



I-95 Corridor Coalition

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



November 2010

I-95 CORRIDOR COALITION VEHICLE PROBE PROJECT: VALIDATION OF INRIXDATA NOVEMBER 2010

Monthly Report

Prepared for:

I-95 Corridor Coalition

Sponsored by:

I-95 Corridor Coalition

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November 2010

Evaluation Results for the State of Maryland

Executive Summary

Travel time samples were collected along approximately 13.4 freeway miles, 5.9 miles of ramps, and 7.6 miles of arterials from Wednesday, October 6, 2010 through Monday, October 18, 2010. Freeway and ramps segments were located at the intersection of US50 and I495/95 on the eastern side of the Washington DC beltway. The arterial data segments were from Route 3 just north on the intersection with US 50. Data collected were 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 nearly 950 hours of observations along eight freeway segments, totaling approximately 13.4 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 average absolute speed error (AASE). The 2.40 MPH AASE measure in the 0-30 MPH band is the lowest recorded error in that band since validation began in July of 2008.

ES Table 1 - Maryland 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		
0-30 MPH	2.40	3.50	1.20	1.50	424	35.3
30-45 MPH	4.30	7.40	3.10	5.40	341	28.4
45-60 MPH	2.60	5.50	2.10	4.50	2785	232.1
> 60 MPH	1.90	4.70	-1.40	-2.70	7837	653.1
All Speeds	2.16	4.93	-0.31	-0.54	11387	948.9

Based upon data collected from October 6, 2010 through October 18, 2010 across 13.4 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 the State of Maryland were validated on four occasions: August 2008, March 2009, February 2010, and October 2010. This represents more than 2800 hours of observations along nearly 83 miles of freeway segments in Maryland. ES Table 2 provides a summary of the cumulative validation effort. As shown, the absolute average speed error and speed error bias is within specification for all speed bins.

ES Table 2 - Maryland - Cumulative to Date						
Speed Bin	Absolute Speed Error		Speed Error Bias		Number of 5 Minute Samples	Hours of Data Collection
	Comparison with SEM Band	Comparison with Mean	Comparison with SEM Band	Comparison with Mean		
0-30 MPH	3.50	4.82	1.37	1.72	1727	143.9
30-45 MPH	4.35	6.76	1.96	3.01	2108	175.7
45-60 MPH	2.11	4.30	0.52	1.38	11198	933.2
> 60 MPH	1.80	4.29	-1.44	-2.81	19578	1631.5
All Speeds	2.14	4.47	-0.46	-0.88	34611	2884.3

Validation data collected from the 5.9 miles of freeway ramps represented seven of the eight ramps within the freeway interchange. This data was analyzed separately and not included in this analysis described above. Ramp data is being evaluated for informational purposes only, and is not subject to the quality specifications for freeway data. Even so, the specifications for freeway AASE were met in all speed categories for the ramp data, and the specifications for freeway speed error bias (SEB) were met in the 30-45 MPH, and 45-60 MPH speed bins. The ramp validation failed to meet the freeway SEB specification by only 0.6 and 0.4 MPH for the 0-30 MPH and >60 MPH speed bins respectively.

Travel time samples collected along Route 3 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.

The validation exercises in Maryland in October of 2010 have been the most productive to date in that data from a total of 19 segments (8 freeway, 7 ramps, and 4 arterials) were collected and analyzed.

Data Collection

Bluetooth sensor deployments in Maryland started on Wednesday, October 6, 2010. The actual deployments in Maryland were performed with the assistance of Maryland Coordinated Highways Action Response Team (CHART) personnel. Sensors remained in the same position until they were retrieved two weeks later on Monday, October 18, 2010. This round of data collections in Maryland 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 Maryland. In this figure, red segments represent freeway segments while the blue color indicates the arterial segments 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 Maryland. These segments cover a total length of about 13 freeway miles, over seven arterial miles, and about six ramp miles. Since some TMC segments in this corridor are less than one mile long, when appropriate, consecutive TMC segments are combined to form path segments longer than one mile. In total, in this document results of validation performed on eight freeways segments are reported; six of which are path segments combined from multiple standard TMC segments. The coordinates of the locations at which the Bluetooth sensors were deployed throughout the state of Maryland 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 which also presents the distances that have been used in the estimation of Bluetooth speeds based on travel times. Details of the algorithm used to estimate equivalent path travel times based on INRIX data feeds for individual TMC segments are provided in a separate report. This algorithm finds an equivalent INRIX travel time (and therefore travel speed) corresponding to each sample Bluetooth travel time observation on the path segment of interest.

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 Maryland. Tables 6 and 7 present detailed data for individual TMC segments in Maryland 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 Maryland, respectively. These figures correspond to Table 4.

