I-95 Corridor Coalition

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

Monthly Report: Pennsylvania

I-95 CORRIDOR COALITION

Dec 2014

I-95 CORRIDOR COALITION VEHICLE PROBE PROJECT VALIDATION OF INRIX DATA DEC 2014

Monthly Report

Prepared for:

I-95 Corridor Coalition

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Evaluation Results for the State of Pennsylvania

Executive Summary

The data from the Vehicle Probe Project is validated using Bluetooth™ Traffic Monitoring (BTM) technology on a near monthly basis. BTM sensors were deployed on the beginning and ending points of seventeen different segments along the US-422 corridor. The Bluetooth sensor deployment covers the range from PA-100 to US-202 along US-422. Travel time data was collected for both directions along the freeway, between July 7 and July 19, 2014. The dataset collected represents approximately 1700 hours of observations along seventeen freeway segments, totaling approximately 42.70 miles. The number of effective five-minute travel time samples observed was 20,404 in total.

ES Table 1, below summarizes the results of the comparison between the validation data and the INRIX data for freeway segments during the above noted period. As shown, the average absolute speed error (AASE) and Speed Error Bias (SEB) were within specification in all speed bins.

ES Table 1 - Pennsylvania Evaluation Summary for Freeway

	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	5.3	6.9	4.6	5.2	445	37.1
30-45 MPH	4.2	7.9	2.8	12.1	497	41.4
45-60 MPH	1.4	4.0	0.6	8.2	7520	626.7
>60 MPH	1.4	4.2	-1.1	0.4	11942	995.2
All Speeds	1.6	4.3	-0.3	3.6	20404	1700.3

Based upon data collected from July 7th, 2014 through July 19th, 2014 across 42.70 miles of roadway.

Data Collection

The data from the Vehicle Probe Project is validated using Bluetooth™ Traffic Monitoring (BTM) technology on a near monthly basis. BTM sensors were deployed on the beginning and ending points of seventeen different segments along the US-422 freeway corridor. The Bluetooth sensor deployment covers the range from PA-100 to US-202 along US-422. Travel time data was collected for both directions along the freeway. The data was collected between July 7 and July 19, 2014 with the assistance of Pennsylvania Department of Transportation (PennDOT) personnel. This round of data collections in Pennsylvania was designed to capture the traffic data on a sample of freeway specifically during a busy weekend anticipated to have significant traffic. Segment locations are chosen with a high-likelihood of observing recurrent and non-recurrent congestions during peak or off-peak periods.

Figure 1 and 2 present an overview snapshot of the roadway segments, over which Bluetooth sensors were deployed along the US-422 corridor in Pennsylvania, eastbound and westbound respectively. Blue segments represent freeway segments selected for analysis.

