I-95 Corridor Coalition
Vehicle Probe Project:
HERE, INRIX and TOMTOM
Data Validation

Report for Pennsylvania (#10)
I-79

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Acknowledgements:
The research team would like to express its gratitude for the assistance it received from the state highway officials in Pennsylvania during the course of this study. Their effort was instrumental during the data collection phase of the project. This report would not have been completed without their help.

Data Collected: June 12 to June 27, 2017
Report Date: October 2017

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Executive Summary

Wireless re-identification traffic monitoring (WRTM) data is collected to validate data for the Vehicle Probe Project. WRTM data includes Bluetooth, Wi-Fi and other wireless traffic monitoring devices that collect signals emitted by in-vehicle electronic equipment. The specific device type used for each validation will be determined based upon applicability and will be defined in the report. Specifications used for comparison include the Average Absolute Speed Error (AASE) and the Speed Error Bias (SEB).

- Bluetooth re-identification sensors were deployed at the beginning and ending points of 14 different segments along the I-79 corridor. Data was collected from both directions.
- Selected segments for the I-79 corridor stretch from Exit 73 to Exit 88 for the northbound, and from Exit 88 to Exit 78 for the southbound corridor. (Refer to Figure 1 below).
- Travel time data was collected for both directions along the corridors, between June 12 and June 27, 2017.
- The selected segments were located within an active work zone.
- The dataset collected represents approximately 2,933 hours of observations along the 14 freeway segments, totaling approximately 30 miles.
- The total number of effective five-minute travel time samples observed was 35,191.
- 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.

ES Table 1 provides a summary description of the study corridor.

ES Table 1– I-79 Freeway Description

Corridor Name	Number of Lanes	AADT	Speed Limit
I-79	2 to 4 lanes per direction	35,000	70 *mph*

ES Table 2, 3 and 4 below summarizes the results of the comparison between the WRTM reference data and the probe data from each vendor for freeway segments during the above noted time period.

ES Table 2- HERE Freeway Evaluation Summary for Pennsylvania					
Speed Bin	**Average Absolute Speed Error (<10mph)**		**Speed Error Bias (<5mph)**		Number of 5 Minute Samples
	Comparison with SEM Band	Comparison with Mean	Comparison with SEM Band	Comparison with Mean	
0-30 MPH	2.8	4.4	2.2	3	1483
30-45 MPH	3.5	7.4	2.4	4.4	800
45-60 MPH	3.5	7.9	2.9	6.4	7233
>60 MPH	1.2	4.5	-0.5	-1.4	25675
All Speeds	1.8	5.3	0.4	0.5	35191
Based upon data collected from June 12, through June 27, 2017 across 30 miles of roadway.					

- For the HERE data as shown in ES Table 2, the average absolute speed error (AASE) was within specification because all speed bins fell below the required maximum value of <10 mph.
- The Speed Error Bias (SEB) was within specifications for all speed bins when compared with the Standard Error of the Mean (SEM) Band.

ES Table 3- INRIX Freeway Evaluation Summary for Pennsylvania					
Speed Bin	**Average Absolute Speed Error (<10mph)**		**Speed Error Bias (<5mph)**		Number of 5 Minute Samples
	Comparison with SEM Band	Comparison with Mean	Comparison with SEM Band	Comparison with Mean	
0-30 MPH	2.9	4.5	2.5	3.3	1480
30-45 MPH	5.7	10.1	4.8	7.7	802
45-60 MPH	3.6	8.1	3.2	7.3	7241
>60 MPH	1.1	4.3	-0.4	-1.3	25636
All Speeds	1.8	5.2	0.6	0.9	35159
Based upon data collected from June 12, through June 27, 2017 across 30 miles of roadway.					

- For the INRIX data shown in ES Table 3, the average absolute speed error (AASE) was within the maximum specification of <10 mph in all speed bins.
- The Speed Error Bias (SEB) was within specifications for all speed bins when compared with the Standard Error of the Mean (SEM) Band except for the first speed bin.