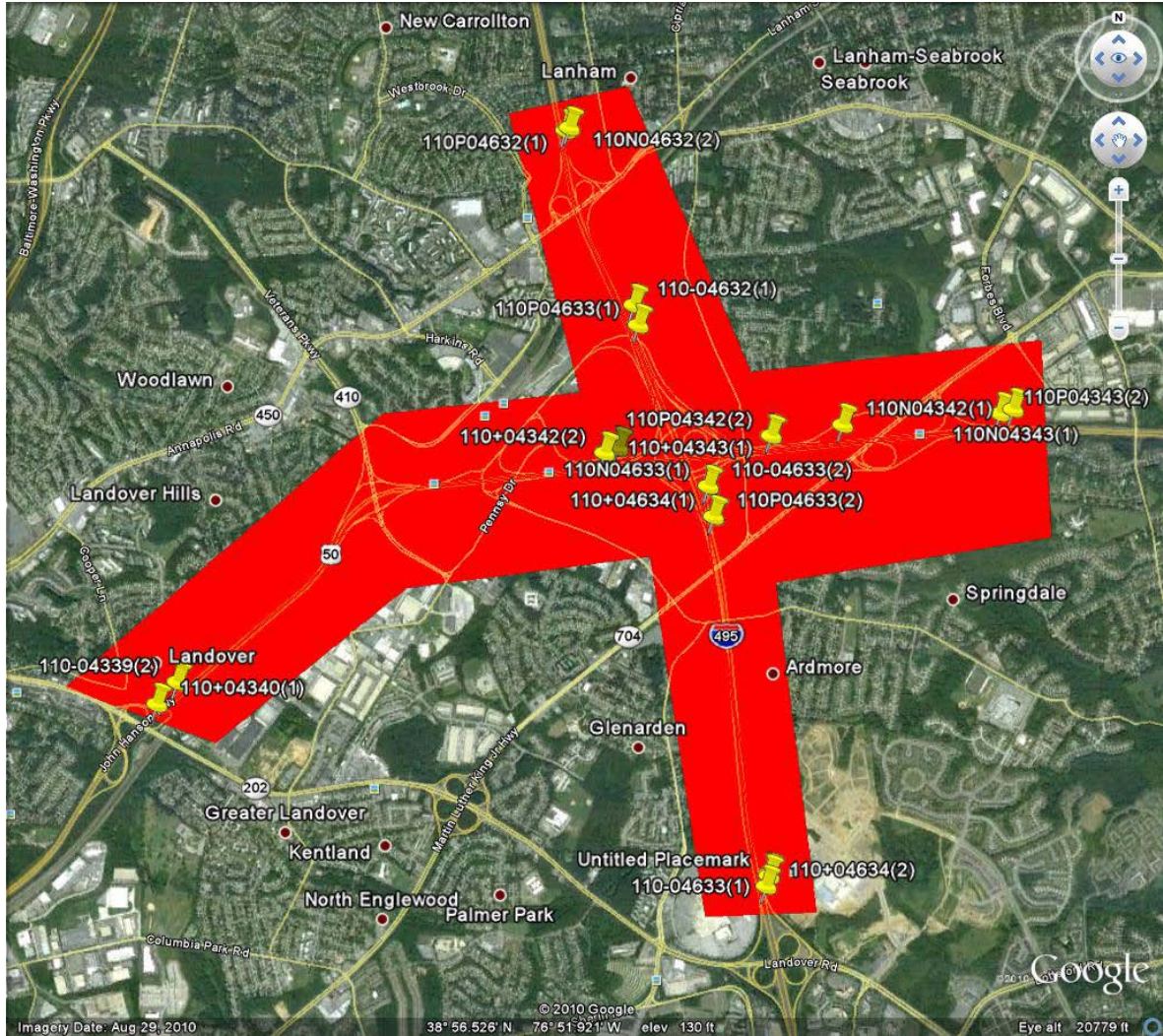


Figure 1
TMC segments selected for validation in Maryland

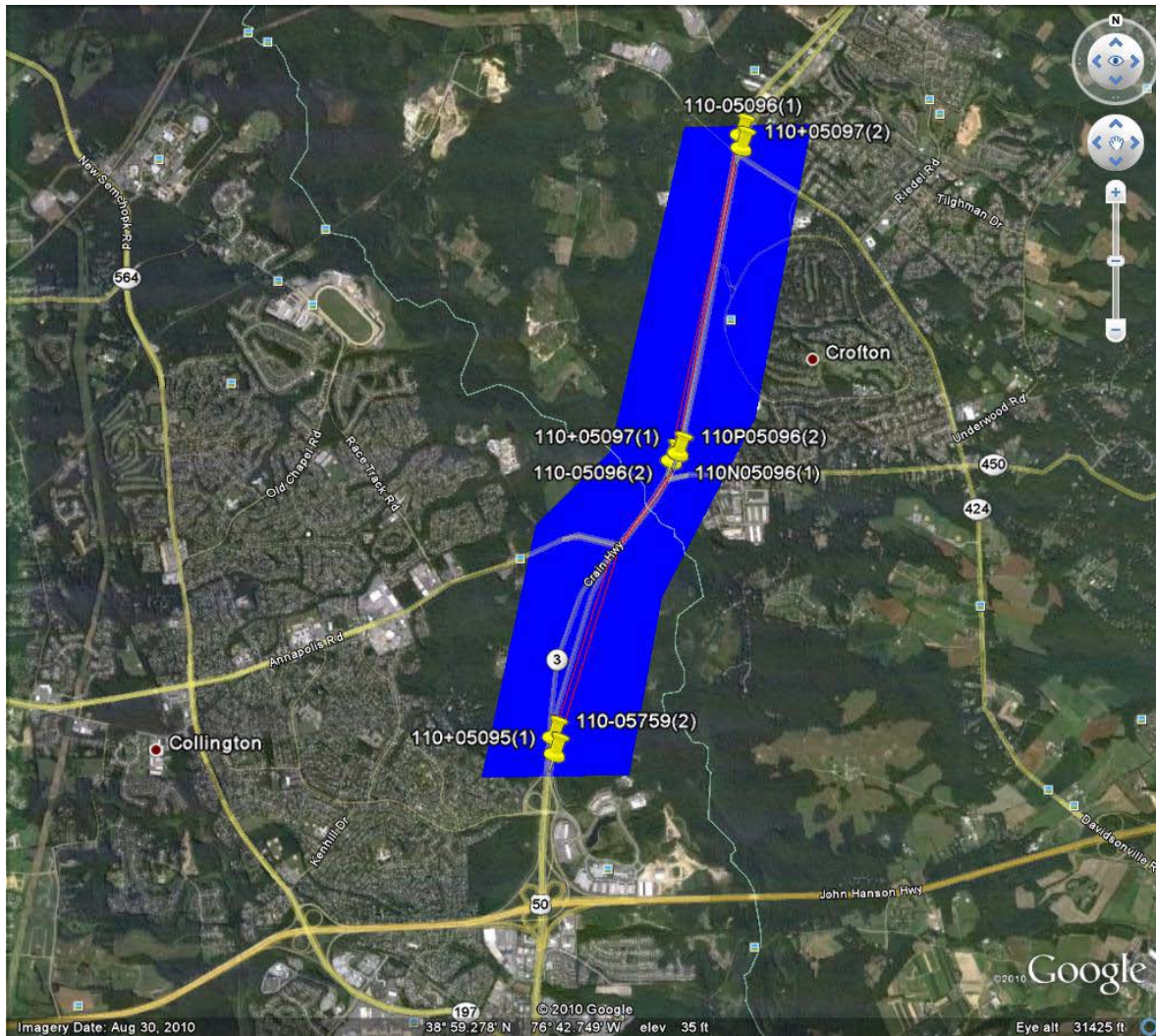


Figure 1 (Cont'd)
TMC segments selected for validation in Maryland

Table 1
Traffic Message Channel segments picked for validation in Maryland

TYPE	TMC	HIGHWAY	STARTING AT	ENDING AT	COUNTY	DIRECTION	LENGTH (mile)
Freeway	110+04340	US-50	MD-202/LANDOVER RD	MD-410/EXIT 5	PRINCE GEORGE'S	EASTBOUND	0.9
Freeway	110P04340	US-50	MD-410/EXIT 5	MD-410/EXIT 5	PRINCE GEORGE'S	EASTBOUND	0.6
Freeway	110+04341	US-50	MD-410/EXIT 5	GARDEN CITY DR/EXIT 6	PRINCE GEORGE'S	EASTBOUND	0.1
Freeway	110P04341	US-50	GARDEN CITY DR/EXIT 6	GARDEN CITY DR/EXIT 6	PRINCE GEORGE'S	EASTBOUND	0.2
Freeway	110+04342	US-50	GARDEN CITY DR/EXIT 6	I-495/I-95/CAPITAL BELTWAY/EXIT 7	PRINCE GEORGE'S	EASTBOUND	0.3
Freeway	110P04342	US-50	I-495/I-95/CAPITAL BELTWAY/EXIT 7	I-495/I-95/CAPITAL BELTWAY/EXIT 7	PRINCE GEORGE'S	EASTBOUND	0.6
Freeway	110+04343	US-50	I-495/I-95/CAPITAL BELTWAY/EXIT 7	MD-704/MLK JR HWY/EXIT 8	PRINCE GEORGE'S	EASTBOUND	0.4
Freeway	110P04343	US-50	MD-704/MLK JR HWY/EXIT 8	MD-704/MLK JR HWY/EXIT 8	PRINCE GEORGE'S	EASTBOUND	0.5
Freeway	110N04343	US-50	MD-704/MLK JR HWY/EXIT 8	MD-704/MLK JR HWY/EXIT 8	PRINCE GEORGE'S	WESTBOUND	0.4
Freeway	110-04342	US-50	MD-704/MLK JR HWY/EXIT 8	I-495/I-95/CAPITAL BELTWAY/EXIT 7	PRINCE GEORGE'S	WESTBOUND	0.3
Freeway	110N04342	US-50	I-495/I-95/CAPITAL BELTWAY/EXIT 7	I-495/I-95/CAPITAL BELTWAY/EXIT 7	PRINCE GEORGE'S	WESTBOUND	0.9
Freeway	110-04341	US-50	I-495/I-95/CAPITAL BELTWAY/EXIT 7	GARDEN CITY DR/EXIT 6	PRINCE GEORGE'S	WESTBOUND	0.3
Freeway	110N04341	US-50	GARDEN CITY DR/EXIT 6	GARDEN CITY DR/EXIT 6	PRINCE GEORGE'S	WESTBOUND	0.4
Freeway	110-04340	US-50	GARDEN CITY DR/EXIT 6	MD-410/EXIT 5	PRINCE GEORGE'S	WESTBOUND	0.1
Freeway	110N04340	US-50	MD-410/EXIT 5	MD-410/EXIT 5	PRINCE GEORGE'S	WESTBOUND	0.4
Freeway	110-04339	US-50	MD-410/EXIT 5	MD-202/LANDOVER RD	PRINCE GEORGE'S	WESTBOUND	0.9
Freeway	110-04633	I-495	MD-202/LANDOVER RD/EXIT 17	US-50/EXIT 19	PRINCE GEORGE'S	COUNTERCLOCKWISE	1.5
Freeway	110N04633	I-495	US-50/EXIT 19	US-50/EXIT 19	PRINCE GEORGE'S	COUNTERCLOCKWISE	0.8
Freeway	110-04632	I-495	US-50/EXIT 19	MD-450/ANNAPOLIS RD/EXIT 20	PRINCE GEORGE'S	COUNTERCLOCKWISE	0.4
Freeway	110N04632	I-495	MD-450/ANNAPOLIS RD/EXIT 20	MD-450/ANNAPOLIS RD/EXIT 20	PRINCE GEORGE'S	COUNTERCLOCKWISE	0.4
Freeway	110P04632	I-495	MD-450/ANNAPOLIS RD/EXIT 20	MD-450/ANNAPOLIS RD/EXIT 20	PRINCE GEORGE'S	CLOCKWISE	0.2
Freeway	110+04633	I-495	MD-450/ANNAPOLIS RD/EXIT 20	US-50/EXIT 19	PRINCE GEORGE'S	CLOCKWISE	0.6
Freeway	110P04633	I-495	US-50/EXIT 19	US-50/EXIT 19	PRINCE GEORGE'S	CLOCKWISE	0.8
Freeway	110+04634	I-495	US-50/EXIT 19	MD-202/LANDOVER RD/EXIT 17	PRINCE GEORGE'S	CLOCKWISE	1.5
SUBTOTAL							13.4