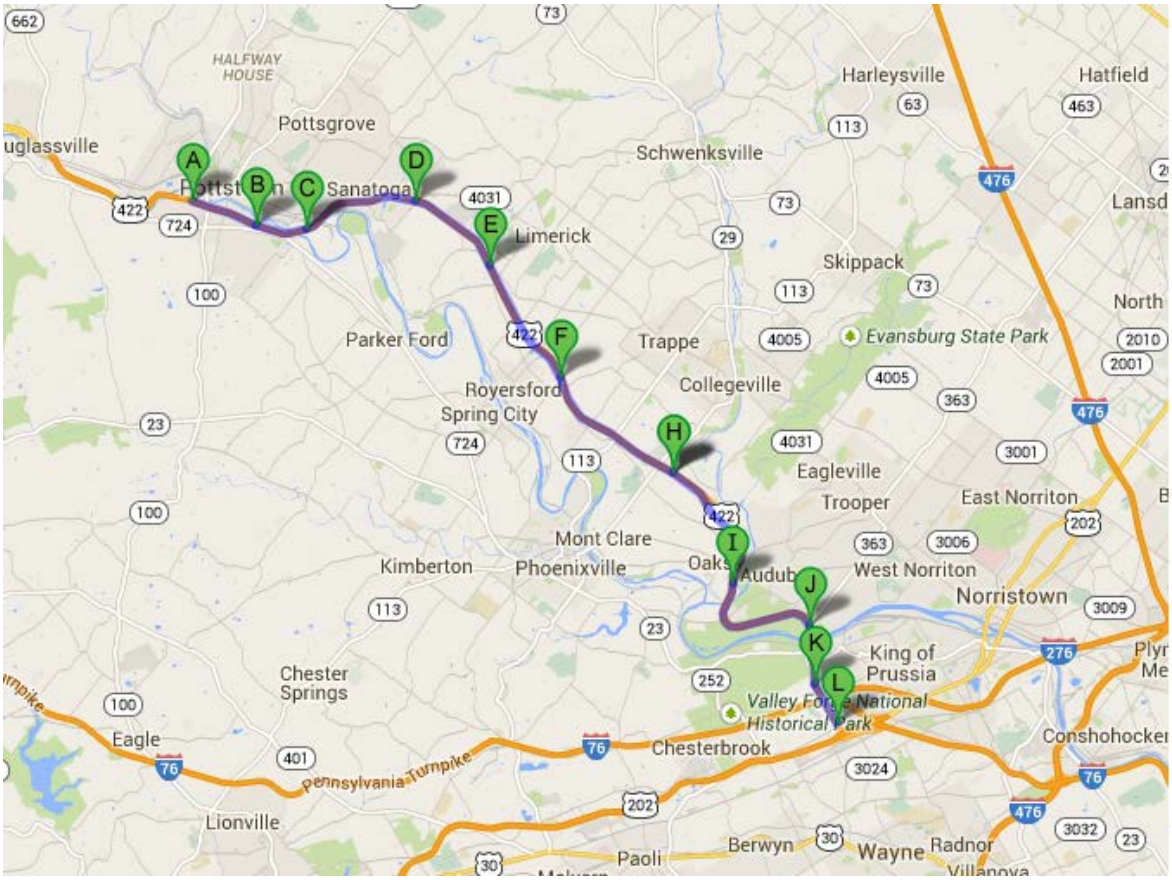

Figure 1 — Locations of all segments selected for eastbound analysis in Pennsylvania

