I-95 Corridor Coalition

I-95 Corridor Coalition Vehicle Probe Project: Validation of INRIX Data

Monthly Report

Delaware

I-95 CORRIDOR COALITION

December 2010

I-95 CORRIDOR COALITION VEHICLE PROBE PROJECT: VALIDATION OF INRIX DATA DECEMBER 2010

Monthly Report

Prepared for:

I-95 Corridor Coalition

Sponsored by:

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December 2010

Evaluation Results for the State of Delaware

Executive Summary

Travel time samples were collected along approximately 14 freeway miles and one mile of arterial from Wednesday, November 3, 2010 through Wednesday, November 17, 2010 in Delaware. Freeway segments studied were located along I-95, I-295, I-495 and DE-1 in New Castle County and the arterial data segment studied was located along US Route 13 between I-295 and DE 141 in New Castle County. Data collected was compared with travel time and speed data reported by INRIX as part of the I-95 Vehicle Probe Project. The freeway validation data below represents approximately 1520 hours of observations along nine freeway segments, totaling more than 14 miles.

ES Table 1, below summarizes the results of the comparison between the validation data and the INRIX data for freeway segments during this period. As shown, both the average absolute speed error and speed error bias were within specification for all speed bins. Even when errors are measured against the mean (rather than the SEM band), INRIX data quality meets contract quality standards for the average absolute speed error (AASE).

ES Table 1 - Delaware Evaluation Summary

	Absolute Speed Error (<10mph)		**Speed Error Bias** (<5mph)		Number of 5 Minute Samples	Hours of Data Collection
Speed Bin	Comparison with SEM Band	Comparison with Mean	Comparison with SEM Band	Comparison with Mean		
0-30 MPH	**3.90**	5.30	**3.00**	3.70	455	37.9
30-45 MPH	**6.20**	8.30	**4.30**	5.70	524	43.7
45-60 MPH	**1.60**	3.40	**0.60**	1.40	5262	438.5
> 60 MPH	**2.00**	4.50	**-1.80**	-3.70	12014	1001.2
All Speeds	2.05	4.31	-0.81	-1.78	18255	1521.3

Based upon data collected from November 3, 2010 through November 17, 2010 across 14.4 miles of roadway.

As part of the on-going validation process, vehicle probe data from each state is validated on a rotating basis. Since the inception of the validation process, data on roadways in Delaware was validated on five occasions: September 2008, February 2009, August 2009, April 2010 and November 2010. These five validations represent more than 4820 hours of observations along approximately 57 miles of freeway segments in Delaware. ES Table 2 provides a summary of the cumulative validation effort. As shown, the absolute average speed error and speed error bias are within specification for all speed bins even when errors are measured against the mean.

ES Table 2 - Delaware - Cumulative to Date						
	Absolute Speed Error		Speed Error Bias		Number of 5 Minute Samples	Hours of Data Collection
Speed Bin	Comparison with SEM Band	Comparison with Mean	Comparison with SEM Band	Comparison with Mean		
0-30 MPH	**5.33**	6.99	**3.49**	4.31	1366	113.8
30-45 MPH	**4.91**	7.38	**2.16**	3.47	2215	184.6
45-60 MPH	**1.87**	4.01	**-0.26**	-0.26	17014	1417.8
> 60 MPH	**2.41**	5.01	**-2.23**	-4.31	37263	3105.3
All Speeds	2.41	4.85	-1.35	-2.62	57858	4821.5

Travel time samples collected along US Route 13 were compared with travel time and speed data reported by INRIX as part of this project. The arterial data is included for informational purposes noting that INRIX has volunteered arterial data at no cost to the Coalition for the first three years, and that the method to evaluate quality on arterial roadways has not been fully evaluated. The Coalition is currently in the process of developing appropriate quality metrics and validation methods.

Data Collection

Bluetooth sensor deployments in Delaware started on Wednesday, November 3, 2010. The actual deployments in Delaware were performed with the assistance of Delaware Department of Transportation (DelDOT) personnel. Sensors remained in the same position until they were retrieved two weeks later on Wednesday, November 17, 2010. This round of data collections in Delaware was designed to cover segments of the highways along which both recurrent and non-recurrent congestions could be expected during both peak and off-peak periods.

Figure 1 presents snapshots of the roadway segments over which Bluetooth sensors were deployed in Delaware. In this figure, red segments represent freeway segments while the blue color indicates the arterial segment selected for analysis in this round of validation.

Table 1 presents a list of specific TMC segments that were selected as the validation sample in Delaware. These segments cover a total length of more than 14 freeway miles and a one mile long arterial segment. In total, this document reports the results of validation performed on nine freeway segments. The coordinates of the locations at which the Bluetooth sensors were deployed throughout the state of Delaware are highlighted in Table 2. It should be noted that the configuration of consecutive TMC segments is such that the endpoint of one TMC segment and the start point of the next TMC segment are overlapping, so one Bluetooth sensor in that location is covering both TMC segments.

Finally, Table 3 summarizes the segment definitions used in the validation process while also presenting the distances that have been used in the estimation of Bluetooth speeds based on travel times.