Table 1 (Cont'd)
Traffic Message Channel segments picked for validation in Maryland

TYPE	TMC	STARTING AT	ENDING AT	COUNTY	DIRECTION	LENGTH (mile)
Ramp	110P14591	I-495/I-95/CAPITAL BELTWAY/EXIT 7	EXIT 7	PRINCE GEORGE'S	I-495	0.1
Ramp	110P14593	EXIT 7	EXIT 7	PRINCE GEORGE'S	I-495 SOUTHBOUND	0.4
Ramp	110P14595	EXIT 7	EXIT 7	PRINCE GEORGE'S	I-495 SOUTHBOUND	0.1
Ramp	110P14591	I-495/I-95/CAPITAL BELTWAY/EXIT 7	EXIT 7	PRINCE GEORGE'S	I-495	0.1
Ramp	110P14597	EXIT 7	EXIT 7A	PRINCE GEORGE'S	I-495 NORTHBOUND	0.8
Ramp	110P14599	EXIT 7A	EXIT 7A	PRINCE GEORGE'S	I-495 NORTHBOUND	0.2
Ramp	110P14605	I-495/I-95/CAPITAL BELTWAY/EXIT 7	EXIT 7B	PRINCE GEORGE'S	I-495 NORTHBOUND	0.2
Ramp	110P14607	EXIT 7B	EXIT 7B	PRINCE GEORGE'S	I-495 NORTHBOUND	0.2
Ramp	110P14609	EXIT 7B	EXIT 7B	PRINCE GEORGE'S	I-495 NORTHBOUND	0.4
Ramp	110P14599	EXIT 7B	EXIT 7B	PRINCE GEORGE'S	I-495 NORTHBOUND	0.2
Ramp	110P14605	I-495/I-95/CAPITAL BELTWAY/EXIT 7	EXIT 7A	PRINCE GEORGE'S	I-495 NORTHBOUND	0.2
Ramp	110P14611	EXIT 7A	EXIT 7A	PRINCE GEORGE'S	I-495 SOUTHBOUND	0.8
Ramp	110P14595	EXIT 7A	EXIT 7A	PRINCE GEORGE'S	I-495 SOUTHBOUND	0.1
Ramp	110P14601	US-50/EXIT 19	EXIT 19A	PRINCE GEORGE'S	US-50 EASTBOUND	0.5
Ramp	110P14613	US-50/EXIT 19	EXIT 19B	PRINCE GEORGE'S	US-50 EASTBOUND	0.3
Ramp	110P14617	EXIT 19B	EXIT 19B	PRINCE GEORGE'S	US-50 WESTBOUND	0.2
Ramp	110P14619	EXIT 19B	EXIT 19B	PRINCE GEORGE'S	US-50 WESTBOUND	0.2
Ramp	110P14613	US-50/EXIT 19	EXIT 19A	PRINCE GEORGE'S	US-50 EASTBOUND	0.3
Ramp	110P14615	EXIT 19A	EXIT 19A	PRINCE GEORGE'S	US-50 EASTBOUND	0.6
SUBTOTAL						5.9

Table 1 (Cont'd)
Traffic Message Channel segments picked for validation in Maryland

TYPE	TMC	HIGHWAY	STARTING AT	ENDING AT	COUNTY	DIRECTION	LENGTH (mile)
Arterial	110+05095	MD-3	BELAIR DR	MD-450/ANNAPOLIS RD	PRINCE GEORGE'S	NORTHBOUND	1.4
Arterial	110P05095	MD-3	MD-450/ANNAPOLIS RD	MD-450/ANNAPOLIS RD	PRINCE GEORGE'S	NORTHBOUND	0.0
Arterial	110+05096	MD-3	MD-450/ANNAPOLIS RD	MD-450/DEFENSE HWY	ANNE ARUNDEL	NORTHBOUND	0.4
Arterial	110P05096	MD-3	MD-450/DEFENSE HWY	MD-450/DEFENSE HWY	ANNE ARUNDEL	NORTHBOUND	0.1
Arterial	110+05097	MD-3	MD-450/DEFENSE HWY	MD-424/CONWAY RD/DAVIDSONVILLE RD	ANNE ARUNDEL	NORTHBOUND	1.8
Arterial	110-05096	MD-3	MD-424/CONWAY RD/DAVIDSONVILLE RD	MD-450/DEFENSE HWY	ANNE ARUNDEL	SOUTHBOUND	2.0
Arterial	110N05096	MD-3	MD-450/DEFENSE HWY	MD-450/DEFENSE HWY	ANNE ARUNDEL	SOUTHBOUND	0.0
Arterial	110-05095	MD-3	MD-450/DEFENSE HWY	MD-450/ANNAPOLIS RD	PRINCE GEORGE'S	SOUTHBOUND	0.4
Arterial	110N05095	MD-3	MD-450/ANNAPOLIS RD	MD-450/ANNAPOLIS RD	PRINCE GEORGE'S	SOUTHBOUND	0.1
Arterial	110-05759	MD-3	MD-450/ANNAPOLIS RD	BELAIR DR	PRINCE GEORGE'S	SOUTHBOUND	1.3
SUBTOTAL							7.6
TOTAL							26.9

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

SEGMENT TYPE	TMC	STANDARD TMC					SENSOR DEPLOYMENT			
		Endpoint (1)		Endpoint (2)		Length (mile)	Endpoint (1)		Endpoint (2)	
		Lat	Long	Lat	Long		Lat	Long	Lat	Long
Freeway	110+04340	38.930693	-76.896916	38.939471	-76.884335	0.91	38.930893	-76.896461		
Freeway	110P04340	38.939471	-76.884335	38.943994	-76.875752	0.61				
Freeway	110+04341	38.943994	-76.875752	38.944185	-76.872979	0.15				
Freeway	110P04341	38.944185	-76.872979	38.944458	-76.869532	0.19				
Freeway	110+04342	38.944458	-76.869532	38.944879	-76.864473	0.27				
Freeway	110P04342	38.944879	-76.864473	38.945841	-76.852433	0.65	38.944584	-76.866348		
Freeway	110+04343	38.945841	-76.852433	38.946458	-76.844685	0.42	38.945515	-76.852615		
Freeway	110P04343	38.946458	-76.844685	38.947108	-76.835857	0.48			38.946949	-76.835197
Freeway	110N04343	38.947338	-76.834908	38.946875	-76.841959	0.38	38.947365	-76.837685		
Freeway	110-04342	38.946875	-76.841959	38.946455	-76.847270	0.29				
Freeway	110N04342	38.946455	-76.847270	38.945155	-76.863491	0.88	38.946609	-76.848061		
Freeway	110-04341	38.945155	-76.863491	38.944675	-76.869291	0.31	38.945316	-76.863228		
Freeway	110N04341	38.944675	-76.869291	38.944117	-76.875912	0.36				
Freeway	110-04340	38.944117	-76.875912	38.943994	-76.877343	0.08				
Freeway	110N04340	38.943994	-76.877343	38.940901	-76.883760	0.43				
Freeway	110-04339	38.940901	-76.883760	38.931938	-76.895442	0.89			38.932426	-76.895050
Freeway	110-04633	38.921208	-76.852594	38.943003	-76.856977	1.53	38.922310	-76.852814		
Freeway	110N04633	38.943003	-76.856977	38.953170	-76.862360	0.76	38.942051	-76.856422		
Freeway	110-04632	38.953170	-76.862360	38.957762	-76.865119	0.35	38.952942	-76.861977		
Freeway	110N04632	38.957762	-76.865119	38.963177	-76.867032	0.39			38.963928	-76.867088
Freeway	110P04632	38.963022	-76.867292	38.959624	-76.866348	0.24	38.962940	-76.867447		
Freeway	110+04633	38.959624	-76.866348	38.952046	-76.862052	0.57				
Freeway	110P04633	38.952046	-76.862052	38.941294	-76.856602	0.80	38.951073	-76.861671		
Freeway	110+04634	38.941294	-76.856602	38.920534	-76.852785	1.45	38.941357	-76.856827	38.921112	-76.852570
SUBTOTAL						13.37				