ES Table 4- TOMTOM Freeway Evaluation Summary for Pennsylvania					
Speed Bin	**Average Absolute Speed Error (<10mph)**		**Speed Error Bias (<5mph)**		Number of 5 Minute Samples
	Comparison with SEM Band	Comparison with Mean	Comparison with SEM Band	Comparison with Mean	
0-30 MPH	1.7	3.3	1.3	2.1	1493
30-45 MPH	3.8	7.9	2.9	5.1	807
45-60 MPH	2.9	7.5	2.1	6	7264
>60 MPH	1.1	4.2	-0.7	-1.5	25760
All Speeds	1.6	4.9	0.0	0.3	35324
Based upon data collected from June 12, through June 27, 2017 across 30 miles of roadway.					

- As shown for TOMTOM data in ES Table 4, the average absolute speed error (AASE) was within specification in all speed bins.
- The Speed Error Bias (SEB) was within specifications for all speed bins when compared with the Standard Error of the Mean (SEM) Band.

Methodology

Corridor Description and Data Collection

Travel time samples were collected along 14 freeway segments with the assistance of Pennsylvania Department of Transportation (PennDOT) personnel. Freeway segments studied were located on the I-79 corridor from Exit 73 to Exit 88 for the northbound, and from Exit 88 to Exit 78 for the southbound corridor. Travel time data was collected for both directions along I-79 freeways between June 12 and June 27, 2017. Segment locations were chosen with a high-likelihood of observing recurrent and non-recurrent congestion during peak and off-peak periods.

Figure 1 presents an overview snapshot of the placement of sensors for the collection of data on the I-79 corridors in Pennsylvania. Blue segments represent freeway segments selected for analysis.

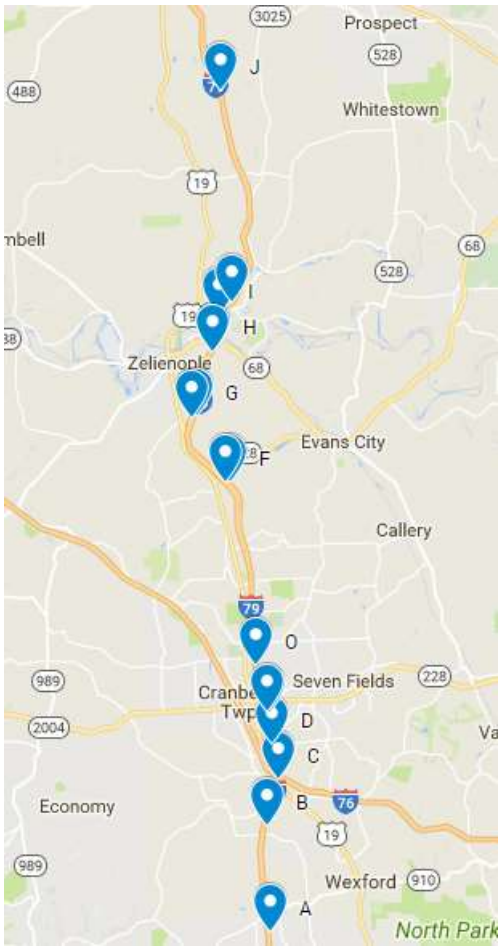

Figure 1- Locations of all segments selected on I-79 for analysis in Pennsylvania

TMC segments selected for validation in Pennsylvania

Table 1 presents the data collection segments from Pennsylvania. As a whole, these segments cover a total length of 30 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, in most cases, one mile or greater for freeways. When appropriate, consecutive TMC segments are combined to form a data collection segment longer than one mile. The results of the validation performed on 14 directional freeway segments are included in this report.

Table 1 contains the summary information on each data collection segment including the latitude/longitude coordinates of the locations at which the WRTM sensors were deployed along the I-79 in Pennsylvania 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 the test segments is often such that the endpoint of one segment coincides with the start point of the next segment, so that one WRTM sensor covers both data collection segments.

An algorithm was developed and documented in a separate report[1] as part of the initial VPP project and is being used for the validation of all vendors in VPPII. Details of the algorithm used to estimate equivalent path travel times based on probe data feeds for individual data collection segments are provided in this separate report. This algorithm finds an equivalent probe travel time (and therefore travel speed) corresponding to each sample WRTM travel time observation on the test segment of interest.