Analysis of Results

Table 4 summarizes the data quality measures obtained as a result of comparison between Bluetooth and all reported INRIX speeds. In all speed bins, INRIX data meets the data quality measures set forth in the contract when errors are measured as a distance from the 1.96 times the standard error band.

Table 5 shows the percentage of the time intervals that fall within 5 mph of the SEM band and the mean for each speed bin for all TMC segments in Delaware. Tables 6 and 7 present detailed data for individual TMC segments in Delaware in similar format as Tables 4 and 5, respectively. Note that for some segments and in some speed bins the comparison results may not be reliable due to small number of observations.

Figures 2 and 3 show the overall speed error biases for different speed bins and the average absolute speed errors for all validation segments in Delaware, respectively. These figures correspond to Table 4.

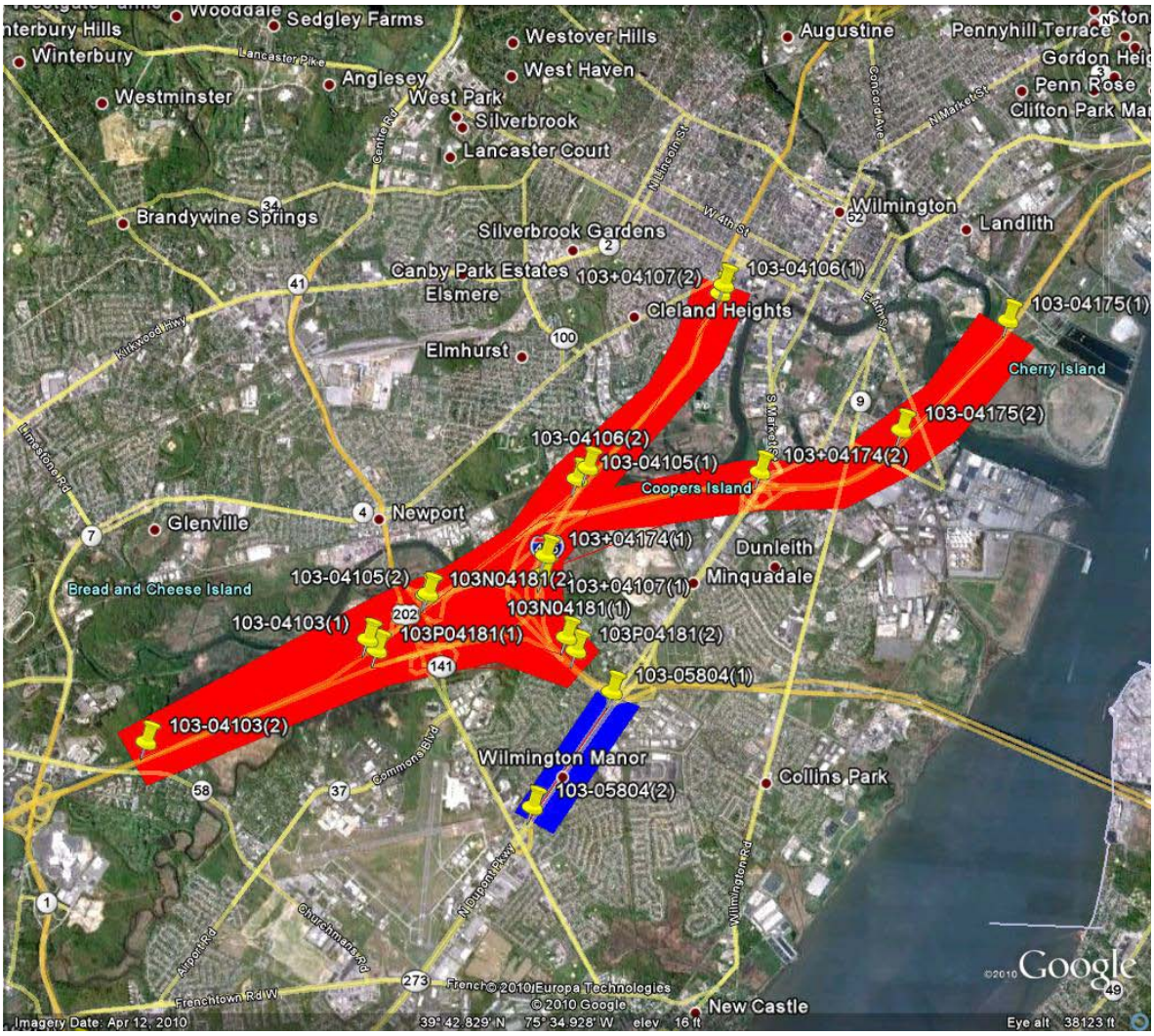

Figure 1
TMC segments selected for validation in Delaware

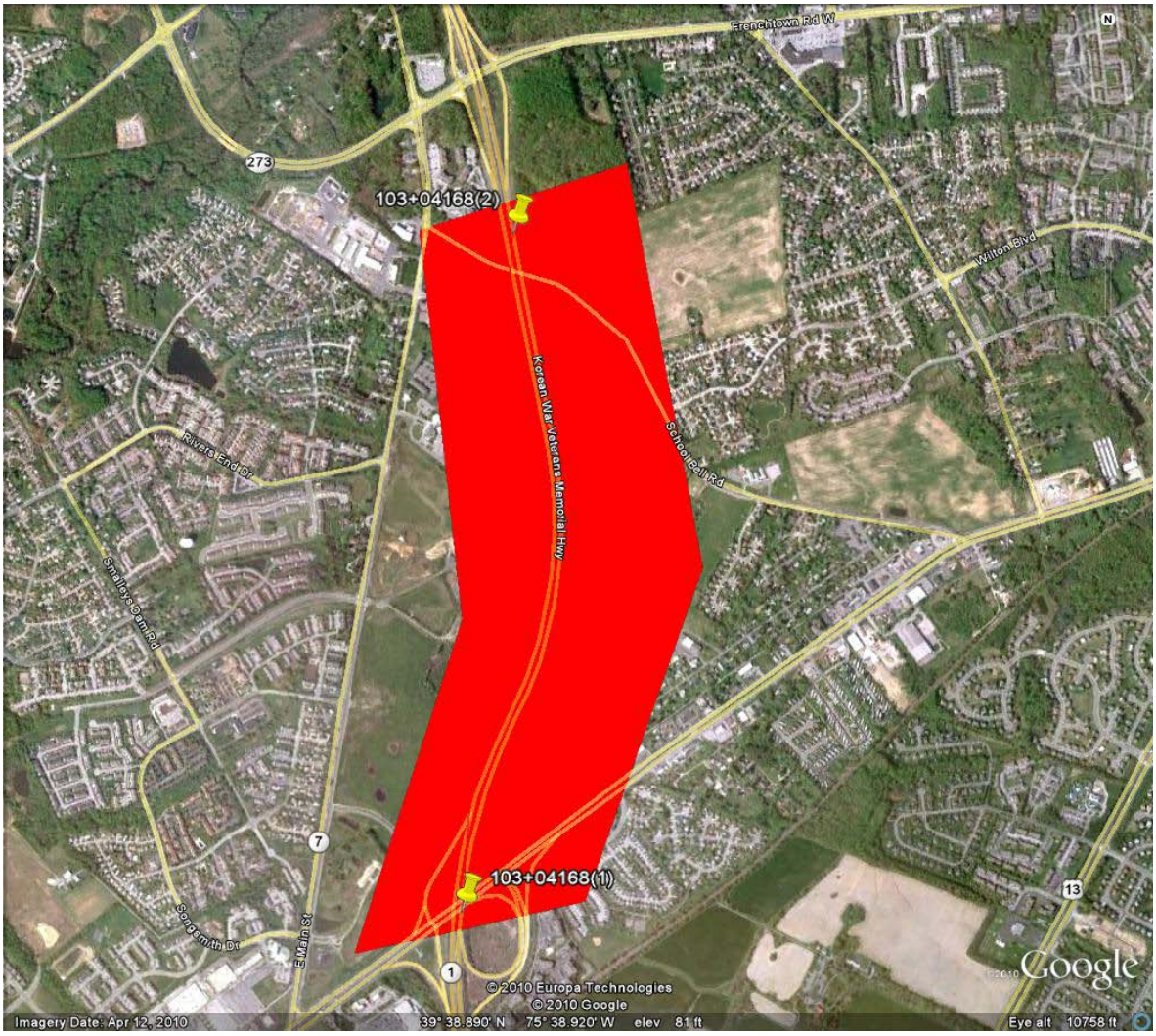

Figure 1 (Cont'd)