Table 2 (Cont'd)
TMC segment lengths and distances between sensor deployment locations in the state of Maryland

SEGMENT TYPE	TMC	STANDARD TMC					SENSOR DEPLOYMENT			
		Endpoint (1)		Endpoint (2)		Length (mile)	Endpoint (1)		Endpoint (2)	
		Lat	Long	Lat	Long		Lat	Long	Lat	Long
Ramp	110P14591	38.944879	-76.864473	38.944902	-76.862652	0.10	38.944584	-76.866348		
Ramp	110P14593	38.944902	-76.862652	38.942539	-76.857293	0.35				
Ramp	110P14595	38.942539	-76.857293	38.941294	-76.856602	0.09			38.941357	-76.856827
Ramp	110P14591	38.94488	-76.86447	38.9449	-76.862652	0.10	38.944584	-76.866348		
Ramp	110P14597	38.9449	-76.86265	38.95013	-76.860502	0.84				
Ramp	110P14599	38.95013	-76.8605	38.95317	-76.86236	0.23			38.952942	-76.861977
Ramp	110P14605	38.94648	-76.8469	38.94631	-76.850877	0.21	38.946609	-76.848061		
Ramp	110P14607	38.94631	-76.85088	38.94665	-76.855261	0.24				
Ramp	110P14609	38.94665	-76.85526	38.95013	-76.860502	0.375				
Ramp	110P14599	38.950125	-76.860502	38.953170	-76.862360	0.23			38.952942	-76.861977
Ramp	110P14605	38.946481	-76.846900	38.946309	-76.850877	0.21	38.946609	-76.848061		
Ramp	110P14611	38.946024	-76.852435	38.942539	-76.857293	0.81				
Ramp	110P14595	38.942539	-76.857293	38.941294	-76.856602	0.09			38.941357	-76.856827
Ramp	110P14601	38.941496	-76.856390	38.945953	-76.851095	0.52	38.942051	-76.856422	38.945515	-76.852615
Ramp	110P14613	38.952489	-76.862308	38.949032	-76.860681	0.25	38.951073	-76.861671		
Ramp	110P14617	38.949042	-76.860441	38.946397	-76.860551	0.19				
Ramp	110P14619	38.946397	-76.860551	38.945155	-76.863491	0.19			38.945316	-76.863228
Ramp	110P14613	38.952489	-76.862308	38.949032	-76.860681	0.25	38.951073	-76.861671		
Ramp	110P14615	38.949032	-76.860681	38.945769	-76.853250	0.62				
SUBTOTAL						5.92				
Arterial	110+05095	38.966532	-76.716523	38.985704	-76.708750	1.41	38.966572	-76.716438		
Arterial	110P05095	38.985704	-76.708750	38.985802	-76.708644	0.01				
Arterial	110+05096	38.985802	-76.708644	38.990419	-76.704129	0.40				
Arterial	110P05096	38.990419	-76.704129	38.992282	-76.702874	0.15				
Arterial	110+05097	38.992282	-76.702874	39.018394	-76.695889	1.84	38.991543	-76.703072	39.018654	-76.695641
Arterial	110-05096	39.019514	-76.695951	38.991623	-76.703591	1.97	39.018654	-76.695641	38.991543	-76.703072
Arterial	110N05096	38.991623	-76.703591	38.991519	-76.703658	0.01	38.991543	-76.703072		
Arterial	110-05095	38.991519	-76.703658	38.986439	-76.708307	0.43				
Arterial	110N05095	38.986439	-76.708307	38.985211	-76.709567	0.11				
Arterial	110-05759	38.985211	-76.709567	38.967960	-76.716685	1.28			38.966572	-76.716438
SUBTOTAL						7.61				
TOTAL						26.90				

Table 3
Path segments identified for validation in Maryland

Type	Validation Segment	STANDARD SEGMENTS INCLUDED								STARTING AT	ENDING AT	LENGTH (MILE)		
		TMC(1)	TMC(2)	TMC(3)	TMC(4)	TMC(5)	TMC(6)	TMC(7)	TMC(8)			Standard	Deployment	Error (%)
Freeway	MD04-0001	110+04340	110P04340	110+04341	110P04341	110+04342				MD-202	I-495/EXIT 7	2.1	2.05	-3.64%
Freeway	MD04-0002	110P04342	110+04343	110P04343						I-495/EXIT 7	MD-704/EXIT 8	1.5	1.68	8.77%
Freeway	MD04-0003	110N04343	110-04342	110N04342						MD-704/EXIT 8	I-495/EXIT 7	1.5	1.45	-6.00%
Freeway	MD04-0004	110-04341	110N04341	110-04340	110N04340	110-04339				I-495/EXIT 7	MD-202	2.1	2.11	1.84%
Freeway	110-04633	110-04633								MD-202/EXIT 17	US-50/EXIT 19	1.5	1.44	-5.68%
Freeway	MD04-0005	110N04633	110-04632	110N04632						US-50/EXIT 19	MD-450/EXIT 20	1.5	1.61	7.45%
Freeway	MD04-0006	110P04632	110+04633	110P04633						MD-450/EXIT 20	US-50/EXIT 19	1.6	1.58	-1.94%
Freeway	110+04634	110+04634								US-50/EXIT 19	MD-202/EXIT 17	1.5	1.46	0.64%
Ramp	MD04-0007	110+04340	110P04340	110+04341	110P04341	110+04342	110P14591	110P14593	110P14595	MD-202	Exit 7	2.7	2.64	-1.14%
Ramp	MD04-0008	110+04340	110P04340	110+04341	110P04341	110+04342	110P14591	110P14597	110P14599	MD-202	Exit 7A	3.3	3.23	-1.99%
Ramp	MD04-0009	110N04343	110-04342	110P14605	110P14607	110P14609	110P14599			MD-704/EXIT 8	Exit 7B	1.7	1.54	-11.16%
Ramp	MD04-0010	110N04343	110-04342	110P14605	110P14611	110P14595				MD-704/EXIT 8	Exit 7A	1.8	1.74	-2.36%
Ramp	MD04-0011	110-04633	110P14601							MD-202/EXIT 17	EXIT 19A - US-50E	2.0	1.86	-9.09%
Ramp	MD04-0012	110P04632	110+04633	110P14613	110P14617	110P14619				MD-450/EXIT 20	EXIT 19B	1.4	1.43	-1.07%
Ramp	MD04-0013	110P04632	110+04633	110P14613	110P14615	110+04343	110P04343			MD-450/EXIT 20	MD-704/EXIT 8	2.6	2.62	1.38%
Arterial	MD04-0014	110+05095	110P05095	110+05096	110P05096					BELAIR DR	MD-450	2.0	2.05	4.58%
Arterial	110+05097	110+05097								MD-450	MD-424	1.8	1.85	0.32%
Arterial	110-05096	110-05096								MD-424	MD-450	2.0	2.05	3.90%
Arterial	MD04-0015	110N05096	110-05095	110N05095	110-05759					MD-450	BELAIR DR	1.8	1.85	1.08%
TOTAL												36.54	36.24	-0.82%