[1] Ali Haghani, Masoud Hamedi, Kaveh Farokhi Sadabadi, Estimation of Travel Times for Multiple TMC Segments, prepared for I-95 Corridor Coalition, February 2010 (link)

Table 1

Segments selected for validation in Pennsylvania

Segment (Map Link)	DESCRIPTION					Deployment	
	Highway Direction	Starting at Ending at	Lane (Min) Lane (Max)	AADT (Min) AADT (Max)	Access Points Speed Limit	Begin Lat/Lon End Lat/Lon	Length (mile)
Freeway							
A1	I-79	PA-910/Exit 73	3	28,000	2	40.610400 -80.094700	2.39
PA10-0001	Northbound	Warrendale Bayne Rd/Exit 75	4	74,000	65	40.644800 -80.096300	
A2	I-79	Warrendale Bayne Rd/Exit 75	3	28,000	1	40.644800 -80.096300	1.00
PA10-0002	Northbound	US-19/Exit 76	4	28,000	65	40.658800 -80.091400	
A3	I-79	US-19/Exit 76	2	28,000	1	40.658800 -80.091400	0.91
PA10-0003	Northbound	I-76/Pennsylvania Tpke	3	28,000	65	40.671400 -80.094200	
A4	I-79	I-76/Pennsylvania Tpke	2	28,000	2	40.671400 -80.094200	0.71
PA10-0004	Northbound	PA-228/Exit 78	3	28,000	65	40.681500 -80.095400	
A5	I-79	PA-228/Exit 78	2	28,000	5	40.681500 -80.095400	5.34
PA10-0005	Northbound	PA-528/Lindsay Rd/Exit83	3	42,000	70	40.756100 -80.111900	
A6	I-79	PA-528/Lindsay Rd/Exit83	2	28,000	2	40.756100 -80.111900	1.89
PA10-0006	Northbound	US-19/Exit 85	3	28,000	70	40.777307 -80.126265	
A7	I-79	US-19/Exit 85	2	28,000	0	40.777307 -80.126265	1.61
PA10-0007	Northbound	PA-68/Exit 87	3	28,000	70	40.798500 -80.118400	
A8	I-79	PA-68/Exit 87	2	28,000	1	40.798500 -80.118400	0.87
PA10-0008	Northbound	Little Creek Rd/Exit 88	3	28,000	70	40.881005 -80.114962	
A9	I-79	Mile Marker93/Sawyer Rd	2	28,000	0	40.881005 -80.114962	4.86
PA10-0009	Southbound	Little Creek Rd/Exit 88	2	33,000	70	40.814212 -80.110985	
A10	I-79	Little Creek Rd/Exit 88	2	28,000	3	40.814212 -80.110985	1.26
PA10-0010	Southbound	PA-68/Exit 87	3	28,000	70	40.798200 -80.118800	
A11	I-79	PA-68/Exit 87	2	28,000	0	40.798200 -80.118800	1.62
PA10-0011	Southbound	US-19/Exit 85	3	28,000	70	40.776957 -80.127878	

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

Segment (Map Link)	DESCRIPTION					Deployment	
	Highway Direction	Starting at Ending at	Lane (Min) Lane (Max)	AADT (Min) AADT (Max)	Access Points Speed Limit	Begin Lat/Lon End Lat/Lon	Length (mile)
Freeway							
A12	I-79	US-19/Exit 85	2	28,000	1	40.776957 -80.127878	1.74
PA10-0012	Southbound	PA-528/Lindsay Rd/Exit83	3	28,000	70	40.756190 -80.113635	
A13	I-79	PA-528/Lindsay Rd/Exit83	2	28,000	3	40.756190 -80.113635	4.33
PA10-0013	Southbound	PA-228/Exit 78	3	42,000	70	40.696657 -80.100735	
A14	I-79	PA-228/Exit 78	2	28,000	1	40.696700 -80.100735	1.09
PA10-0014	Southbound	I-76/Pennsylvania Tpke	4	28,000	70	40.681500 -80.095700	

Analysis of Freeways

The following sections summarize the data quality measures obtained as a result of comparison between WRTM and all reported probe speeds. Specifications used for comparison 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 WRTM 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 bins have proven to be the critical specification (and most difficult) to attain. It is important to consider that the weather ranged from rain to heavy rain during the data collection[2].

