I-95 Corridor Coalition

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

Monthly Report: Maryland

I-95 CORRIDOR COALITION

March 2012

I-95 CORRIDOR COALITION VEHICLE PROBE PROJECT VALIDATION OF INRIX DATA OCTOBER 2011

Monthly Report

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March 2012

Evaluation Results for the State of Maryland

Executive Summary

Travel time samples were collected in Maryland along approximately 14 freeway miles, seven arterial miles, and nearly three miles of ramp facilities from Thursday, October 6, 2011 through Monday, October 17, 2011. The results of validation performed on the freeway segments and ramp segments are included in this report. The results for the four arterial segments will be presented in a separate report.

Freeway segments studied were located along I-695 in Anne Arundel and Baltimore Counties. Data collected for the freeway validation 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 785 hours of observations along six freeway segments, totaling approximately 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, the average absolute speed error (AASE) and Speed Error Bias (SEB) were within specification for all speed bins. Even when errors are measured against the mean (rather than the SEM band) the data meets contract specifications for both the AASE and the SEB.

ES Table 1 - Maryland 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	**2.40**	3.60	**1.40**	1.80	868	72.3
30-45 MPH	**4.30**	6.50	**3.20**	4.60	371	30.9
45-60 MPH	**1.70**	4.10	**1.40**	3.20	3026	252.2
> 60 MPH	**0.90**	3.00	**-0.40**	-1.00	5148	429.0
All Speeds	1.43	3.55	0.49	0.83	9413	784.4

Based upon data collected from October 6, 2011 through October 17, 2011 across 14.3 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 Maryland was validated on five occasions: July/August 2008, March 2009, February 2010, October 2010 and October 2011. These five validations represent nearly 3670 hours of observations along nearly 100 miles of freeway segments in Maryland. ES Table 2 provides a summary of the cumulative validation effort. As shown, the average absolute speed error and speed error bias are within specification for all speed bins even when errors are measured against the mean.

ES Table 2 - Maryland - Cumulative to Date						
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	**3.13**	4.41	**1.38**	1.75	2595	216.3
30-45 MPH	**4.35**	6.72	**2.14**	3.25	2479	206.6
45-60 MPH	**2.03**	4.25	**0.71**	1.76	14224	1185.3
> 60 MPH	**1.61**	4.02	**-1.23**	-2.43	24726	2060.5
All Speeds	1.99	4.27	-0.26	-0.51	44024	3668.7

Regarding the ramp data collected as part of this validation effort, it should be noted that no data quality specifications are currently in effect for freeway ramps. However, when the INRIX data is compared to the data quality measures set forth in the contract for mainline freeways, the ramp data meets the freeway specifications when errors are measured as a distance from the 1.96 times the standard error band, in all speed bins less than 60 mph. The absence of any observations at above 60 mph in these segments is compatible with expected operational speeds on a ramp facility.

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 in Maryland from Thursday, October 6, 2011 through Monday, October 17, 2011 with the assistance of Maryland Coordinated Highways Action Response Team (CHART) personnel. This round of data collections in Maryland was designed to capture traffic data on a sample of freeways, ramps, and arterials. Locations are chosen with a high-likelihood of observing recurrent and non-recurrent congestionduring peak or off-peak periods.

Figure 1 presents a snapshot of the roadway segments over which Bluetooth sensors were deployed in Maryland. Red segments represent freeway segments selected for analysis along I-695. The blue segments represent arterial segments on US-1 and MD-193. Ramp data was also collected at the interchange connecting I-695 and I-95.

