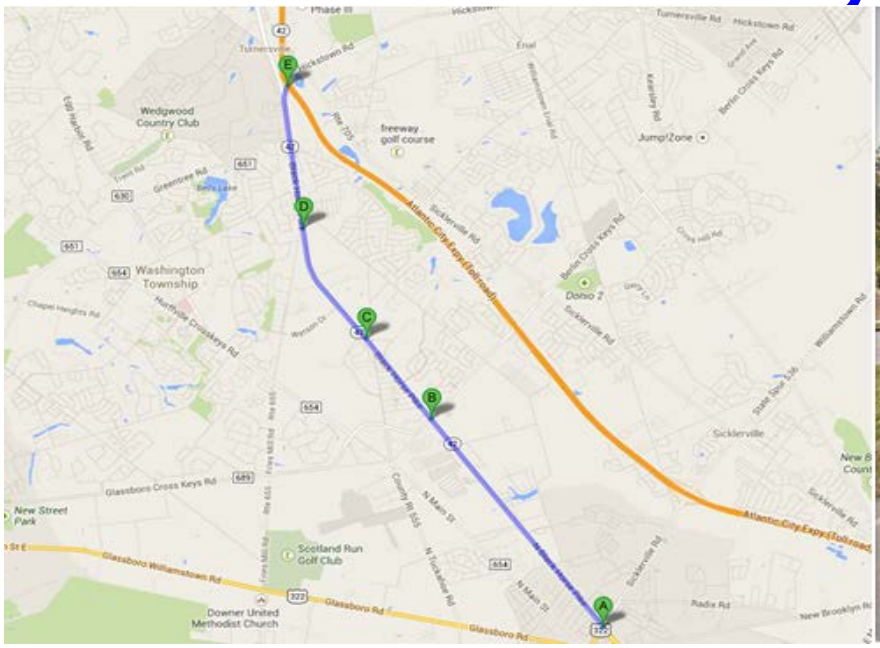
PA US-322 Segment 30 Distribution Analysis



PA US-322
Slowdown Analysis

	Total	Fully	Partially	Failed
Major	37	18	16	3
	100%	49%	43%	8%
Minor	21	11	8	2
	100%	52%	38%	10%

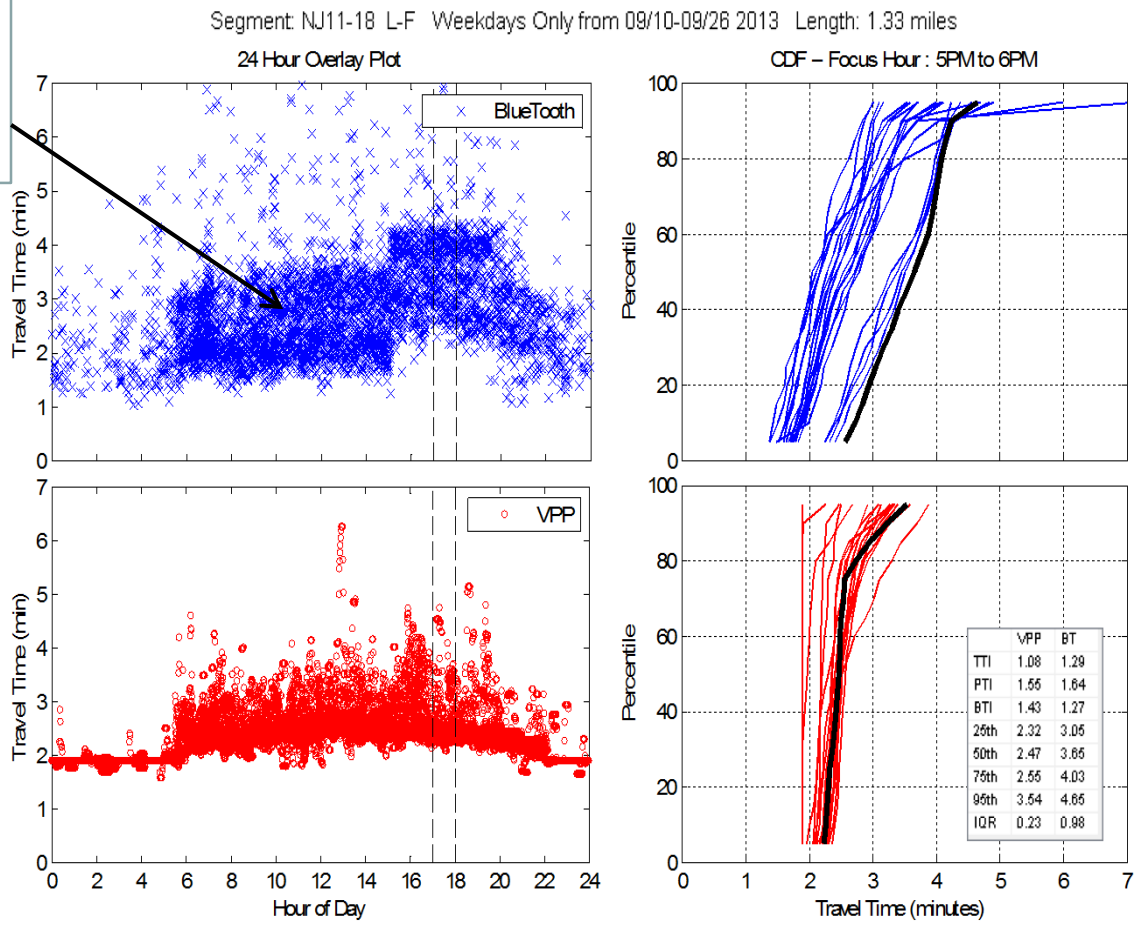
Sample of Mixed Performance New Jersey Route 42