[2] The ground-truth data collected for this report as well as detailed daily comparison graphs for all segments are available for download upon request. Please email masoud@umd.edu for such inquiries.

Results

Analysis of Freeway Results for HERE Data

Table 2 shows the results of the comparison between the WRTM reference data and the HERE data. As stated before, the average absolute speed error (AASE) was within specifications in all speed bins. The Speed Error Bias (SEB) was within specifications for all speed bins when compared with the Standard Error of the Mean (SEM) Band.

Table 2- HERE Data quality measures for freeway segments in Pennsylvania

Speed Bin	Average Absolute Speed Error (<10mph)		Speed Error Bias (<5mph)		Number of 5 Minute Samples
	Comparison with SEM Band	Comparison with Mean	Comparison with SEM Band	Comparison with Mean	
0-30 MPH	2.8	4.4	2.2	3	1483
30-45 MPH	3.5	7.4	2.4	4.4	800
45-60 MPH	3.5	7.9	2.9	6.4	7233
>60 MPH	1.2	4.5	-0.5	-1.4	25675
All Speeds	1.8	5.3	0.4	0.5	35191
Based upon data collected from June 12, through June 27, 2017 across 30 miles of roadway.					

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

Table 3- Percent observations meeting HERE 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	34%	83%	0%	72%	1483
30-45	40%	71%	0%	45%	800
45-60	32%	69%	0%	28%	7233
60+	64%	92%	0%	65%	25675

Analysis of Freeway Results for INRIX Data

Table 4 shows the results of the comparison between the WRTM reference data and the INRIX data. As stated before, the average absolute speed error (AASE) was within specification in all speed bins. The Speed Error Bias (SEB) was within specifications for all speed bins when compared with the Standard Error of the Mean (SEM) Band except for the first speed bin.

Table 4- INRIX Data quality measures for freeway segments in Pennsylvania

Speed Bin	Average Absolute Speed Error (<10mph)		Speed Error Bias (<5mph)		Number of 5 Minute Samples
	Comparison with SEM Band	Comparison with Mean	Comparison with SEM Band	Comparison with Mean	
0-30 MPH	2.9	4.5	2.5	3.3	1480
30-45 MPH	5.7	10.1	4.8	7.7	802
45-60 MPH	3.6	8.1	3.2	7.3	7241
>60 MPH	1.1	4.3	-0.4	-1.3	25636
All Speeds	1.8	5.2	0.6	0.9	35159
Based upon data collected from June 12, through June 27, 2017 across 30 miles of roadway.					

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

Table 5- Percent observations meeting INRIX 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	36%	83%	0%	73%	1480
30-45	29%	57%	0%	31%	802
45-60	30%	68%	0%	25%	7241
60+	67%	93%	0%	67%	25636

Analysis of Freeway Results for TOMTOM Data

Table 6 shows the results of the comparison between the WRTM reference data and the TOMTOM data. As stated before, the average absolute speed error (AASE) was within specification in all speed bins. The Speed Error Bias (SEB) was within specifications for all speed bins when compared with the Standard Error of the Mean (SEM) Band.

Table 6- TOMTOM Data quality measures for freeway segments in Pennsylvania

Speed Bin	Average Absolute Speed Error (<10mph)		Speed Error Bias (<5mph)		Number of 5 Minute Samples
	Comparison with SEM Band	Comparison with Mean	Comparison with SEM Band	Comparison with Mean	
0-30 MPH	1.7	3.3	1.3	2.1	1493
30-45 MPH	3.8	7.9	2.9	5.1	807
45-60 MPH	2.9	7.5	2.1	6	7264
>60 MPH	1.1	4.2	-0.7	-1.5	25760
All Speeds	1.6	4.9	0	0.3	35324
Based upon data collected from June 12, through June 27, 2017 across 30 miles of roadway.					

Table 7 shows the percentage of the time the TOMTOM data falls within 5 mph of the SEM band and the mean for each speed bin for all freeway data segments in this validation report.