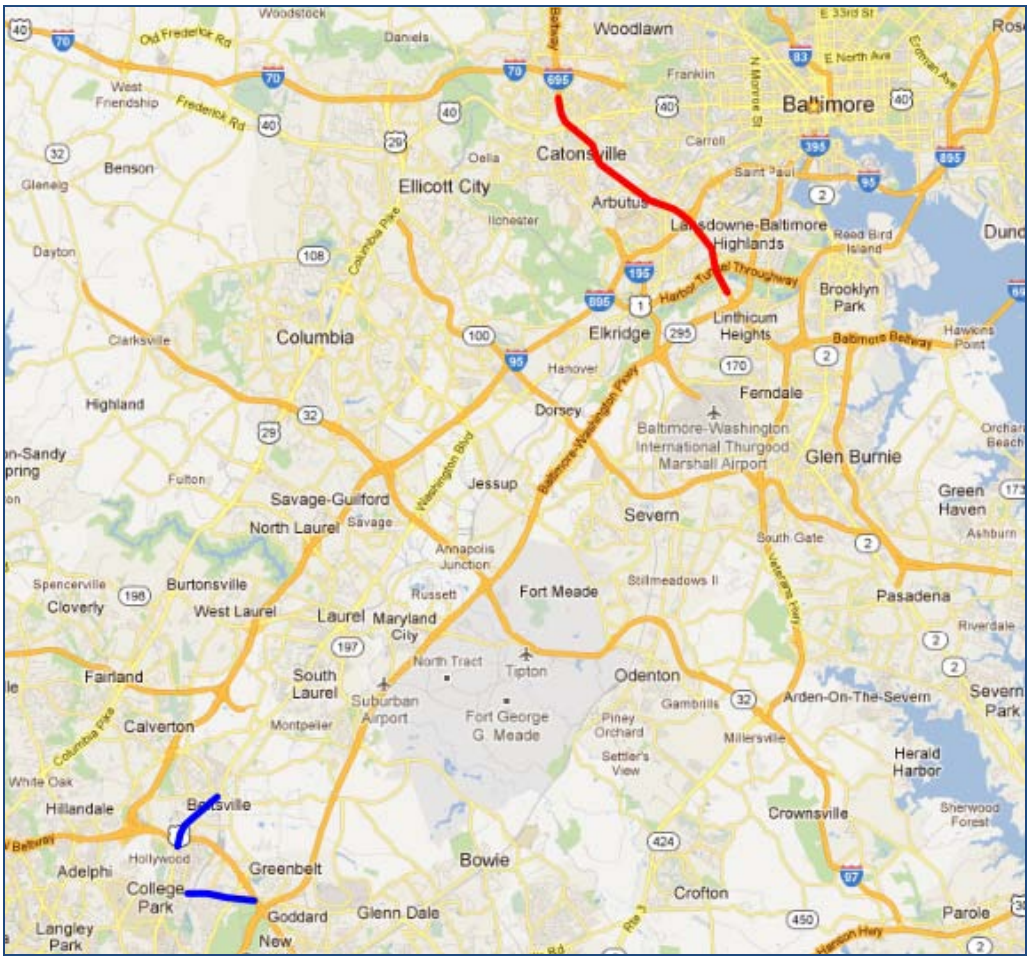

Figure 1
TMC segments selected for validation in Maryland

Table 1 presents a list of data collection segments from Maryland. In total, these segments cover a total length of approximately14 freeway miles, about seven arterial miles, and nearly three miles of ramp facilities. Data collection segments are comprised of one or more Traffic Message Channel (TMC) base segments, such that total length of the data collection segment is one mile long or greater for freeways. When appropriate, consecutive TMC segments are combined to form a data collection segment longer than one mile. The results of validation performed on six freeway segments, and three ramp segments are included in this report. The results for the four arterial segments will be presented in a separate report. Table 1 contains summary information on each data collection segment. Click on the map link to see a detailed map for the respective data collection segment. The latitude/longitude coordinates of the locations at which the Bluetooth sensors were deployed, throughout the state of Marylandare provided in Table 1 as well as an active map link to view the data collection segment in detail. 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 segmentsare 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 1Segments selected for validation in Maryland