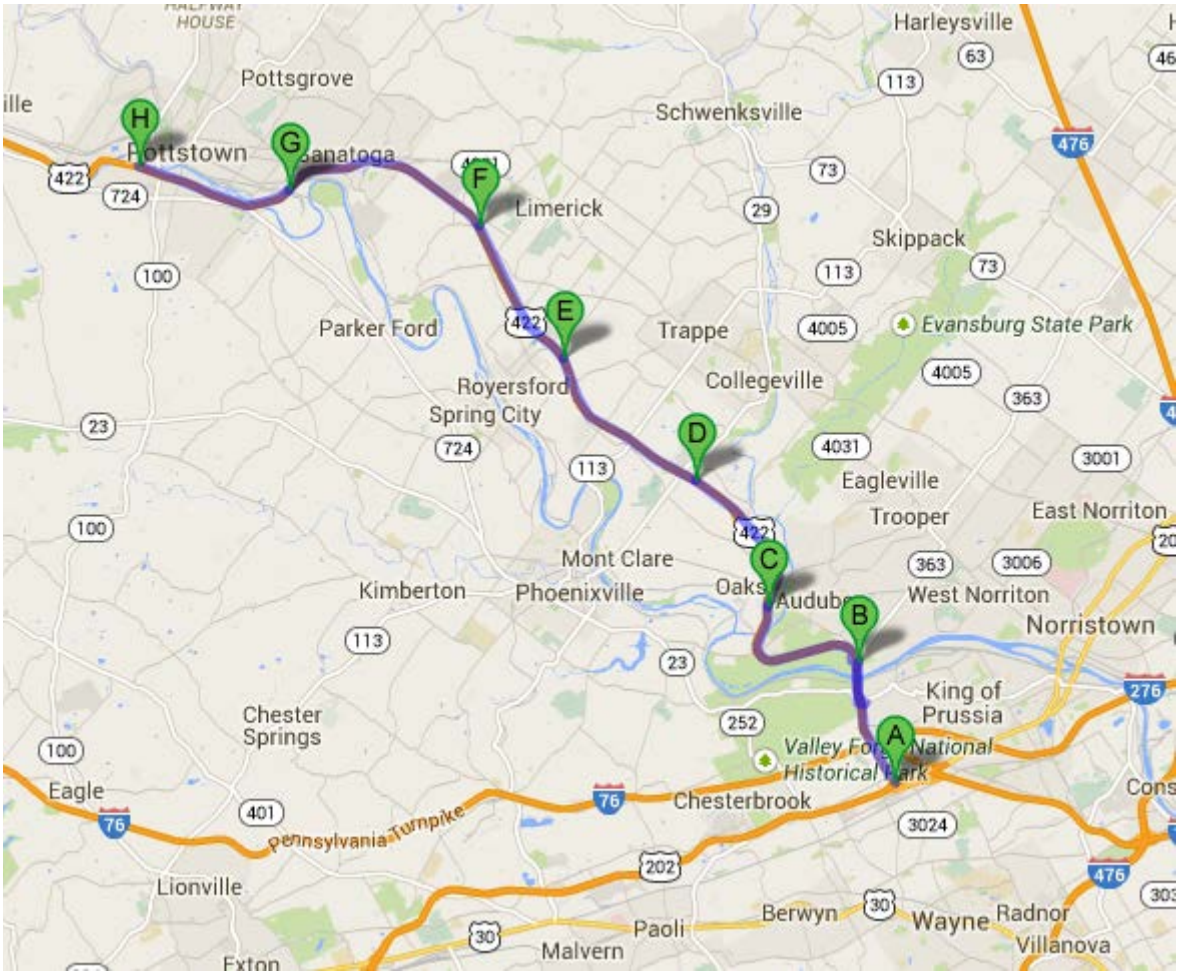

Figure 2 — Locations of all segments selected for westbound analysis in Pennsylvania

TMC segments selected for validation in Pennsylvania

Table 1 presents a list of data collection segments from Pennsylvania. In total, these segments cover a total length of approximately 42.7 freeway miles. Data collection segments are comprised of one or more Traffic Message Channel (TMC) base segments, such that the total length of the data collection segment is one mile long or greater for freeway studies. When appropriate, consecutive TMC segments are combined to form a data collection segment longer than one mile. The results of the validation performed on seventeen freeway segments are included in this report. Table 1 contains summary information on each data collection segment. The latitude/longitude coordinates of the locations at which the Bluetooth sensors were deployed along US-422 in the state of Pennsylvania are provided in Table 1 as well as an active map link to view the data collection segment in detail. Click on the map link to see a detailed map for the respective data collection segment. It should be noted that the configuration of test segments is often such that the endpoint of one segment coincides with the start point of the next segment, so that one Bluetooth sensor covers both data collection segments.

Table 1 also provides data on the precise length of the TMCs comprising the test segment as compared to the measured length between Bluetooth™ Traffic Monitoring (BTM) sensors placed on the roadway. Details of the algorithm used to estimate equivalent path travel times based on INRIX data feeds for individual data collection segments are provided in a separate report. This algorithm finds an equivalent INRIX travel time (and therefore travel speed) corresponding to each sample BTM travel time observation on the test segment of interest.