Table 7- Percent observations meeting TOMTOM 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	38%	90%	0%	79%	1493
30-45	36%	69%	0%	42%	807
45-60	30%	79%	0%	26%	7264
60+	70%	95%	0%	72%	25760

Appendix

Table A.1 to A.3 presents detailed data for individual TMC segments in this validation for all three vendors. Note that for some segments and in some speed bins the comparison results may not be reliable due to the small number of observations.

Table A. 1
HERE data quality measures for individual freeway validation segments in the state of Pennsylvania

Path	Standard TMC length	Sensor 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	
PA10-0001	2.39	2.39	0-30	1.9	2.0	3.7	3.9	12*
			30-45	6.0	6.0	8.5	8.7	16*
			45-60	5.2	5.3	9.2	9.4	1880
			60+	1.5	1.7	4.5	5.2	1288
PA10-0002	1.00	1.00	0-30	0.0	0.0	0.0	1.3	3*
			30-45	2.1	2.1	4.6	5.8	16*
			45-60	-0.6	0.8	-0.8	5.0	26*
			60+	-1.1	1.1	-4.3	5.1	891
PA10-0003	0.91	0.91	0-30	-1.4	1.7	-1.4	3.2	3*
			30-45	8.0	8.1	13.3	13.7	24*
			45-60	4.1	4.2	8.9	9.3	1266
			60+	0.5	0.8	1.9	4.2	1928
PA10-0004	0.71	0.71	0-30	2.5	4.0	3.5	9.2	25*
			30-45	-2.2	3.7	-3.5	11.0	25*
			45-60	-0.1	2.5	4.4	8.9	367
			60+	-0.8	0.9	-2.1	4.9	2440
PA10-0005	5.34	5.34	0-30	0.7	1.7	0.8	2.5	193
			30-45	-0.6	2.8	-1.1	6.3	31
			45-60	0.3	1.0	1.7	4.0	162
			60+	-1.1	1.3	-3.0	3.9	2381
PA10-0006	1.89	1.89	0-30	1.2	1.6	1.5	2.9	329
			30-45	0.5	2.4	-0.3	6.5	27*
			45-60	-0.1	1.6	0.1	4.8	166
			60+	-0.7	1.0	-2.1	3.8	2352
PA10-0007	1.61	1.61	0-30	0.9	1.7	1.6	3.0	159
			30-45	2.6	3.3	5.6	7.4	168
			45-60	2.3	2.7	6.0	7.1	1024
			60+	0.7	1.1	2.7	4.3	1377
PA10-0008	0.87	0.87	0-30	1.8	2.1	3.0	4.3	38
			30-45	1.8	3.2	3.0	6.1	160
			45-60	0.1	1.5	1.6	5.3	160
			60+	-2.9	3.0	-7.5	7.9	2230
PA10-0009	4.86	4.86	0-30	3.3	3.8	3.7	5.2	42
			30-45	2.4	3.4	2.7	5.1	21*
			45-60	2.3	3.0	4.0	5.9	63
			60+	0.0	0.7	0.1	2.9	2495
PA10-0010	1.27	1.26	0-30	6.9	6.9	8.8	9.1	182
			30-45	3.9	4.0	7.0	8.2	73
			45-60	2.2	2.9	4.5	7.0	211
			60+	-0.8	0.9	-2.5	4.0	1885

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

Table A.1 (Cont'd)
HERE data quality measures for individual freeway validation segments in the state of Pennsylvania

Path	Standard TMC length	Sensor 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	
PA10-0011	1.62	1.62	0-30	2.7	3.2	3.8	5.0	187
			30-45	1.4	2.8	2.3	5.8	55
			45-60	0.9	2.0	2.4	5.8	907
			60+	-0.2	1.4	0.1	4.5	1406
PA10-0012	1.74	1.74	0-30	1.1	1.9	1.3	3.7	138
			30-45	2.8	3.8	4.9	8.1	111
			45-60	1.6	2.1	3.8	5.4	291
			60+	-0.6	1.2	-1.8	4.5	1175
PA10-0013	4.33	4.33	0-30	2.5	3.0	3.6	4.7	172
			30-45	1.4	2.0	2.1	4.1	55
			45-60	0.8	1.3	2.9	4.8	100
			60+	-0.5	0.7	-2.7	3.9	1727
PA10-0014	1.09	1.09	0-30	-	-	-	-	-
			30-45	7.5	8.2	19.6	21.1	18*
			45-60	2.4	3.2	7.9	9.1	610.0
			60+	-0.3	1.3	0.1	4.6	2100.0

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

Table A.2 presents detailed data for individual TMC segments for INRIX. Note that for some segments and in some speed bins the comparison results may not be reliable due to the small number of observations.