TMC segments selected for validation in Delaware

Table 1
Traffic Message Channel segments picked for validation in Delaware

TYPE	TMC	HIGHWAY	STARTING AT	ENDING AT	COUNTY	DIRECTION	LENGTH (mile)
Freeway	**103P04181**	I-295	EXIT 5A	I-95	NEW CASTLE	NORTHBOUND	1.5
Freeway	**103-04106**	I-95	DE-4/MARYLAND AVE/6TH AVE/EXIT 6	I-495/I-295/EXIT 5	NEW CASTLE	SOUTHBOUND	1.7
Freeway	**103N04181**	I-295	I-95	I-95	NEW CASTLE	SOUTHBOUND	1.3
Freeway	**103-04103**	I-95	EXIT 5A	DE-58/EXIT 4	NEW CASTLE	SOUTHBOUND	1.8
Freeway	**103-04105**	I-95	I-495/I-295/EXIT 5	I-295/US-202/DE-141/EXIT 5	NEW CASTLE	SOUTHBOUND	1.4
Freeway	**103+04107**	I-95	I-495/I-295/EXIT 5	DE-4/MARYLAND AVE/6TH AVE/EXIT 6	NEW CASTLE	NORTHBOUND	2.5
Freeway	**103+04174**	I-495	I-295/I-95	US-13/N DUPONT HWY/EXIT 1	NEW CASTLE	NORTHBOUND	1.8
Freeway	**103-04175**	I-495	12TH ST/EXIT 3	TERMINAL AVE/EXIT 2	NEW CASTLE	SOUTHBOUND	1.1
Freeway	**103+04168**	DE-1	US-40/EXIT 160	DE-273/EXIT 162	NEW CASTLE	NORTHBOUND	1.4
Sub-Total							14.4
Arterial	**103-05804**	US-13	I-295	DE-141/W BASIN RD	NEW CASTLE	SOUTHBOUND	1.0
Sub-Total							1.0
TOTAL							**15.4**