SEGMENT (Map Link)	DESCRIPTION			TMC CODES		Deployment		
	Highway Direction	State County	Starting at Ending at	Begin End	Number Length	Begin Lat/Lon End Lat/Lon		Length % Diff
FREEWAYS								All Lengths in Miles
F1 (MD05-0001)	I-695 CW	Maryland Anne Arundel & Baltimore	MD-295/Baltimore Washington Pkwy/Exit 7 I-95/Exit 11	110+04510 110+04514	9 1.9	39.22358 39.24672	-76.66073 -76.67516	1.8 -3.19%
F2 (110P04514)	I-695 CW	Maryland Baltimore	I-95/Exit 11 I-95/Exit 11	110P04514 -	1 1.2	39.24672 39.25582	-76.67516 -76.6896	1.01 -12.26%
F3 (MD05-0002)	I-695 CW	Maryland Baltimore	US-1/Southwestern Blvd/Exit 12 I-70/Exit 16	110+04516 110+04520	9 4.2	39.25582 39.2966	-76.6896 -76.74251	4.24 1.35%
F4 (MD05-0003)	I-695 CCW	Maryland Baltimore	I-70/Exit 16 I-95/Exit 11	110-04519 110-04514	10 4.7	39.29817 39.25319	-76.74345 -76.68416	4.71 1.16%
F5 (MD05-0004)	I-695 CCW	Maryland Baltimore	I-95/Exit 11 Hollins Ferry Rd/Exit 9	110N04514 110-04512	4 1.6	39.25319 39.23742	-76.68416 -76.66824	1.41 -13.52%
F6 (MD05-0005)	I-695 CCW	Maryland Anne Arundel & Baltimore	Hollins Ferry Rd/Exit 9 MD-295/Baltimore Washington Pkwy/Exit 7	110N04512 110-04509	6 1.1	39.23742 39.22229	-76.66824 -76.66055	1.13 7.56%
TOTALS				- -	39 14.7	- -	- -	14.3 -
RAMPS								All Lengths in Miles
R1 (MD05-0010)	I-95 NB to I-695 CW	Maryland Baltimore	-	110P15079 110P15065	2 1.0	39.249746 39.256136	-76.67964 -76.691398	1.02 2.49%
R2 (MD05-0011)	I-695 CCW to I-95 NB	Maryland Baltimore	-	110P14999 110P14995	2 1.0	39.254304 39.254635	-76.686302 -76.676372	0.96 -5.38%
R3 (110P14961)	I-695 CW to I-95 NB	Maryland Baltimore	-	110P14961 -	2 0.6	39.246054 39.254635	-76.674821 -76.676372	0.66 2.81%
TOTALS				- -	6 2.6	- -	- -	2.64 -

ARTERIALS								All Lengths in Miles
A1 (MD05-0006)	MD-193 EB	Maryland Prince George's	Greenbelt Rd I-495/I-95	110+09831 110+09833	4 1.7	38.99796 38.99574	-76.92277 -76.8906	1.74 -0.55%
A2 (MD05-0007)	MD-193 WB	Maryland Prince George's	I-495/I-95 Greenbelt Rd	110-09832 110-09830	4 1.7	38.99593 38.99796	-76.88883 -76.92277	1.83 4.64%
A3 (MD05-0008)	US-1 NB	Maryland Prince George's	I-495/I-95 MD-212/Powder Mill Rd	110P09538 110+09540	4 1.7	39.01546 39.03465	-76.92775 -76.90735	1.75 1.09%
A4 (MD05-0009)	US-1 SB	Maryland Prince George's	MD-212/Powder Mill Rd I-495/I-95	110-09539 110N09538	4 1.7	39.03465 39.01546	-76.90735 -76.92775	1.75 0.65%
TOTALS				- -	16 6.8	- -	- -	7.07 -

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: 0-30MPH, 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 is consistently under or over estimates speed as compared to ground truth speed. Based upon 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 data, 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 highlight in Table 2. AASE below 10 MPH meet contract spec. AASE below 5 MPH are considered exceptional quality.