Table 1
Segments selected for validation in Pennsylvania

SEGMENT (Map Link)	DESCRIPTION			TMC CODES		Deployment		
	Highway	State	Starting at	Begin	Number	Begin Lat/Lon		Length
	Pennsylvania	County	Ending at	End	Length	End Lat/Lon		% Diff
FREEWAY								All Lengths in Miles
F1	US-422	Pennsylvania	PA-100	103N04492	4	40.241307	-75.665607	1.5
PA07-0001	Eastbound	Chester	Keim St	103-04490	1.26	40.233847	-75.639926	19.05%
F2	US-422	Pennsylvania	Keim St	103N04490	5	40.233847	-75.639926	1.1
PA07-0002	Eastbound	Chester	Armand Hammer Blvd	103N04488	1.12	40.232548	-75.620141	-1.79%
F3	US-422	Pennsylvania	Armand Hammer Blvd	103-04487	1	40.232548	-75.620141	2.5
PA07-0003	Eastbound	Montgomery	Evergreen Rd	103-04487	2.45	40.241489	-75.576775	2.04%
F4	US-422	Pennsylvania	Evergreen Rd	103N04487	2	40.241489	-75.576775	2.1
PA07-0004	Eastbound	Montgomery	Lewis Rd	103-04486	2.18	40.222012	-75.547694	-3.67%
F5	US-422	Pennsylvania	Lewis Rd	103N04486	3	40.222012	-75.547694	2.8
PA07-0005	Eastbound	Montgomery	Walnut St	103N04485	2.43	40.188017	-75.519068	15.23%
F6	US-422	Pennsylvania	Walnut St	103-04484	2	40.188017	-75.519068	3.2
PA07-0006	Eastbound	Montgomery	PA-29	103N04484	3.3	40.158925	-75.475061	-3.03%
F7	US-422	Pennsylvania	PA-29	103-04483	2	40.158925	-75.475061	3
PA07-0007	Eastbound	Montgomery	Egypt Rd	103N04483	3.01	40.125085	-75.451151	-0.33%
F8	US-422	Pennsylvania	Egypt Rd	103-04482	1	40.125085	-75.451151	2.8
PA07-0008	Eastbound	Montgomery	PA-363	103-04482	3.01	40.112794	-75.420592	-6.98%
F9	US-422	Pennsylvania	PA-363	103N04482	3	40.112794	-75.420592	1.3
PA07-0009	Eastbound	Montgomery	PA-23	103N04481	1.02	40.094886	-75.418075	27.45%

Table 1 (Cont'd)
Segments selected for validation in Pennsylvania

SEGMENT (Map Link)	DESCRIPTION			TMC CODES		Deployment		
	Highway	State	Starting at	Begin	Number	Begin Lat/Lon		Length
	Pennsylvania	County	Ending at	End	Length	End Lat/Lon		% Diff
FREEWAY								All Lengths in Miles
F10	US-422	Pennsylvania	PA-23	103-04480	3	40.094886	-75.418075	0.9
PA07-00010	Eastbound	Montgomery	US-202	103-04479	1.2	40.082871	-75.409671	-25.00%
F11	US-422	Pennsylvania	US-202	103+04480	6	40.080117	-75.406991	2.4
PA07-0011	Westbound	Montgomery	PA-363	103P04482	2.38	40.111929	-75.419832	0.84%
F12	US-422	Pennsylvania	PA-363	103+04483	1	40.111929	-75.419832	2.9
PA07-0012	Westbound	Montgomery	Egypt Rd	103+04483	3.16	40.126203	-75.450615	-8.28%
F13	US-422	Pennsylvania	Egypt Rd	103P04483	2	40.126203	-75.450615	3
PA07-0013	Westbound	Montgomery	PA-29	103+04484	2.65	40.159417	-75.475419	13.09%
F14	US-422	Pennsylvania	PA-29	103P04484	2	40.159417	-75.475419	3.4
PA07-0014	Westbound	Montgomery	Walnut St	103+04485	3.49	40.191598	-75.520618	-2.63%
F15	US-422	Pennsylvania	Walnut St	103P04485	3	40.191598	-75.520618	2.9
PA07-0015	Westbound	Montgomery	Lewis Rd	103P04486	2.5	40.226142	-75.54964	16.10%
F16	US-422	Pennsylvania	Lewis Rd	103+04487	3	40.226142	-75.54964	4
PA07-0016	Westbound	Montgomery	Armand Hammer Blvd	103+04488	4.35	40.23565	-75.614631	-8.01%
F17	US-422	Pennsylvania	Armand Hammer Blvd	103P04488	9	40.23565	-75.614631	2.9
PA07-0017	Westbound	Chester	PA-100	103P04492	2.66	40.241704	-75.666419	9.18%

Analysis of Freeway Results

Table 2 summarizes the data quality measures obtained as a result of comparison between Bluetooth and all reported INRIX speeds. Specifications include the Average Absolute Speed Error (AASE) and the Speed Error Bias (SEB).