Table 2
TMC segment lengths and distances between sensor deployment locations in the state of Delaware

SEGMENT TYPE	TMC	STANDARD TMC					Sensor Actual Location					ERROR IN SEGMENT LENGTH (%)
		Endpoint (1)		Endpoint (2)		Length	Endpoint (1)		Endpoint (2)		Length	
		Lat	Long	Lat	Long	(mile)	Lat	Long	Lat	Long	(mile)	
Freeway	**103P04181**	39.698225	-75.610400	39.698202	-75.583275	1.5	39.698318	-75.609612	39.697495	-75.582535	1.57	2.1%
Freeway	**103-04106**	39.736472	-75.563122	39.717357	-75.581666	1.7	39.735626	-75.563858	39.717903	-75.581223	1.56	-6.5%
Freeway	**103N04181**	39.699608	-75.584586	39.703968	-75.603690	1.3	39.699745	-75.584496	39.704567	-75.603294	1.27	-3.2%
Freeway	**103-04103**	39.699375	-75.611638	39.688650	-75.641743	1.8	39.700115	-75.610184	39.689117	-75.640883	1.81	2.3%
Freeway	**103-04105**	39.716168	-75.583136	39.704166	-75.603425	1.4	39.717903	-75.581223	39.704567	-75.603294	1.50	10.2%
Freeway	**103+04107**	39.706171	-75.587758	39.735580	-75.563602	2.5	39.707287	-75.587692	39.737068	-75.562622	2.50	1.6%
Freeway	**103+04174**	39.708144	-75.587429	39.716907	-75.558203	1.8	39.707283	-75.587585	39.716869	-75.559425	1.80	-0.3%
Freeway	**103-04175**	39.732740	-75.524405	39.721286	-75.538924	1.1	39.733093	-75.524246	39.721184	-75.539398	1.15	4.1%
Freeway	**103+04168**	39.636657	-75.653156	39.656538	-75.651225	1.4	39.637856	-75.65287	39.656803	-75.651215	1.35	-4.4%
SUBTOTAL						**14.4**					**14.51**	**0.5%**
Arterial	**103-05804**	39.693905	-75.578401	39.681887	-75.589200	1.0	39.693893	-75.578621	39.681503	-75.59008	1.06	5.0%
SUBTOTAL						**1.0**					**1.06**	**5.0%**
TOTAL						**15.4**					**15.57**	**0.8%**

Table 3
Path segments identified for validation in Delaware

Type	Validation Segment	STANDARD SEGMENTS INCLUDED	STARTING AT	ENDING AT	LENGTH (MILE)		
		TMC(1)			Standard	Deployment	Error (%)
Freeway	**103P04181**	103P04181	EXIT 5A	I-95	1.5	1.57	2.12%
Freeway	**103-04106**	103-04106	DE-4/MARYLAND AVE/6TH AVE/EXIT 6	I-495/I-295/EXIT 5	1.7	1.56	-6.47%
Freeway	**103N04181**	103N04181	I-95	I-95	1.3	1.27	-3.16%
Freeway	**103-04103**	103-04103	EXIT 5A	DE-58/EXIT 4	1.8	1.81	2.29%
Freeway	**103-04105**	103-04105	I-495/I-295/EXIT 5	I-295/US-202/DE-141/EXIT 5	1.4	1.50	10.20%
Freeway	**103+04107**	103+04107	I-495/I-295/EXIT 5	DE-4/MARYLAND AVE/6TH AVE/EXIT 6	2.5	2.50	1.56%
Freeway	**103+04174**	103+04174	I-295/I-95	US-13/N DUPONT HWY/EXIT 1	1.8	1.80	-0.33%
Freeway	**103-04175**	103-04175	12TH ST/EXIT 3	TERMINAL AVE/EXIT 2	1.1	1.15	4.07%
Freeway	**103+04168**	103+04168	US-40/EXIT 160	DE-273/EXIT 162	1.4	1.35	-4.44%
Arterial	**103-05804**	103-05804	I-295	DE-141/W BASIN RD	1.0	1.06	5.04%
TOTAL					**15.4**	**15.57**	**0.83%**

Table 4
Data quality measures for freeway segments greater than one mile in Delaware

SPEED BIN	Data Quality Measures for				No. of Obs.
	1.96 SE Band		Mean		
	Speed Error Bias	Average Absolute Speed Error	Speed Error Bias	Average Absolute Speed Error	
0-30	3.0	3.9	3.7	5.3	455
30-45	4.3	6.2	5.7	8.3	524
45-60	0.6	1.6	1.4	3.4	5262
60+	-1.8	2.0	-3.7	4.5	12014

Table 5
Percent observations meeting data quality criteria for freeway segments greater than one mile in Delaware