Table 2
Date quality measures for freeway segments greater than one mile in Maryland: Speed Error Bias (SEB) and Average Absolute Speed Error (AASE)

	Data Quality Measures for				
	1.96 SEM Band		Mean		
SPEED BIN	SEB 5 mph (contract specfications)	AASE 10 mph (contract specfications)	SEB	AASE	No. of Obs.
0-30	1.4	2.4	1.8	3.6	868
30-45	3.2	4.3	4.6	6.5	371
45-60	1.4	1.7	3.2	4.1	3026
60+	-0.4	0.9	-1	3	5148

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 Maryland.

Table 3
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	30%	87%	0%	79%	868
30-45	25%	67%	0%	54%	371
45-60	46%	88%	0%	69%	3026
60+	61%	96%	0%	82%	5148

The Score metric in the VPP data provides an indication on whether speed data is based on real-time information or relies primarily on historical data. Three discrete values correspond to:

"30" – high confidence, based on real-time time data for that specific segment

"20" – medium confidence, based on real-time data across multiple segments and/or based on a combination of expected and real-time data

"10" – low confidence, based primarily on historical data

Anything less than of "30" is an indication of reliance on some type of historical data or averaging of data across a broad geographic area. Table 4 presents AASE and SEB data on reported INRIX speeds with a score less than 25, greater than or equal to 25, and for all Score values. (Note that although Score is a discrete value of 10, 20, or 30 for any given TMC segment at a given time, aggregating the data from multiple TMC segments over time creates rational values of Score between 10 and 30.)

Table 4
Data quality measures by Score Value for INRIX speed data on freeway segment in Maryland

SPEED BIN	SCORE	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	< 25	-	-	-	-	0
	>= 25	1.4	2.4	1.8	3.6	868
	ALL	1.4	2.4	1.8	3.6	868
30-45	< 25	-	-	-	-	0
	>= 25	3.2	4.3	4.6	6.5	371
	ALL	3.2	4.3	4.6	6.5	371
45-60	< 25	0.7	0.7	4.7	4.7	17*
	>= 25	1.4	1.8	3.2	4.1	3009
	ALL	1.4	1.7	3.2	4.1	3026
60+	< 25	0	0	-1.6	1.6	1*
	>= 25	-0.4	0.9	-1	3	5147
	ALL	-0.4	0.9	-1	3	5148

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

Tables 6 and 7 present detailed data for individual TMC segments in Maryland in 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 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	
110P04514	1.2	1.0	0-30	2.2	2.9	2.7	4.4	270
			30-45	7.0	8.4	8.8	11.3	40
			45-60	1.8	2.2	4.1	4.9	889
			60+	-0.3	1.2	-0.7	3.6	442
MD05-0001	1.9	1.8	0-30	2.7	3.3	3.7	4.9	131
			30-45	5.2	6.9	7.2	10.4	51
			45-60	1.1	1.7	3.3	4.3	499
			60+	-0.3	0.9	-0.8	3.0	893
MD05-0002	4.2	4.2	0-30	0.0	1.6	-0.1	2.1	256
			30-45	2.6	3.3	3.4	4.6	138
			45-60	0.7	1.3	1.7	2.9	545
			60+	-0.4	0.9	-1.3	2.6	1157
MD05-0003	4.7	4.7	0-30	4.5	4.5	8.1	8.3	26*
			30-45	1.7	2.1	3.6	4.5	106
			45-60	1.7	1.8	3.6	3.9	487
			60+	0.1	0.4	0.4	2.0	647
MD05-0004	1.6	1.4	0-30	2.1	2.8	2.4	3.5	60
			30-45	5.8	8.0	7.9	10.5	12*
			45-60	1.9	2.1	4.6	5.1	229
			60+	0.2	0.7	0.5	2.8	782
MD05-0005	1.1	1.1	0-30	0.5	1.4	0.5	2.5	125
			30-45	1.6	4.9	2.5	8.3	24*
			45-60	0.7	1.2	2.0	3.5	377
			60+	-1.0	1.3	-2.7	3.8	1227