Average Absolute Speed Error (AASE)
The AASE is defined as the mean absolute value of the difference between the mean speed reported from the VPP and the ground truth mean speed for a specified time period. The AASE is the primary accuracy metric. Based on the contract specifications, the speed data from the VPP shall have a maximum average absolute error of 10 miles per hour (MPH) in each of four speed ranges: 0-30 MPH, 30-45 MPH, 45-60 MPH, and > 60 MPH.

Speed Error Bias (SEB)
The SEB is defined as the average speed error (not the absolute value) in each speed range. SEB is a measure of whether the speed reported in the VPP consistently under or over estimates speed as compared to ground truth speed. Based on the contract specifications, the VPP data shall have a maximum SEB of +/- 5 MPH in each of speed ranges as defined above.

The results are presented as compared against the mean of the ground truth data as well as the 95th percent confidence interval for the mean, referred to as the Standard Error of the Mean (SEM) band. The SEM band takes into account any uncertainty in the ground truth speed as measured by BTM equipment due to limited samples and/or data variance. Contract specifications are assessed against the SEM band. (See the *Vehicle Probe Project: Data Use and Application Guide* for additional details on the validation process.) The AASE in the lower two speed bands have proven to be the critical specification (and most difficult) to attain, and are highlighted in Table 2. AASE below 10 MPH meet contract specifications. AASE below 5 MPH are considered exceptional quality. As shown, the average absolute speed error (AASE) was within specification for all speed bins.

TABLE 2 Data quality measures for freeway segments in Pennsylvania

SPEED BIN	Data Quality Measures for				No. of 5 Minute Samples	Hours of Data Collection
	1.96 SEM Band		Mean			
	SEB 5 mph (contract specifications)	AASE 10 mph	SEB	AASE		
0-30	4.6	5.3	5.7	6.9	445	37
30-45	2.8	4.2	5.5	7.9	497	41
45-60	0.6	1.4	1.7	4.0	7520	627
60+	-1.1	1.4	-2.6	4.2	11942	995

Table 3 shows the percentage of the time INRIX data falls within 5 mph of the SEM band and the mean for each speed bin for all freeway data segments in Pennsylvania.

Table 3 Percent observations meeting data quality criteria for freeway segments in Pennsylvania

SPEED BIN	Data Quality Measures for				No. of Obs.
	1.96 SEM 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	17%	70%	0%	62%	445
30-45	24%	67%	0%	45%	497
45-60	57%	91%	0%	70%	7520
60+	58%	91%	0%	69%	11942

Tables 4 and 5 present detailed data for individual TMC segments in Pennsylvania in a similar format as Tables 2 and 3, respectively. Note that for some segments and in some speed bins the comparison results may not be reliable due to small number of observations.

Table 4
Data quality measures for individual freeway validation segments in the state of Pennsylvania

TMC	Standard TMC length	Bluetooth distance	SPEED BIN	Data Quality Measures for				No. of Obs.
				1.96 SEM Band		Mean		
				Speed Error Bias	Average Absolute Speed Error	Speed Error Bias	Average Absolute Speed Error	
PA07-0001	1.3	1.5	0-30	-	-	-	-	-
			30-45	2.9	8.9	-2.0	15.1	4*
			45-60	0.1	1.8	1.3	4.8	279
			60+	-1.6	1.8	-3.5	4.7	911
PA07-0002	1.1	1.1	0-30	11.4	11.6	13.2	14.4	67
			30-45	3.6	4.5	6.2	9.6	62
			45-60	0.6	1.7	2.3	5.1	813
			60+	-1.5	1.6	-5.6	6.2	660
PA07-0003	2.5	2.5	0-30	-	-	-	-	-
			30-45	-	-	-	-	-
			45-60	0.9	2.1	3.6	5.3	38
			60+	-0.5	0.5	-3.3	3.3	4*
PA07-0004	2.2	2.1	0-30	-	-	-	-	-
			30-45	-	-	-	-	-
			45-60	1.6	1.6	5.0	5.1	22*
			60+	0.6	0.6	2.2	2.6	19*
PA07-0005	2.4	2.8	0-30	-	-	-	-	-
			30-45	-	-	-	-	-
			45-60	2.2	2.3	5.3	5.6	163
			60+	-0.1	0.9	0.0	3.3	953
PA07-0006	3.3	3.2	0-30	12.5	12.5	13.6	13.6	2*
			30-45	8.3	8.3	10.6	10.7	19*
			45-60	1.9	2.5	4.0	5.5	124
			60+	-0.6	1.1	-1.0	3.4	988
PA07-0007	3.0	3	0-30	3.5	4.0	5.2	5.9	98
			30-45	1.9	3.6	8.2	11.0	74
			45-60	0.1	2.2	3.5	7.2	117
			60+	-1.3	1.4	-3.0	4.1	1425
PA07-0008	3.0	2.8	0-30	-0.5	1.5	-0.6	2.1	114
			30-45	0.4	3.2	0.7	4.3	146
			45-60	1.5	2.4	4.1	5.5	189
			60+	-0.8	1.3	-1.8	3.7	1894