SPEED BIN	Data Quality Measures for				No. of Obs.
	1.96 SE Band		Mean		
	Percentage falling inside the band	Percentage falling within 5 mph of the band	Percentage equal to the mean	Percentage within 5 mph of the mean	
0-30	27%	77%	0%	67%	455
30-45	11%	48%	0%	31%	524
45-60	47%	91%	0%	76%	5262
60+	43%	85%	0%	63%	12014

Table 6
Data quality measures for individual freeway validation segments greater than one mile in the state of Delaware

TMC	Standard TMC length	Bluetooth distance	SPEED BIN	Data Quality Measures for				No. of Obs.
				1.96 SE Band		Mean		
				Speed Error Bias	Average Absolute Speed Error	Speed Error Bias	Average Absolute Speed Error	
103+04107	**2.46**	**2.50**	0-30	4.3	5.0	4.9	6.2	26*
			30-45	5.7	6.2	6.9	8.1	49
			45-60	0.8	0.9	2.0	2.7	418
			60+	-0.6	0.9	-1.8	2.8	895
103+04174	**1.81**	**1.80**	0-30					
			30-45					
			45-60	1.0	1.0	3.5	3.5	20*
			60+	-3.1	3.2	-6.1	6.4	2213
103-04103	**1.77**	**1.81**	0-30	3.0	3.4	4.0	4.6	32
			30-45	3.4	4.1	4.8	6.0	47
			45-60	1.6	1.9	3.4	4.1	264
			60+	-1.0	1.5	-2.2	3.5	1498
103-04105	**1.36**	**1.50**	0-30	4.6	5.5	5.9	7.9	28*
			30-45	4.3	5.4	5.5	7.0	178
			45-60	1.2	1.9	2.6	3.8	456
			60+	-0.5	0.9	-1.5	2.9	1590
103-04106	**1.67**	**1.56**	0-30	1.2	2.1	1.6	3.4	233
			30-45	4.5	6.8	5.0	9.2	48
			45-60	0.4	1.9	1.0	3.8	303
			60+	-1.6	1.8	-3.3	4.1	1555
103-04175	**1.10**	**1.15**	0-30					
			30-45					
			45-60	1.5	1.5	5.5	5.5	43
			60+	-1.4	1.7	-3.7	4.8	1781
103N04181	**1.31**	**1.27**	0-30	11.5	13.1	13.5	15.9	51
			30-45	6.0	7.8	8.7	11.1	137
			45-60	1.1	1.4	2.1	3.2	2599
			60+	-1.6	1.7	-4.4	4.7	78
103P04181	**1.54**	**1.57**	0-30	2.4	2.7	2.6	3.1	50
			30-45	1.7	8.5	1.5	9.9	18*
			45-60	-1.3	2.1	-2.0	4.0	1027
			60+	-3.8	4.0	-5.9	6.3	1286
103+04168	**1.41**	**1.35**	0-30	1.6	2.6	1.8	3.4	35
			30-45	-0.1	5.3	-0.2	6.6	47
			45-60	0.9	1.0	2.7	3.1	132
			60+	-1.4	1.7	-3.0	4.0	1118

*Results in the specified row may not be reliable due to small number of observations

Table 7
Observations meeting data quality criteria for individual freeway validation segments greater than one mile in the state of Delaware

TMC	SPEED BIN	Data Quality Measures for								No. of Obs.
		1.96 SE Band				Mean				
		Speed Error Bias		Average Absolute Speed Error		Speed Error Bias		Average Absolute Speed Error		
		No. falling inside the band	% falling inside the band	No. falling within 5 mph of the band	% falling within 5 mph of the band	No. equal to the mean	% equal to the mean	No. within 5 mph of the mean	% within 5 mph of the mean	
103+04107	0-30	2	8%	16	62%	0	0%	13	50%	26*
	30-45	9	18%	28	57%	0	0%	19	39%	49
	45-60	240	57%	402	96%	1	0%	360	86%	418
	60+	496	55%	867	97%	0	0%	770	86%	895
103+04174	0-30									
	30-45									
	45-60	11	55%	19	95%	0	0%	15	75%	20*
	60+	649	29%	1597	72%	1	0%	873	39%	2213
103-04103	0-30	3	9%	26	81%	0	0%	21	66%	32
	30-45	11	23%	34	72%	0	0%	24	51%	47
	45-60	109	41%	234	89%	0	0%	181	69%	264
	60+	656	44%	1367	91%	0	0%	1126	75%	1498
103-04105	0-30	8	29%	19	68%	0	0%	19	68%	28*
	30-45	13	7%	96	54%	0	0%	72	40%	178
	45-60	185	41%	400	88%	4	1%	335	73%	456
	60+	933	59%	1542	97%	0	0%	1354	85%	1590
103-04106	0-30	89	38%	204	88%	0	0%	176	76%	233
	30-45	11	23%	23	48%	0	0%	13	27%	48
	45-60	150	50%	261	86%	1	0%	229	76%	303
	60+	623	40%	1379	89%	2	0%	1038	67%	1555
103-04175	0-30									
	30-45									
	45-60	19	44%	37	86%	0	0%	26	60%	43
	60+	940	53%	1558	87%	0	0%	1032	58%	1781
103N04181	0-30	5	10%	16	31%	0	0%	9	18%	51
	30-45	9	7%	35	26%	0	0%	11	8%	137
	45-60	1287	50%	2398	92%	0	0%	2055	79%	2599
	60+	27	35%	72	92%	0	0%	50	64%	78
103P04181	0-30	8	16%	43	86%	0	0%	42	84%	50
	30-45	2	11%	6	33%	0	0%	3	17%	18*
	45-60	410	40%	902	88%	0	0%	689	67%	1027
	60+	302	23%	833	65%	0	0%	587	46%	1286
103+04168	0-30	7	20%	28	80%	0	0%	26	74%	35
	30-45	4	9%	27	57%	0	0%	22	47%	47
	45-60	84	64%	124	94%	0	0%	109	83%	132
	60+	496	44%	1019	91%	0	0%	759	68%	1118