Data Set Name	Road Number	Road Name	Validation Date Span	# of Segments	# of Through Lanes	AADT Range (in 1000s)	Length (mile)	# Signals / Density	# of Access Points	Median Barrier	Speed Limit (mph)
NJ-11	NJ-42	Black Horse Pike	Sep 10 - 24, 2013	8	2	25-54	12.5	23 / 1.8	260	Yes	45-50

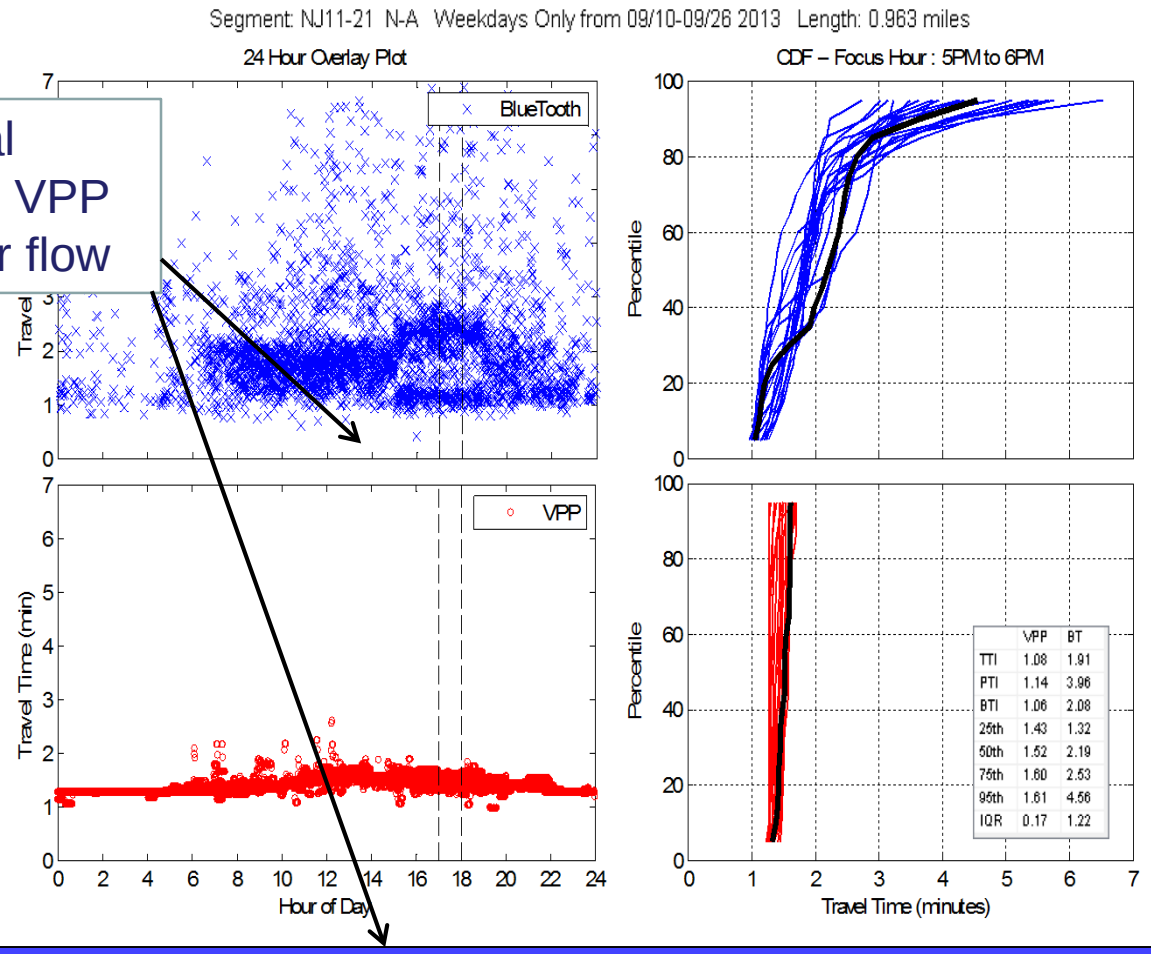
NJ11-18, 5PM – 6PM

Signal Timing Change at 3pm

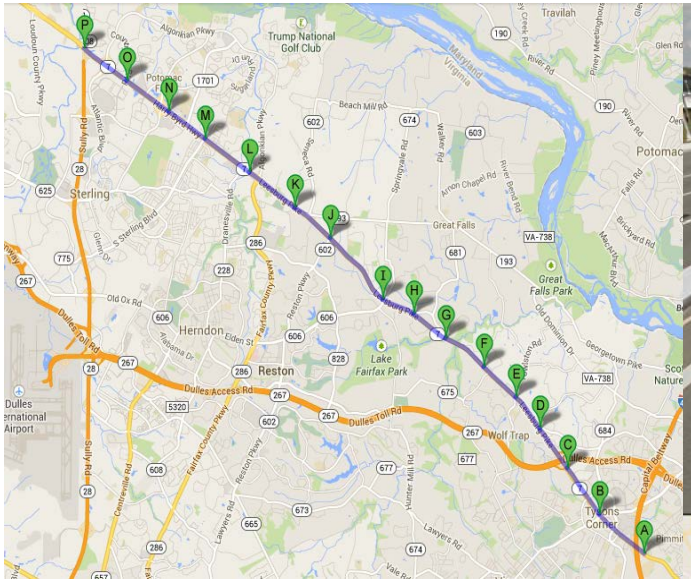


NJ11-21, 5PM – 6PM

Bimodal Distribution, VPP favors faster flow



Sample of Mixed and Poorly Performing Data VA Route 7



Data Set Name	Road Number	Road Name	Validation Date Span	# of Segments	# of Lanes (Per Direction)	AADT Range (in 1000s)	Length (mile)	# Signals / Density	# of Access Points	Median Barrier	Speed Limit (mph)
VA-07	VA-7	Leesburg Pike and Harry Byrd Hwy	April 5-16, 2014	30	2-4	45-60	30.5	57 / 1.9	203	Yes	35-55

VA-7 Traditional Results

Table CS7-2-2 VA-7 without segments 9 and 10 Evaluation Summary

Speed Bin	Absolute Speed Error (<10mph)		Speed Error Bias (<5mph)		Number of 5 Minute Samples	Hours of Data Collection
	Comparison with SEM Band	Comparison with Mean	Comparison with SEM Band	Comparison with Mean		
0-15 MPH	7.5	10.8	7.5	10.7	840	70.0
15-25 MPH	4.5	7.8	4.3	7.3	4131	344.3
25-35 MPH	2.1	7	2.1	4.8	6328	527.3
>35 MPH	2.2	6.3	-1.6	-3.5	28126	2343.8
All Speeds	2.7	6.6	-0.2	-0.8	39425	3285.4