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

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	1.2	2.4	1.5	3.5	424
30-45	3.1	4.3	5.4	7.4	341
45-60	2.1	2.6	4.5	5.5	2785
60+	-1.4	1.9	-2.7	4.7	7837

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

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	25%	88%	0%	82%	424
30-45	26%	68%	0%	48%	341
45-60	34%	80%	0%	50%	2785
60+	49%	86%	0%	63%	7837

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

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	
110+04634	1.35	1.46	0-30	5.8	5.8	7.3	7.3	2*
			30-45	3.0	3.2	5.3	5.8	37
			45-60	1.7	1.9	4.2	4.8	663
			60+	0.1	0.7	0.4	2.8	636
110-04633	1.52	1.44	0-30	1.4	2.2	1.9	3.4	189
			30-45	4.2	4.8	5.5	6.7	157
			45-60	2.2	2.4	4.1	4.6	789
			60+	-0.4	0.9	-0.9	2.9	1137
MD04-0001	2.13	2.05	0-30					1*
			30-45	3.7	3.7	29.6	29.6	281
			45-60	-0.1	1.1	0.3	3.2	762
			60+	-1.5	1.6	-3.6	4.4	
MD04-0002	1.43	1.68	0-30	-1.0	2.7	-2.5	4.4	17*
			30-45	-1.9	3.4	-0.2	7.5	24*
			45-60	-2.1	2.3	-3.4	4.7	40
			60+	-5.2	5.2	-9.1	9.2	818
MD04-0003	1.54	1.45	0-30					
			30-45					
			45-60	1.0	1.0	5.2	5.2	6*
			60+	-3.1	3.2	-6.4	7.1	432
MD04-0004	2.06	2.11	0-30	-0.3	1.2	-0.5	2.6	69
			30-45	-0.5	2.8	6.5	11.6	28*
			45-60	-0.5	1.4	1.2	5.1	83
			60+	-2.7	2.7	-5.8	6.2	1070
MD04-0005	1.54	1.61	0-30	1.4	2.7	1.7	3.4	142
			30-45	1.7	3.2	2.5	4.8	48
			45-60	1.0	2.3	2.5	4.6	164
			60+	-0.8	1.2	-1.7	3.4	2267
MD04-0006	1.73	1.58	0-30	13.1	13.1	18.0	18.0	5*
			30-45	5.9	6.2	9.8	10.6	46
			45-60	4.1	4.1	8.0	8.2	759
			60+	1.2	1.4	3.7	4.4	715

*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 Maryland

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	
110+04634	0-30	0	0%	0	0%	0	0%	0	0%	2*
	30-45	13	35%	27	73%	0	0%	22	59%	37
	45-60	241	36%	585	88%	0	0%	376	57%	663
	60+	445	70%	622	98%	0	0%	545	86%	636
110-04633	0-30	53	28%	169	89%	0	0%	152	80%	189
	30-45	40	25%	97	62%	0	0%	82	52%	157
	45-60	253	32%	650	82%	1	0%	467	59%	789
	60+	660	58%	1093	96%	0	0%	936	82%	1137
MD04-0001	0-30									
	30-45	0	0%	1	100%	0	0%	0	0%	1*
	45-60	163	58%	267	95%	2	1%	220	78%	281
	60+	389	51%	669	88%	0	0%	479	63%	762
MD04-0002	0-30	5	29%	14	82%	0	0%	11	65%	17*
	30-45	8	33%	20	83%	0	0%	12	50%	24*
	45-60	23	58%	32	80%	0	0%	29	73%	40
	60+	138	17%	444	54%	0	0%	153	19%	818
MD04-0003	0-30									
	30-45									
	45-60	4	67%	6	100%	0	0%	4	67%	6*
	60+	168	39%	314	73%	0	0%	176	41%	432
MD04-0004	0-30	31	45%	67	97%	0	0%	62	90%	69
	30-45	9	32%	23	82%	0	0%	9	32%	28*
	45-60	58	70%	73	88%	0	0%	51	61%	83
	60+	420	39%	820	77%	0	0%	459	43%	1070
MD04-0005	0-30	17	12%	123	87%	0	0%	122	86%	142
	30-45	13	27%	39	81%	0	0%	28	58%	48
	45-60	65	40%	137	84%	0	0%	95	58%	164
	60+	1214	54%	2112	93%	0	0%	1757	78%	2267
MD04-0006	0-30	0	0%	1	20%	0	0%	1	20%	5*
	30-45	7	15%	24	52%	0	0%	9	20%	46
	45-60	146	19%	473	62%	0	0%	158	21%	759
	60+	387	54%	656	92%	0	0%	454	64%	715