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

Table 4 (Cont'd)
Data quality measures for individual freeway validation segments in the state of Pennsylvania

TMC	Standard TMC length	Bluetooth distance	SPEED BIN	Data Quality Measures for				No. of Obs.
				1.96 SEM Band		Mean		
				Speed Error Bias	Average Absolute Speed Error	Speed Error Bias	Average Absolute Speed Error	
PA07-0009	1.0	1.3	0-30	22.8	22.8	24.8	24.8	3*
			30-45	1.8	2.1	3.7	4.9	17*
			45-60	-0.6	1.1	-0.5	3.2	614
			60+	-1.8	1.9	-4.5	5.1	1351
PA07-0010	1.2	0.9	0-30	-	-	-	-	-
			30-45	7.5	7.5	11.1	11.2	32
			45-60	-0.2	0.7	-0.7	2.9	1777
			60+	-2.7	2.7	-6.9	6.9	202
PA07-0011	2.4	2.4	0-30	5.1	5.4	6.0	6.5	141
			30-45	3.4	4.4	6.2	8.1	59
			45-60	0.0	1.1	0.7	3.3	446
			60+	-2.2	2.3	-4.6	5.1	1080
PA07-0013	2.7	3	0-30	3.1	3.1	10.4	10.6	12*
			30-45	2.3	2.5	4.3	4.6	37
			45-60	0.6	1.1	2.7	4.2	99
			60+	-1.0	1.1	-2.7	3.6	205
PA07-0014	3.5	3.4	0-30	21.5	21.5	23.3	23.4	4*
			30-45	5.8	5.8	8.5	8.5	8*
			45-60	2.1	2.1	5.7	5.9	41
			60+	-0.1	0.9	-0.2	3.5	402
PA07-0015	2.5	2.9	0-30	-	-	-	-	-
			30-45	0.0	0.0	18.3	18.3	1*
			45-60	1.6	1.8	4.6	5.2	248
			60+	-0.4	0.8	-1.2	3.2	1561
PA07-0016	4.3	4	0-30	11.7	11.7	12.5	12.5	4*
			30-45	3.9	4.5	10.4	11.2	34
			45-60	1.2	1.5	2.7	3.8	1816
			60+	-1.9	1.9	-4.4	4.6	33
PA07-0017	2.7	2.9	0-30	-	-	-	-	-
			30-45	11.2	11.2	16.7	16.7	4*
			45-60	1.1	1.5	3.2	4.3	734
			60+	-1.1	1.3	-2.4	3.4	254

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

Table 5
Observations meeting data quality criteria for individual freeway validation segments in the state of Pennsylvania