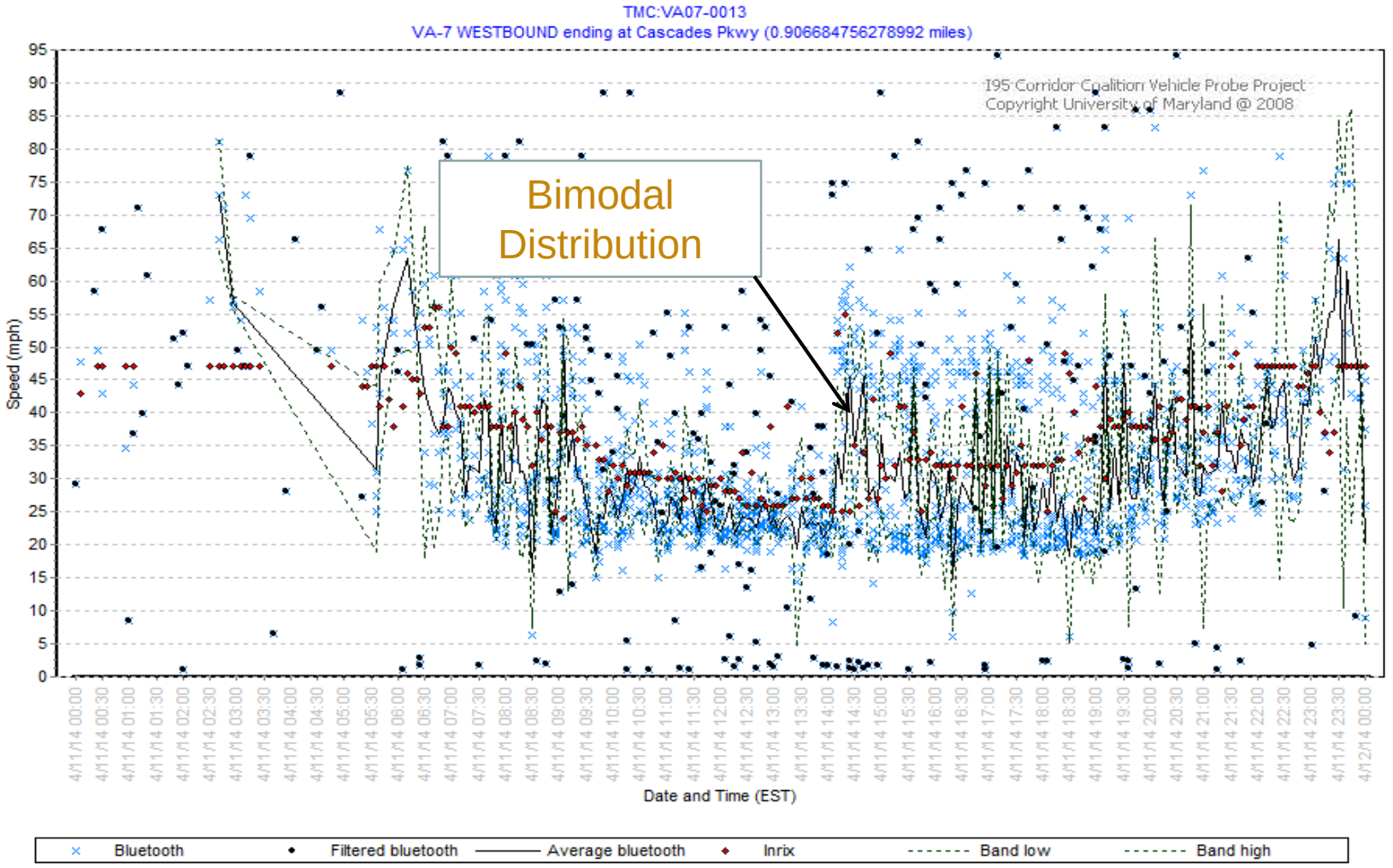
No Construction

Table CS7-2-3 VA-7 Segment 9 and 10 Evaluation Summary

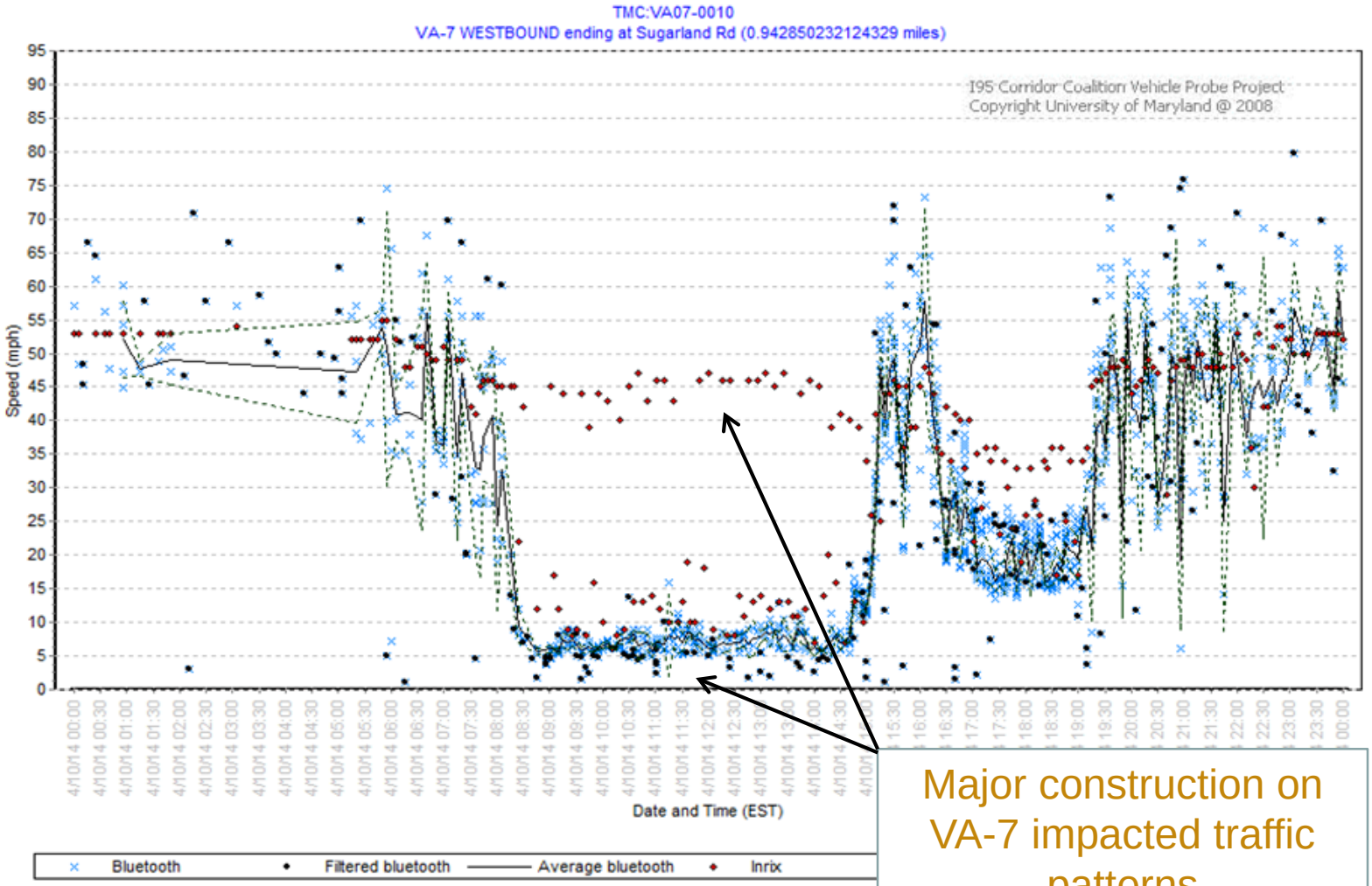
Speed Bin	Absolute Speed Error (<10mph)		Speed Error Bias (<5mph)		Number of 5 Minute Samples	Hours of Data Collection
	Comparison with SEM Band	Comparison with Mean	Comparison with SEM Band	Comparison with Mean		