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

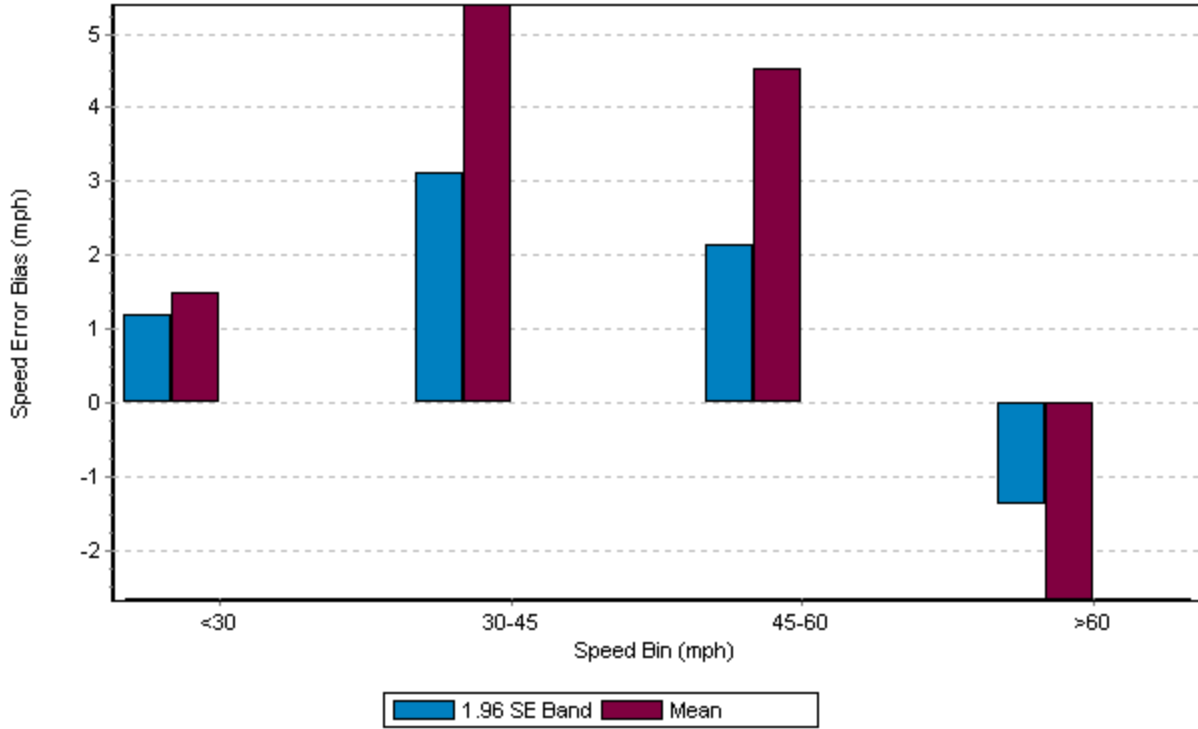


Figure 2
Speed error bias for freeway segments greater than one mile in Maryland

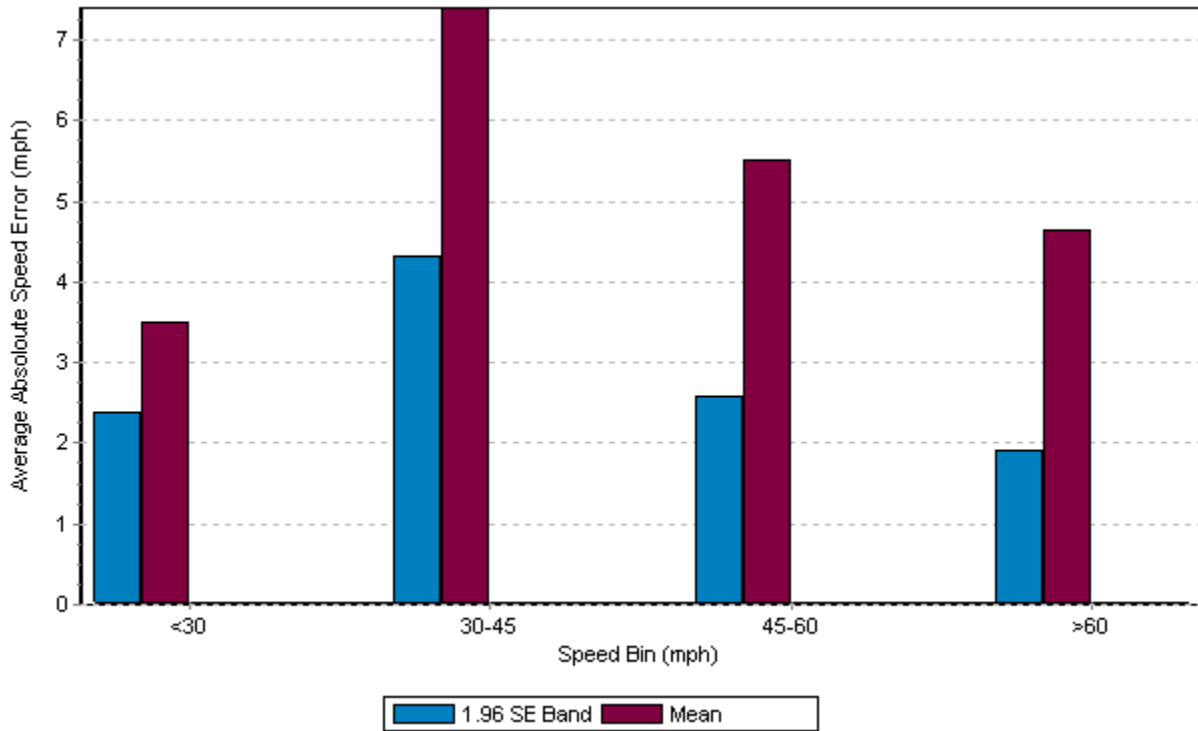


Figure 3
Average absolute speed error for freeway segments greater than one mile in Maryland

Analysis of Results for Arterials

The arterial data segments analyzed as part of this validation effort were from Route 3 just north on the intersection with US 50. Travel time samples collected along Route 3 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 four arterial segments considered in this round of validations. In all speed bins below 60 mph, INRIX data meets the data quality measures set forth for freeways when errors are measured as a distance from the 1.96 times the standard error band. In addition, small number of observations made in the speed bin above 60 mph is compatible with the posted speed limits on the arterial segments in question.

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 all arterial segments in Maryland. Tables 10 and 11 present detailed data for individual arterial segments in Maryland in similar format as Tables 8 and 9, 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 4 and 5 show the overall speed error biases for different speed bins, and the average absolute speed errors for all considered arterial segments in Maryland, respectively. These figures correspond to Table 8.

Table 8
Data quality measures for arterial segments greater than one mile in Maryland

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	3.8	4.1	7.6	8.3	352
30-45	1.7	2.2	4.5	6.1	1335
45-60	-1.0	1.4	-2.9	5.0	1216
60+	-9.4	9.4	-14.5	14.5	59

Table 9
Percent observations meeting data quality criteria for arterial segments greater than one mile in Maryland

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	24%	71%	0%	51%	352
30-45	49%	83%	0%	46%	1335
45-60	66%	89%	0%	59%	1216
60+	3%	22%	0%	0%	59

Table 10
Data quality measures for individual arterial validation segments greater than one mile in the state of Maryland

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	
110+05097	1.87	1.85	0-30	4.6	4.7	8.1	8.4	242
			30-45	2.1	2.5	5.5	6.7	844
			45-60	-0.6	1.5	-0.9	4.2	501
			60+	-14.6	14.6	-15.6	15.6	2*
110-05096	1.97	2.05	0-30	2.7	2.7	18.7	18.9	8*
			30-45	0.5	1.0	3.3	5.3	47
			45-60	-3.0	3.0	-6.0	6.5	71
			60+	-11.3	11.3	-14.2	14.2	2*
MD04-0014	1.90	2.05	0-30	1.7	2.5	5.3	7.2	100
			30-45	1.1	1.6	2.5	5.1	433
			45-60	-1.0	1.2	-4.1	5.5	642
			60+	-9.1	9.1	-14.5	14.5	55
MD04-0015	1.80	1.85	0-30	5.0	5.0	19.7	19.7	2*
			30-45	1.5	1.5	6.9	6.9	11*
			45-60	-0.4	0.4	-3.9	3.9	2*
			60+					

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

Table 11
Observations meeting data quality criteria for individual arterial validation segments
greater than one mile in the state of Maryland

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	
110+05097	0-30	40	17%	158	65%	0	0%	121	50%	242
	30-45	376	45%	677	80%	0	0%	339	40%	844
	45-60	288	57%	451	90%	1	0%	342	68%	501
	60+	0	0%	0	0%	0	0%	0	0%	2*
110-05096	0-30	4	50%	6	75%	0	0%	1	13%	8*
	30-45	33	70%	43	91%	0	0%	28	60%	47
	45-60	35	49%	53	75%	0	0%	30	42%	71
	60+	0	0%	0	0%	0	0%	0	0%	2*
MD04-0014	0-30	41	41%	86	86%	0	0%	56	56%	100
	30-45	242	56%	375	87%	1	0%	245	57%	433
	45-60	473	74%	581	91%	0	0%	347	54%	642
	60+	2	4%	13	24%	0	0%	0	0%	55
MD04-0015	0-30	0	0%	1	50%	0	0%	0	0%	2*
	30-45	6	55%	11	100%	0	0%	4	36%	11*
	45-60	1	50%	2	100%	0	0%	1	50%	2*
	60+									