*Results in the specified row may not be reliable due to small number of observations

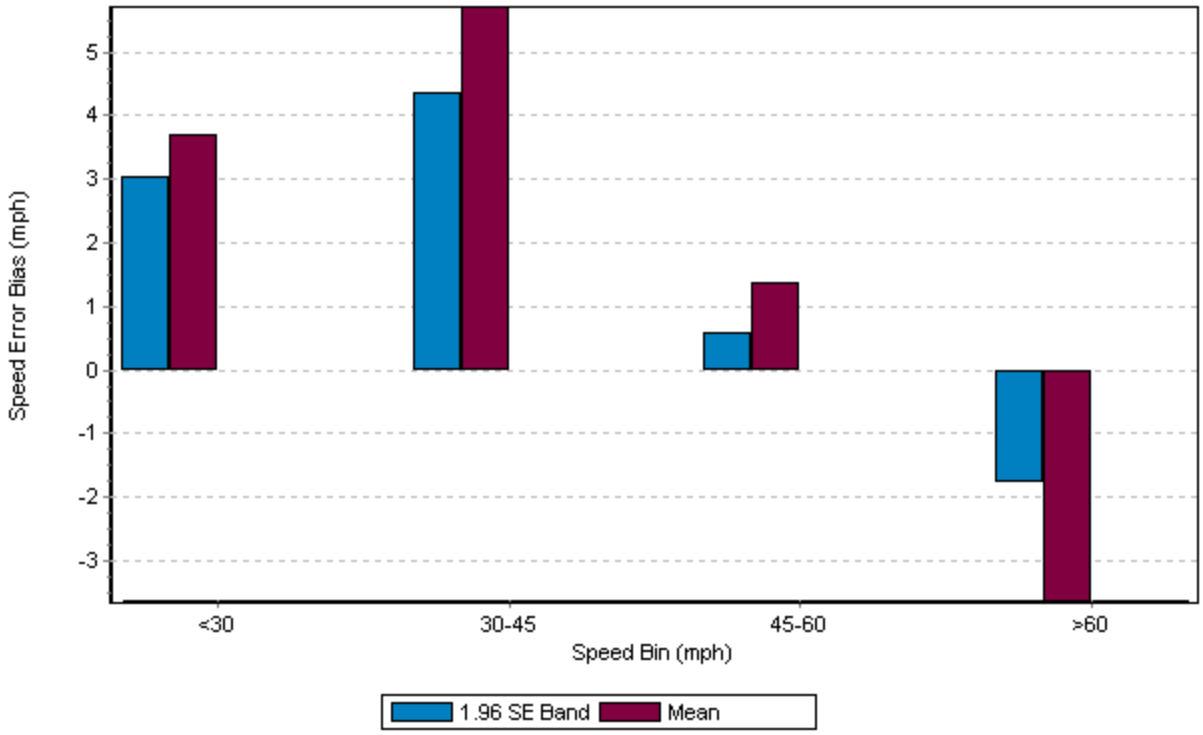

Figure 2
Speed error bias for freeway segments greater than one mile in Delaware

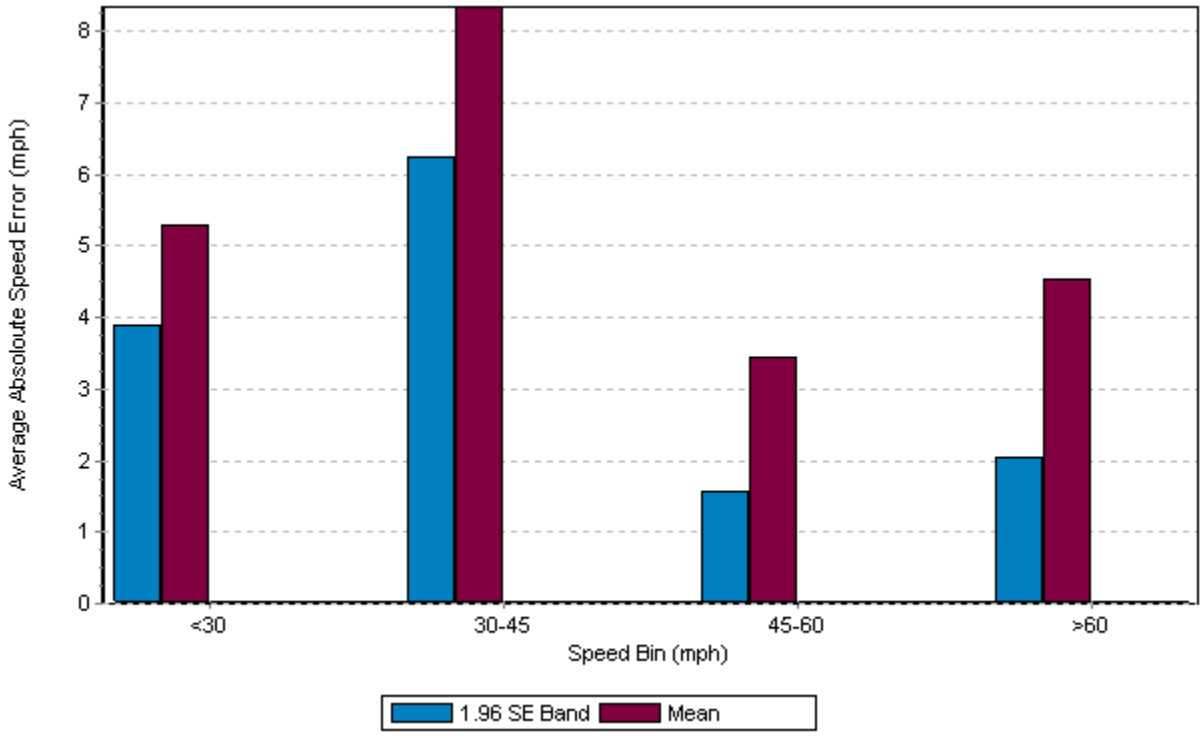

Figure 3
Average absolute speed error for freeway segments greater than one mile in Delaware

Analysis of Results for Arterials

Travel time samples collected along US Route 13 were compared with travel time and speed data reported by INRIX as part of this project. The arterial data is included for informational purposes noting that INRIX has volunteered arterial data at no cost to the Coalition for the first three years, and that the method to evaluate quality on arterial roadways has not been fully evaluated. The Coalition is currently in the process of developing appropriate quality metrics and validation methods.

Table 8 summarizes the data quality measures obtained as a result of comparison between Bluetooth and all reported INRIX speeds on one arterial segment considered in this round of validations. In all speed bins above 30 mph, INRIX data meets the freeway data quality measures set forth in the contract when errors are measured as a distance from the 1.96 times the standard error band. In less than 30 mph speed bin, INRIX data barely fails to meet data quality measures solely based on the bias criterion.