0-15 MPH	18.3	19.3	18.2	19.1	217	18.1
15-25 MPH	10.8	13.8	10.6	13.4	270	22.5
25-35 MPH	6.5	12.0	6.5	12.0	368	30.7
>35 MPH	1.7	5.2	-0.6	-0.9	2792	232.7
All Speeds	3.9	7.4	2.0	2.6	3647	303.9

Construction Zone

VA-7 (Segment 13) 4/11/2014
No Construction



VA-7 (Sement-10) 4/10/2014 Construction Zone



Slowdown Analysis

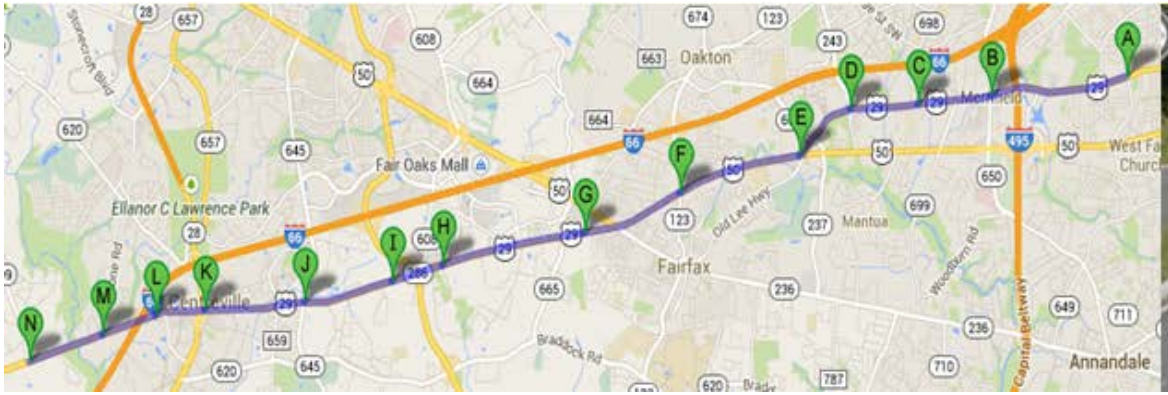
VA-7 (without Construction)