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

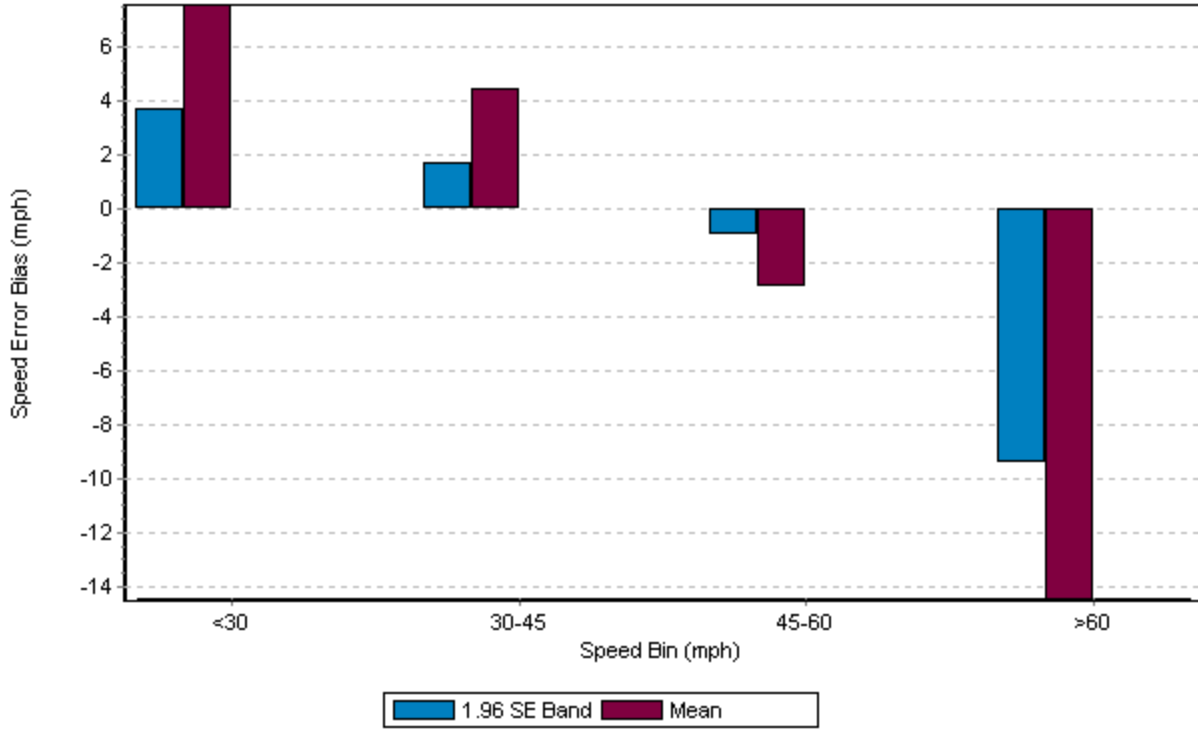


Figure 4
Speed error bias for arterial segments greater than one mile in Maryland

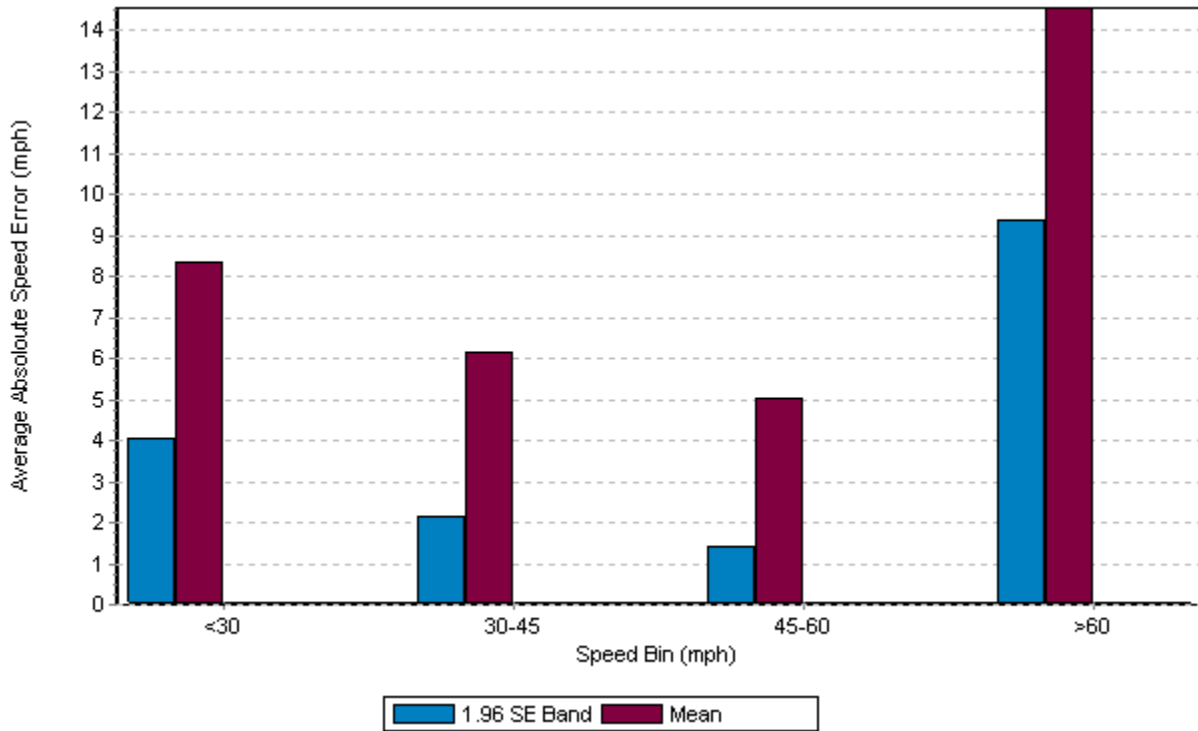


Figure 5
Average absolute speed error for arterial segments greater than one mile in Maryland

Analysis of Results for Ramps

Ramp segments analyzed were located at the intersection of US50 and I495/95 on the eastern side of the Washington DC beltway. Validation data collected from the 5.9 miles of freeway ramps represented seven of the eight ramps within the freeway interchange. Ramp data is being evaluated for informational purposes only, and is not subject to the quality specifications for freeway data. Even so, the specifications for freeway AASE were met in all speed categories for the ramp data, and the specifications for freeway speed error bias (SEB) were met in the 30-45 MPH, and 45-60 MPH speed bins. The ramp validation failed to meet the freeway SEB specification by only 0.6 and 0.4 MPH for the 0-30 MPH and >60 MPH speed bins respectively.

Table 12 summarizes the data quality measures obtained as a result of comparison between Bluetooth and all reported INRIX speeds on seven ramp segments considered in this round of validations. In all speed bins below 60 mph, INRIX data meets the data quality measures set forth for freeways when errors are measured as a distance from the 1.96 times the standard error band. However, in more than 60mph speed bin, INRIX data just barely fails to meet the freeway data quality criteria.

Table 13 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 ramp segments in Maryland. Tables 14 and 15 present detailed data for individual ramp segments in Maryland in similar format as Tables 12 and 13, 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 6 and 7 show the overall speed error biases for different speed bins, and the average absolute speed errors for all considered ramp segments in Maryland, respectively. These figures correspond to Table 12.

Table 12
Data quality measures for ramp segments greater than one mile in Maryland

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	5.6	5.9	9.1	10.0	381
30-45	1.6	2.4	3.6	5.6	982
45-60	-0.7	1.4	-1.4	3.6	4940
60+	-5.4	5.4	-9.2	9.2	1223

Table 13
Percent observations meeting data quality criteria for ramp segments greater than one mile in Maryland

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	24%	60%	0%	40%	381
30-45	43%	81%	0%	56%	982
45-60	56%	92%	0%	75%	4940
60+	18%	54%	0%	21%	1223

Table 14
Data quality measures for individual ramp validation segments greater than one mile in the state of Maryland

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	
MD04-0007	2.67	2.64	0-30	12.4	12.4	18.1	18.1	2*
			30-45					
			45-60	0.4	0.7	1.0	3.1	38
			60+	-1.0	1.0	-2.9	3.1	10*
MD04-0008	3.29	3.23	0-30	10.6	10.6	20.3	20.3	10*
			30-45	2.5	3.7	7.5	9.6	8*
			45-60	0.3	0.8	0.9	2.9	129
			60+	-1.7	1.7	-3.7	3.7	3*
MD04-0009	1.68	1.54	0-30	12.1	12.1	16.5	16.6	60
			30-45	4.8	5.1	8.2	9.5	73
			45-60	-0.5	1.3	-1.0	3.5	828
			60+	-3.4	3.4	-7.1	7.1	137
MD04-0010	1.73	1.74	0-30	2.5	2.5	9.0	9.6	7*
			30-45	1.0	1.1	4.1	5.4	47
			45-60	-1.5	1.7	-3.3	4.2	616
			60+	-7.7	7.7	-11.6	11.6	8*
MD04-0011	2.04	1.86	0-30	2.3	2.5	4.0	4.6	158
			30-45	3.3	3.5	6.5	7.1	133
			45-60	0.6	1.1	2.1	3.4	498
			60+	-1.3	1.3	-3.6	3.6	46
MD04-0012	1.43	1.43	0-30	3.6	4.0	10.7	11.2	5*
			30-45	2.2	2.2	6.5	6.5	14*
			45-60	0.2	1.1	1.3	3.7	235
			60+	-4.9	4.9	-9.0	9.0	9*
MD04-0013	2.48	2.62	0-30	2.6	3.4	11.4	13.8	24*
			30-45	-0.3	1.6	1.6	6.1	61
			45-60	-0.4	0.8	-1.2	2.8	862
			60+	-2.7	2.7	-6.0	6.0	250