TMC	SPEED BIN	Data Quality Measures for								No. of Obs.
		1.96 SEM 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	
PA07-0001	0-30	-	-	-	-	-	-	-	-	-
	30-45	2	50%	2	50%	0	0%	0	0%	4*
	45-60	156	56%	247	89%	5	2%	186	67%	279
	60+	532	58%	801	88%	0	0%	582	64%	911
PA07-0002	0-30	19	28%	35	52%	0	0%	29	43%	67
	30-45	23	37%	42	68%	0	0%	24	39%	62
	45-60	500	62%	709	87%	1	0%	474	58%	813
	60+	470	71%	591	90%	0	0%	358	54%	660
PA07-0003	0-30	-	-	-	-	-	-	-	-	-
	30-45	-	-	-	-	-	-	-	-	-
	45-60	21	55%	34	89%	0	0%	22	58%	38
	60+	2	50%	4	100%	0	0%	3	75%	4*
PA07-0004	0-30	-	-	-	-	-	-	-	-	-
	30-45	-	-	-	-	-	-	-	-	-
	45-60	10	45%	20	91%	0	0%	13	59%	22*
	60+	16	84%	18	95%	0	0%	16	84%	19*
PA07-0005	0-30	-	-	-	-	-	-	-	-	-
	30-45	-	-	-	-	-	-	-	-	-
	45-60	59	36%	137	84%	0	0%	69	42%	163
	60+	605	63%	902	95%	1	0%	748	78%	953
PA07-0006	0-30	0	0%	0	0%	0	0%	0	0%	2*
	30-45	1	5%	5	26%	0	0%	3	16%	19*
	45-60	48	39%	99	80%	0	0%	67	54%	124
	60+	654	66%	916	93%	0	0%	772	78%	988
PA07-0007	0-30	15	15%	69	70%	0	0%	59	60%	98
	30-45	22	30%	48	65%	0	0%	23	31%	74
	45-60	61	52%	95	81%	0	0%	49	42%	117
	60+	805	56%	1286	90%	3	0%	952	67%	1425
PA07-0008	0-30	27	24%	110	96%	0	0%	102	89%	114
	30-45	21	14%	115	79%	0	0%	102	70%	146
	45-60	69	37%	158	84%	0	0%	93	49%	189
	60+	1025	54%	1769	93%	0	0%	1384	73%	1894

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

Table 5 (Cont'd)
Observations meeting data quality criteria for individual freeway validation segments in the state of Pennsylvania

TMC	SPEED BIN	Data Quality Measures for								No. of Obs.
		1.96 SEM 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	
PA07-0009	0-30	0	0%	1	33%	0	0%	1	33%	3*
	30-45	9	53%	14	82%	0	0%	12	71%	17*
	45-60	392	64%	570	93%	1	0%	479	78%	614
	60+	646	48%	1172	87%	1	0%	759	56%	1351
PA07-0010	0-30	-	-	-	-	-	-	-	-	-
	30-45	4	13%	9	28%	0	0%	2	6%	32
	45-60	1180	66%	1733	98%	5	0%	1485	84%	1777
	60+	65	32%	160	79%	0	0%	60	30%	202
PA07-0011	0-30	8	6%	84	60%	0	0%	74	52%	141
	30-45	15	25%	38	64%	0	0%	22	37%	59
	45-60	286	64%	418	94%	4	1%	349	78%	446
	60+	490	45%	896	83%	1	0%	651	60%	1080
PA07-0013	0-30	5	42%	10	83%	0	0%	8	67%	12*
	30-45	10	27%	33	89%	0	0%	24	65%	37
	45-60	67	68%	91	92%	1	1%	71	72%	99
	60+	136	66%	194	95%	0	0%	145	71%	205
PA07-0014	0-30	1	25%	2	50%	0	0%	1	25%	4*
	30-45	1	13%	5	63%	0	0%	3	38%	8*
	45-60	16	39%	36	88%	0	0%	19	46%	41
	60+	255	63%	386	96%	1	0%	300	75%	402
PA07-0015	0-30	-	-	-	-	-	-	-	-	-
	30-45	1	100%	1	100%	0	0%	0	0%	1*
	45-60	109	44%	220	89%	1	0%	136	55%	248
	60+	1035	66%	1503	96%	0	0%	1237	79%	1561
PA07-0016	0-30	0	0%	2	50%	0	0%	2	50%	4*
	30-45	9	26%	21	62%	0	0%	7	21%	34
	45-60	923	51%	1638	90%	0	0%	1262	69%	1816
	60+	15	45%	29	88%	0	0%	21	64%	33
PA07-0017	0-30	-	-	-	-	-	-	-	-	-
	30-45	0	0%	1	25%	0	0%	0	0%	4*
	45-60	417	57%	658	90%	1	0%	481	66%	734
	60+	161	63%	235	93%	0	0%	202	80%	254

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