	Total	Fully	Partially	Failed
Major Slowdowns	75	18	32	25
	100%	24%	43%	33%

VA-7 (with Construction)

	Total	Fully	Partially	Failed
Major Slowdowns	22	1	5	16
	100%	5%	23%	73%

Sample of Poor Performance Virginia US-29



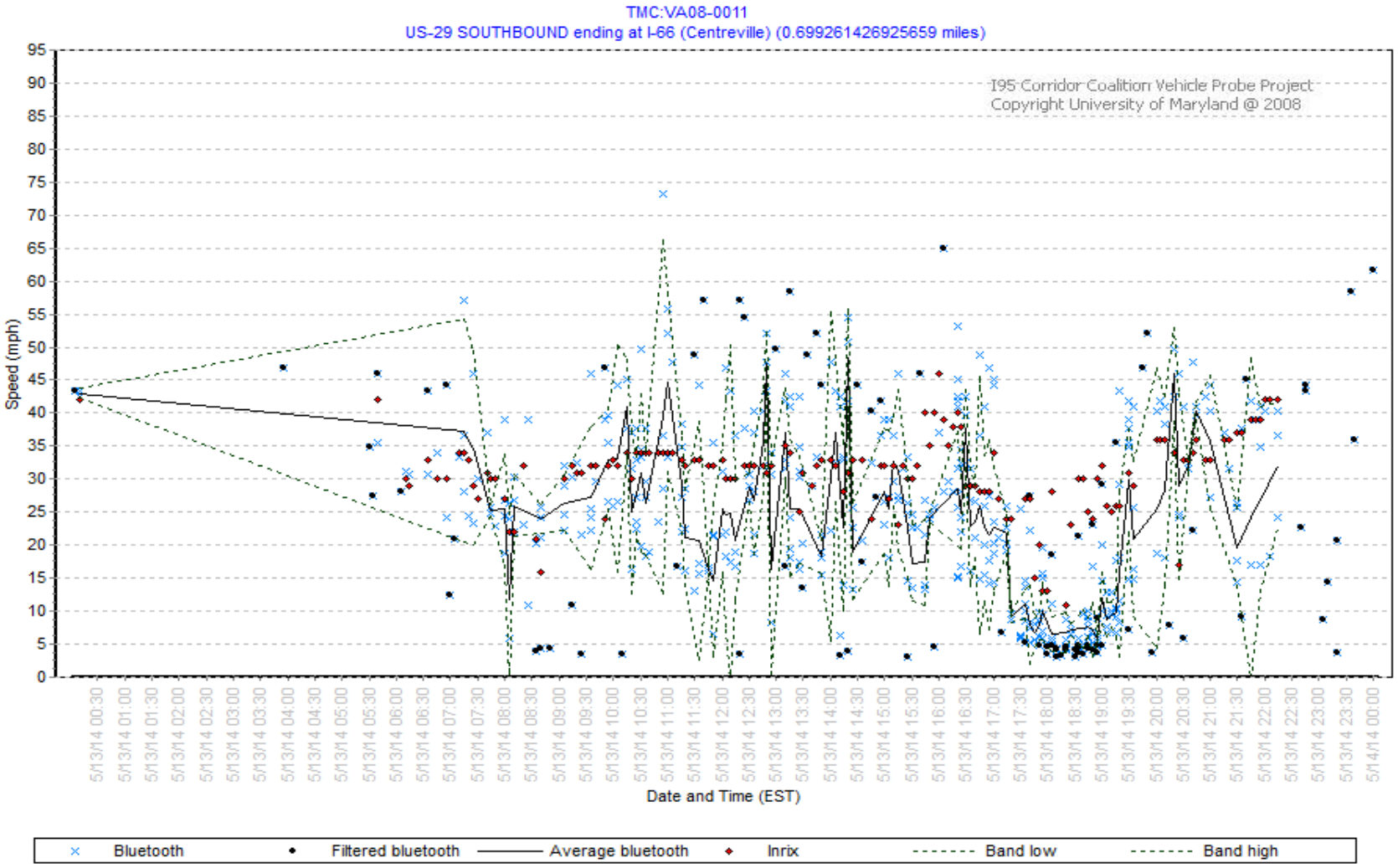
Road Number	Road Name	Validation Date Span	# of Segments	# of Through Lanes	AADT (in 1000s)	Length (mile)	# Signals / Density	# of Access Points	Median Barrier	Speed Limit (mph)
US-29	Lee Hwy	May 8-19, 2014	26	2-4	15-45	31.9	115/3.6	287	Partial	35-50