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

Table 15
Observations meeting data quality criteria for individual ramp validation segments greater than one mile in the state of Maryland

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	
110+05097	0-30	0	0%	0	0%	0	0%	0	0%	2*
	30-45									
	45-60	25	66%	37	97%	0	0%	32	84%	38
	60+	7	70%	10	100%	0	0%	8	80%	10*
110-05096	0-30	1	10%	4	40%	0	0%	2	20%	10*
	30-45	2	25%	6	75%	0	0%	2	25%	8*
	45-60	83	64%	125	97%	0	0%	110	85%	129
	60+	1	33%	3	100%	0	0%	2	67%	3*
MD04-0014	0-30	5	8%	13	22%	0	0%	8	13%	60
	30-45	24	33%	38	52%	0	0%	18	25%	73
	45-60	479	58%	768	93%	2	0%	637	77%	828
	60+	40	29%	98	72%	0	0%	45	33%	137
110+05097	0-30	2	29%	6	86%	0	0%	3	43%	7*
	30-45	26	55%	44	94%	0	0%	24	51%	47
	45-60	301	49%	546	89%	1	0%	402	65%	616
	60+	0	0%	2	25%	0	0%	0	0%	8*
110-05096	0-30	55	35%	127	80%	0	0%	97	61%	158
	30-45	39	29%	96	72%	0	0%	59	44%	133
	45-60	295	59%	469	94%	0	0%	383	77%	498
	60+	26	57%	44	96%	0	0%	36	78%	46
MD04-0014	0-30	1	20%	3	60%	0	0%	2	40%	5*
	30-45	6	43%	13	93%	0	0%	5	36%	14*
	45-60	153	65%	225	96%	0	0%	175	74%	235
	60+	3	33%	7	78%	0	0%	2	22%	9*
MD04-0015	0-30	8	33%	17	71%	0	0%	10	42%	24*
	30-45	35	57%	53	87%	0	0%	34	56%	61
	45-60	542	63%	841	98%	0	0%	739	86%	862
	60+	61	24%	209	84%	0	0%	95	38%	250

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

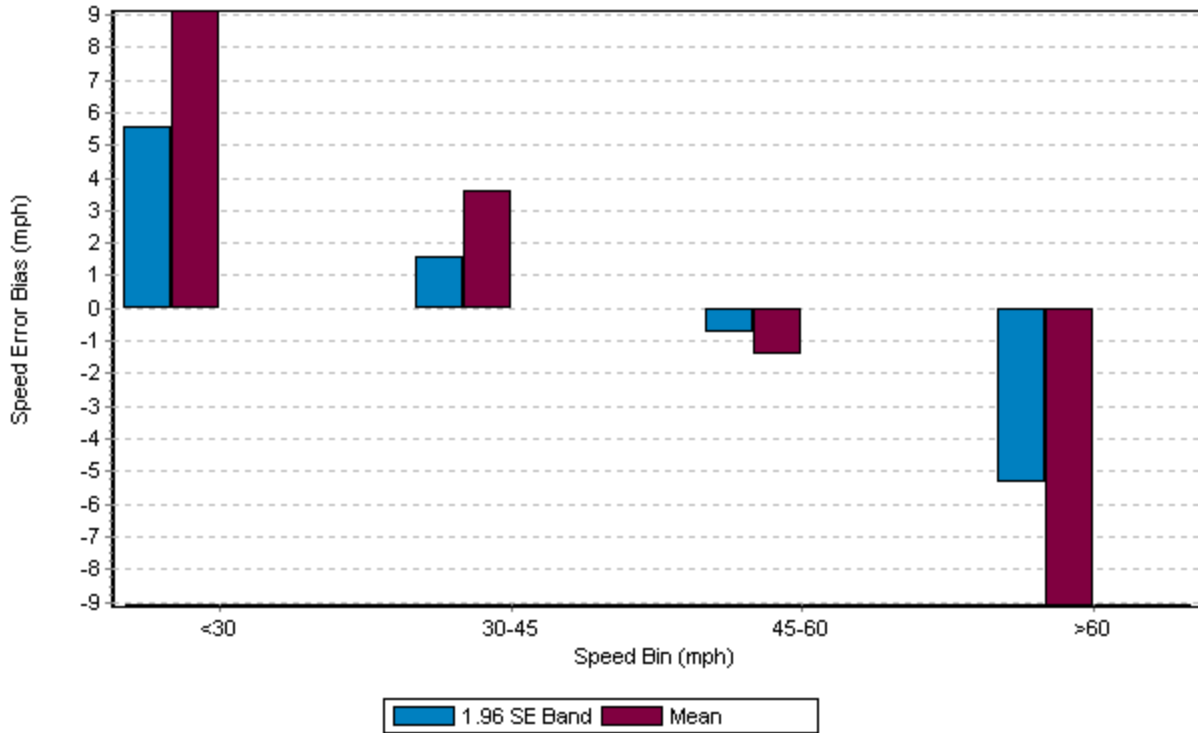


Figure 6
Speed error bias for ramp segments greater than one mile in Maryland

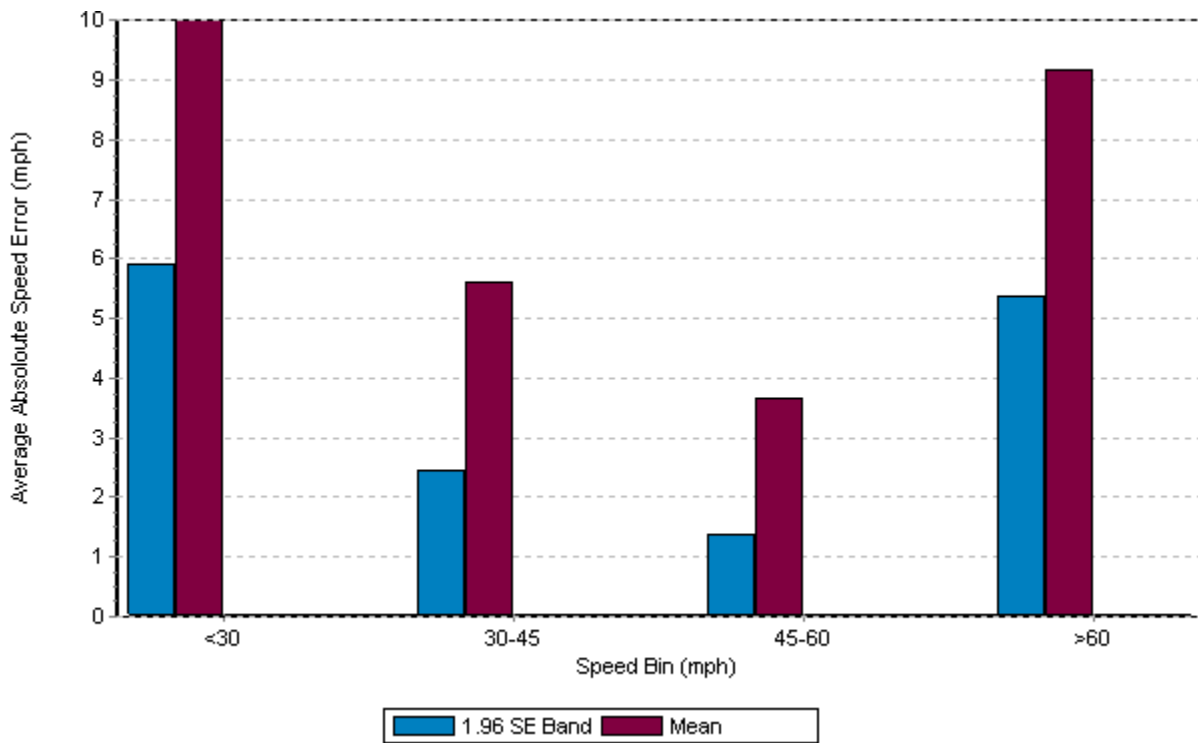


Figure 7
Average absolute speed error for ramp segments greater than one mile in Maryland