Table A. 2
INRIX data quality measures for individual freeway validation segments in the state of Pennsylvania

Path	Standard TMC length	Sensor 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	
PA10-0001	2.39	2.39	0-30	6.0	6.5	8.2	9.5	12*
			30-45	11.6	11.7	13.9	14.7	16*
			45-60	5.9	5.9	10.1	10.1	1882
			60+	1.9	1.9	5.1	5.3	1285
PA10-0002	1.00	1.00	0-30	18.9	18.9	22.6	22.6	3*
			30-45	6.9	6.9	7.8	11.0	16*
			45-60	2.1	2.3	5.5	6.6	26*
			60+	-0.8	1.0	-3.9	4.8	894
PA10-0003	0.91	0.91	0-30	15.4	17.5	15.6	20.0	3*
			30-45	11.8	11.8	18.0	18.0	24*
			45-60	3.0	3.0	7.6	7.8	1275
			60+	0.2	0.6	0.4	3.8	1919
PA10-0004	0.71	0.71	0-30	5.8	6.1	11.3	12.2	25*
			30-45	1.8	2.7	6.0	9.6	26*
			45-60	0.5	1.0	3.9	5.6	369
			60+	-1.3	1.4	-4.7	6.0	2438
PA10-0005	5.34	5.34	0-30	0.4	0.9	0.6	1.7	194
			30-45	2.7	3.4	4.4	6.6	31
			45-60	1.4	1.8	3.5	5.5	157
			60+	-0.8	1.0	-2.5	3.5	2385
PA10-0006	1.89	1.89	0-30	1.3	1.5	1.8	2.8	319
			30-45	2.8	3.7	3.3	8.0	25*
			45-60	0.9	2.2	2.8	5.9	167
			60+	-0.4	0.7	-1.3	3.3	2359
PA10-0007	1.61	1.61	0-30	1.4	1.9	1.8	3.3	160
			30-45	4.1	4.5	7.7	8.9	167
			45-60	2.6	2.9	6.8	7.5	1018
			60+	0.6	0.9	2.4	3.9	1381
PA10-0008	0.87	0.87	0-30	2.9	2.9	4.6	5.1	39
			30-45	3.6	4.3	5.4	7.5	161
			45-60	1.6	2.5	5.2	7.2	160
			60+	-2.3	2.4	-6.6	7.1	2226
PA10-0009	4.86	4.86	0-30	6.0	6.0	7.7	7.7	42
			30-45	8.2	8.2	10.4	10.4	21*
			45-60	3.1	3.8	5.4	7.1	63
			60+	0.2	0.6	0.5	2.7	2492
PA10-0010	1.27	1.26	0-30	6.9	7.3	8.7	10.0	182
			30-45	5.7	8.5	8.9	14.6	74
			45-60	1.4	3.9	3.7	8.4	211
			60+	-1.0	1.2	-2.6	4.3	1875
PA10-0011	1.62	1.62	0-30	2.2	2.9	3.0	4.5	187
			30-45	5.2	7.1	7.0	10.9	56
			45-60	1.4	2.1	4.4	6.0	909
			60+	-0.1	1.0	0.0	3.9	1400

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

Table A.2 (Cont'd)
INRIX data quality measures for individual freeway validation segments in the state of Pennsylvania

Path	Standard TMC length	Sensor 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	
PA10-0012	1.74	1.74	0-30	3.5	4.2	4.3	6.2	140
			30-45	5.7	6.8	9.3	11.5	112
			45-60	3.2	3.5	6.9	7.6	291
			60+	-0.4	1.0	-1.0	4.1	1166
PA10-0013	4.33	4.33	0-30	0.4	1.0	0.7	2.4	174
			30-45	1.2	2.4	1.6	4.4	55
			45-60	1.5	2.3	3.9	6.1	100
			60+	-0.4	0.7	-2.4	3.9	1720
PA10-0014	1.09	1.09	0-30	-	-	-	-	-
			30-45	12.5	12.5	25.7	25.7	18*
			45-60	3.6	3.7	10.0	10.1	613
			60+	0.4	0.7	1.5	3.9	2096

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

Table A.3 presents detailed data for individual TMC segments for TomTom. Note that for some segments and in some speed bins the comparison results may not be reliable due to the small number of observations.