- Wide range of properties
- Signal density of 3.6 per mile

Slowdown Analysis – Virginia US-29

	Total	Fully	Partially	Failed
Major Slowdowns	49	4	21	24
	100%	8%	43%	49%

VA US29 (Segment 8) 5/13/2014



Outline

- Background on Initiative
- Executive Summary …. '*the short story*'
- Case Studies and Methodology
- *"A tale of three arterials" …*
- **Bringing it all together**
- Future direction

Arterial Probe Data Rec's

Likely to have usable probe data	Possibly usable probe data	Likely not usable probe data
• **<= 1 signals per mile** • AADT > 40000 • Fully or Partially captures >75% slowdowns	• **<= 2 signals per mile** • AADT 20K to 40K • May Fail to capture > 25% of slowdowns • Should be tested	• **>=2 signals per mile** • Not recommended

- **Probe data quality most correlated to signal density**
- Increased volume aids probe data quality, but does not overcome issues resulting from high signal density
- Accuracy anticipated to improve with increased probe density and better processing

Top Level Take-Aways

- **Expectations are running ahead of reality**
- Probe data **usable** on highest class arterials
  - Signal density < 1 per mile on average
  - Travel times are proportional to ground truth
  - May still miss some slowdowns, and may want to test
- Use with caution on mid class and below
  - Erratic performance, will miss large portion of slowdowns
- Consistent positive bias at low speeds

Additional Insights / Issues

- As probe data improves, delay will increase
- Challenged by severe queuing / multi-cycle delays
- Not sensitive bi-modal traffic patterns
  - Significant Optimistic Bias
  - Increased volume aids to ‘split the difference’
  - Does not reflect impact of signal timing changes
- Major disruptions (such as construction) appear problematic