*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	
110P04514	0-30	94	35%	219	81%	0	0%	188	70%	270
	30-45	6	15%	13	33%	0	0%	9	23%	40
	45-60	389	44%	748	84%	0	0%	524	59%	889
	60+	267	60%	413	93%	0	0%	323	73%	442
MD05-0001	0-30	42	32%	109	83%	0	0%	95	73%	131
	30-45	13	25%	21	41%	0	0%	15	29%	51
	45-60	239	48%	440	88%	1	0%	340	68%	499
	60+	578	65%	847	95%	2	0%	746	84%	893
MD05-0002	0-30	53	21%	244	95%	0	0%	237	93%	256
	30-45	30	22%	103	75%	0	0%	92	67%	138
	45-60	293	54%	501	92%	0	0%	446	82%	545
	60+	645	56%	1119	97%	0	0%	1010	87%	1157
MD05-0003	0-30	6	23%	16	62%	0	0%	6	23%	26*
	30-45	39	37%	91	86%	0	0%	72	68%	106
	45-60	161	33%	438	90%	0	0%	351	72%	487
	60+	476	74%	642	99%	0	0%	610	94%	647
MD05-0004	0-30	17	28%	46	77%	0	0%	44	73%	60
	30-45	2	17%	4	33%	0	0%	4	33%	12*
	45-60	81	35%	197	86%	1	0%	126	55%	229
	60+	516	66%	755	97%	0	0%	657	84%	782
MD05-0005	0-30	47	38%	117	94%	0	0%	113	90%	125
	30-45	4	17%	15	63%	0	0%	9	38%	24*
	45-60	234	62%	349	93%	0	0%	295	78%	377
	60+	643	52%	1149	94%	0	0%	887	72%	1227

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

Analysis of Results for Ramps

Table 8 summarizes the data quality measures obtained as a result of comparison between BTM equipment and all reported INRIX speeds on three ramp segments in this round of validations. In all speed bins less than 60 mph, INRIX data meets the data quality measures set forth in the contract for mainline freeways, when errors are measured as a distance from the 1.96 times the standard error band. No data quality specifications are currently in effect for freeway ramps. In addition, it should be noted that the absence of any observations at above 60 mph in these segments is compatible with expected operational speeds on a ramp facility.

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 this ramp segment in Maryland.

Table 8
Data quality measures for the ramp segment 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	2.5	4.3	3.5	6.4	144
30-45	2.5	4.4	5.1	8.0	335
45-60	0.2	1.5	0.8	3.7	1177
60+					

Table 9
Percent observations meeting data freeway quality criteria for the 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	23%	70%	0%	58%	144
30-45	28%	64%	0%	30%	335
45-60	57%	91%	0%	76%	1177
60+					

Tables 10 and 11 present detailed data for individual ramp segments in Maryland in similar format as Tables 8 and 9, respectively.

Table 10
Data quality measures for individual ramp segments 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	
110P14961	0.6	0.7	0-30					
			30-45	1.1	3.5	4.2	7.4	147
			45-60	-0.3	1.7	0.2	4.5	222
			60+					
MD05-0010	1.0	1.0	0-30	1.7	3.7	3.2	6.2	94
			30-45	3.2	4.9	5.0	8.0	143
			45-60	0.3	1.5	1.1	3.6	636
			60+					
MD05-0011	1.0	1.0	0-30	3.9	5.5	4.1	6.8	50
			30-45	4.8	5.6	8.4	9.8	45
			45-60	0.2	1.1	0.7	3.4	319
			60+					

Table 11
Observations meeting freeway data quality criteria for individual ramp segments 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	
110P14961	0-30									
	30-45	58	39%	107	73%	0	0%	56	38%	147
	45-60	141	64%	201	91%	0	0%	161	73%	222
	60+									
MD05-0010	0-30	21	22%	66	70%	0	0%	53	56%	94
	30-45	30	21%	83	58%	0	0%	40	28%	143
	45-60	340	53%	574	90%	0	0%	487	77%	636
	60+									
MD05-0011	0-30	12	24%	35	70%	0	0%	30	60%	50
	30-45	7	16%	26	58%	0	0%	6	13%	45
	45-60	192	60%	296	93%	2	1%	249	78%	319
	60+									