Table 9 shows the percentage of the time intervals that fall within 5 mph of the SEM band and the mean for each speed bin for the arterial segment in Delaware.

Figures 4 and 5 show the overall speed error biases for different speed bins, and the average absolute speed errors for the arterial segment in Delaware, respectively. These figures correspond to Table 8.

Table 8
Data quality measures for individual arterial validation segments greater than one mile in the state of Delaware

TMC	Standard TMC length	Bluetooth distance	SPEED BIN	Data Quality Measures for				No. of Obs.
				1.96 SE Band		Mean		
				Speed Error Bias	Average Absolute Speed Error	Speed Error Bias	Average Absolute Speed Error	
103-05804	1.01	1.06	0-30	5.1	5.1	9.8	9.9	972
			30-45	0.4	1.1	0.8	4.5	590
			45-60	-4.1	4.3	-7.9	8.9	82
			60+					

Table 9
Observations meeting data quality criteria for individual arterial validation segments greater than one mile in the state of Delaware

TMC	SPEED BIN	Data Quality Measures for								No. of Obs.
		1.96 SE Band				Mean				
		Speed Error Bias		Average Absolute Speed Error		Speed Error Bias		Average Absolute Speed Error		
		No. falling inside the band	% falling inside the band	No. falling within 5 mph of the band	% falling within 5 mph of the band	No. equal to the mean	% equal to the mean	No. within 5 mph of the mean	% within 5 mph of the mean	
103-05804	0-30	225	23%	542	56%	0	0%	255	26%	972
	30-45	404	68%	539	91%	0	0%	383	65%	590
	45-60	17	21%	51	62%	0	0%	13	16%	82
	60+									