Outline

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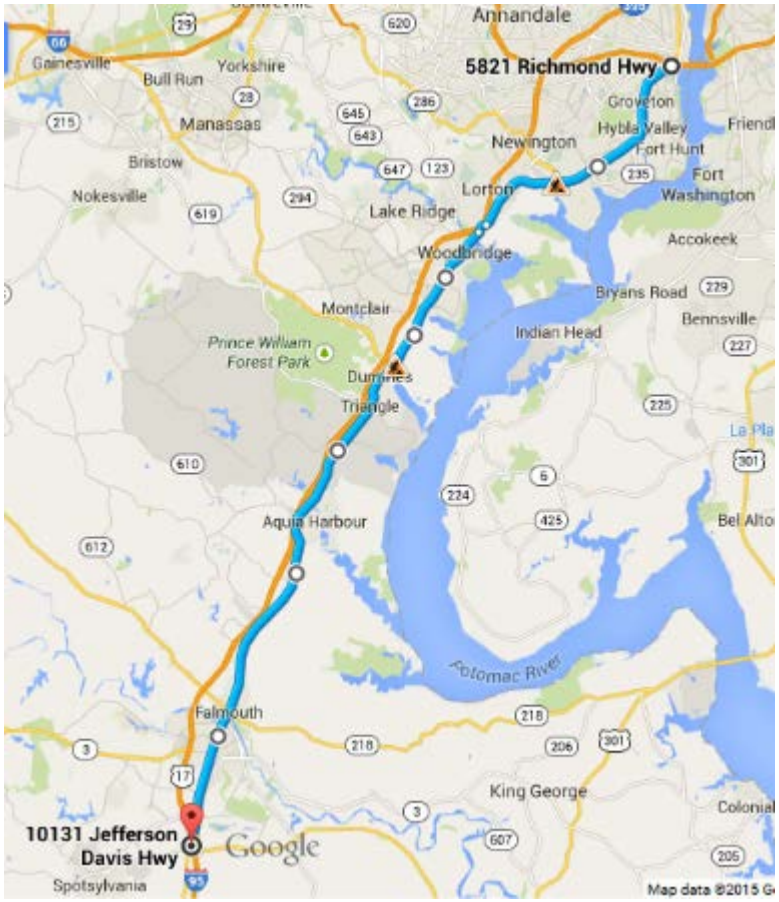
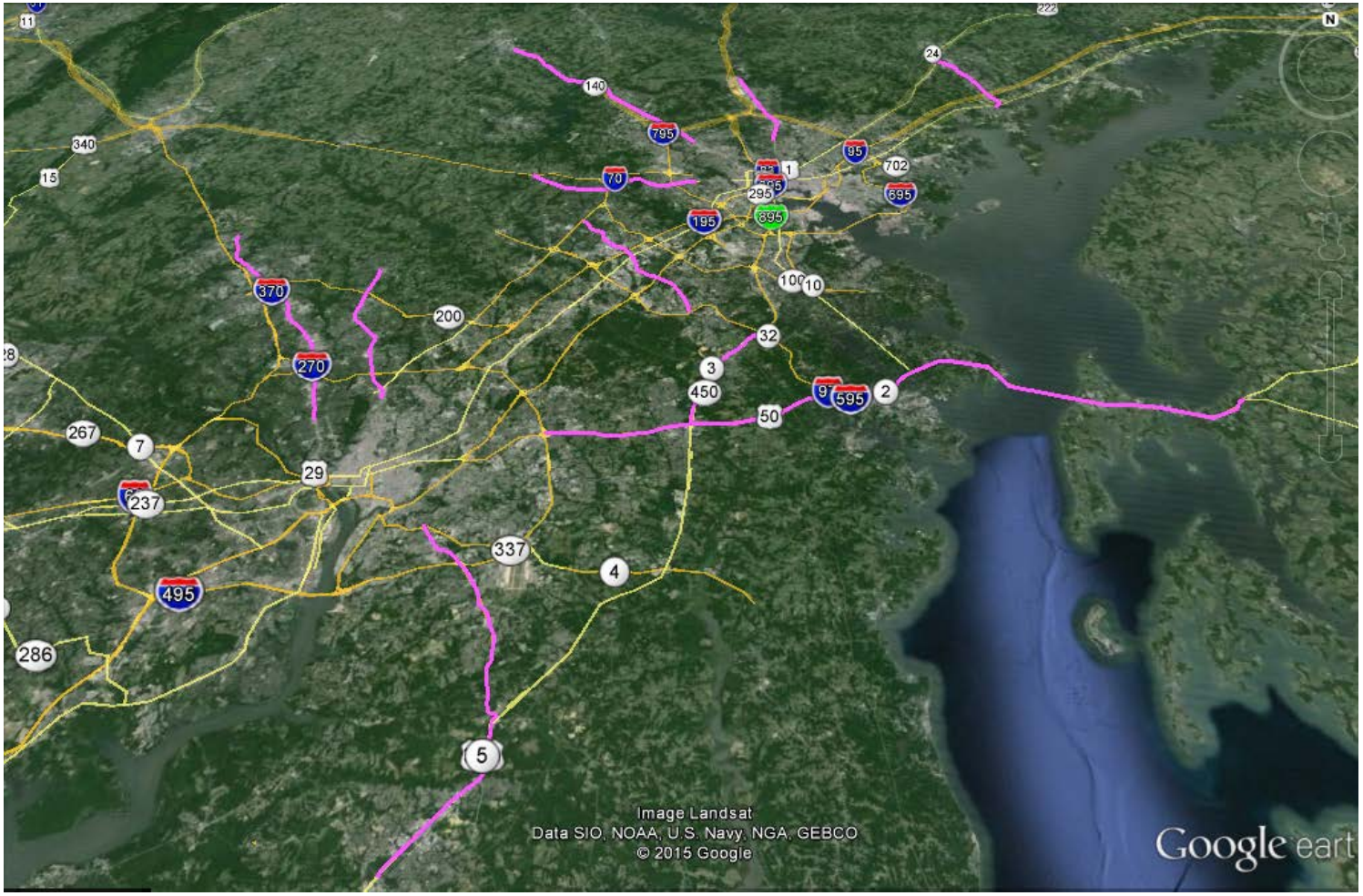
Future Validations

- US-1 in VA
  - DC to Fredericksburg
  - Multi-Vendor
  - > 2 signals per mile

  '**Encouraging early results**'
- Spring 2015
  - Maryland Supplemental Coverage (120 miles all three vendors)



Maryland Supplemental Coverage



Arterial Report and Data

- Draft copies posted to:

  https://app.box.com/I95-ArterialValidationArchive

- Full report will be posted to Coalition Web Site in May

Questions?

- Stan Young
  - seyoung@umd.edu
- Masoud Hamedi
  - masoud@umd.edu
- Elham Sharifi
  - esharifi@umd.edu

Thank You

I-95 CORRIDOR COALITION