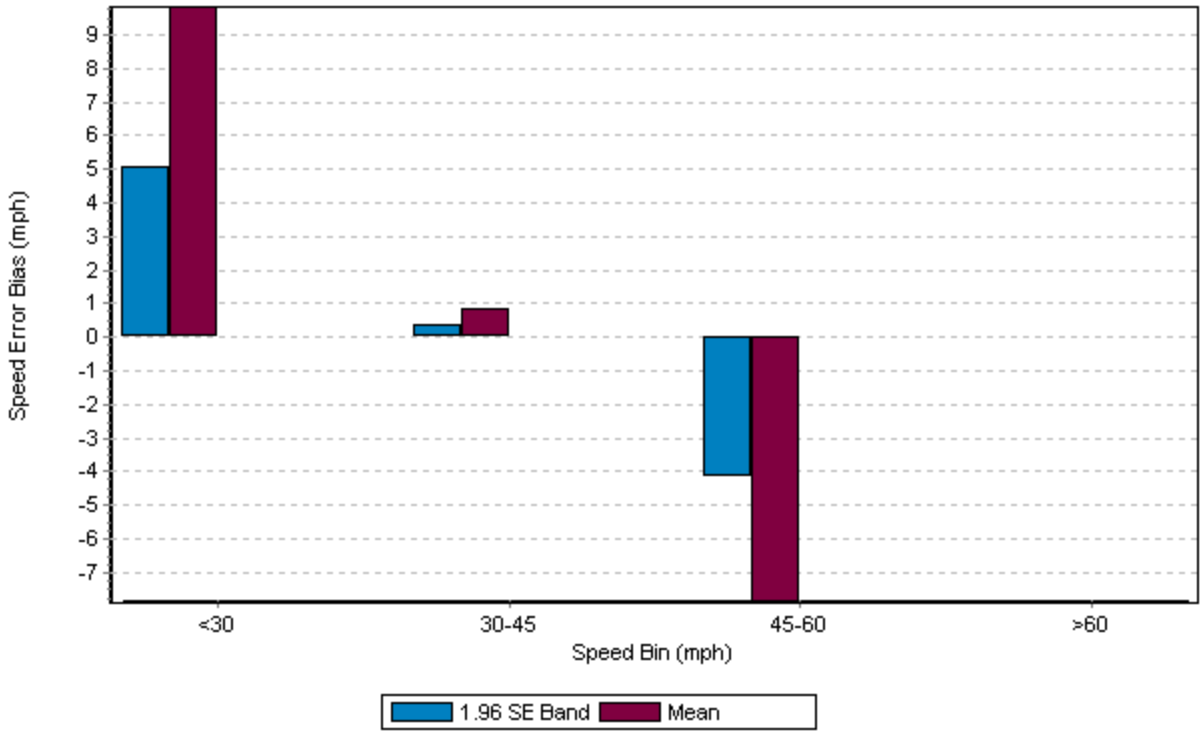

Figure 4
Speed error bias for arterial segments greater than one mile in Delaware

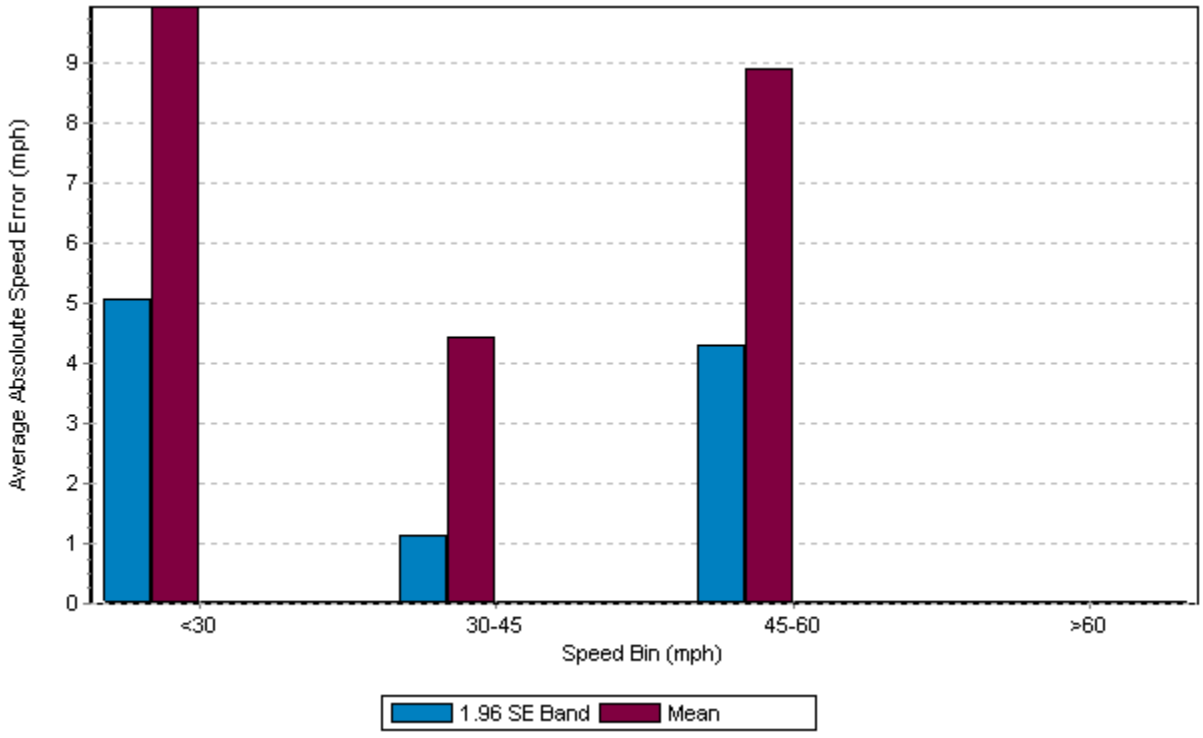

Figure 5
Average absolute speed error for arterial segments greater than one mile in Delaware