Table A. 3
TOMTOM data quality measures for individual freeway validation segments in the state of Pennsylvania

Path	Standard TMC length	Sensor 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	
PA10-0001	2.39	2.39	0-30	3.6	3.6	5.8	5.8	12*
			30-45	6.8	6.8	9.1	9.4	16*
			45-60	2.2	2.5	5.8	6.4	1888
			60+	-0.1	0.3	0.1	2.1	1291
PA10-0002	1.00	1.00	0-30	5.6	5.6	9.3	9.3	3*
			30-45	1.4	2.0	2.4	5.5	16*
			45-60	-0.9	1.8	-1.0	6.1	26*
			60+	-1.7	1.7	-6.2	6.4	894
PA10-0003	0.91	0.91	0-30	0.4	1.2	0.6	3.6	3*
			30-45	7.0	7.3	11.6	13.0	24*
			45-60	2.3	2.6	7.1	7.6	1276
			60+	-0.1	0.2	-0.3	2.9	1930
PA10-0004	0.71	0.71	0-30	0.6	1.0	3.1	5.1	25*
			30-45	-1.3	2.1	-3.3	9.6	26*
			45-60	-0.5	1.4	3.4	6.8	369
			60+	-0.9	0.9	-4.1	4.9	2450
PA10-0005	5.34	5.34	0-30	0.0	1.0	-0.1	1.8	194
			30-45	0.3	2.3	0.1	5.9	31
			45-60	1.1	2.5	3.9	6.9	162
			60+	-0.8	0.9	-2.5	3.3	2393
PA10-0006	1.89	1.89	0-30	0.2	0.7	-0.2	1.9	332
			30-45	-1.2	2.8	-4.1	7.3	27*
			45-60	-0.1	1.8	0.7	5.2	167
			60+	-0.4	0.8	-0.5	3.2	2359
PA10-0007	1.61	1.61	0-30	0.6	0.8	1.4	2.0	160
			30-45	3.7	3.9	7.6	8.5	170
			45-60	3.8	3.8	8.7	8.9	1027
			60+	0.9	0.9	4.3	4.6	1381
PA10-0008	0.87	0.87	0-30	3.9	4.1	5.7	6.3	39
			30-45	3.3	4.2	5.2	7.3	161
			45-60	0.4	1.2	2.3	5.1	160
			60+	-2.0	2.0	-6.3	6.7	2237
PA10-0009	4.86	4.86	0-30	4.6	4.6	6.2	6.2	42
			30-45	3.9	3.9	6.0	6.0	21*
			45-60	1.6	2.7	2.9	5.7	63
			60+	0.4	0.5	1.6	2.6	2504
PA10-0010	1.27	1.26	0-30	3.3	3.4	4.9	5.7	182
			30-45	1.6	2.9	3.5	7.5	74
			45-60	0.7	1.5	1.9	5.0	211
			60+	-0.4	0.6	-1.3	3.3	1893
PA10-0011	1.62	1.62	0-30	1.1	1.3	2.0	2.7	187
			30-45	1.3	3.1	1.8	6.1	56
			45-60	2.2	3.5	5.7	8.3	910
			60+	-2.4	3.3	-1.0	6.8	1411

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

Table A.3 (Cont'd)
TOMTOM data quality measures for individual freeway validation segments in the state of Pennsylvania

Path	Standard TMC length	Sensor 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	
PA10-0012	1.74	1.74	0-30	0.6	1.3	0.8	2.9	140
			30-45	3.8	4.2	5.9	8.1	112
			45-60	3.4	4.0	6.5	8.4	291
			60+	-0.4	1.0	-0.1	4.2	1177
PA10-0013	4.33	4.33	0-30	3.1	3.1	5.1	5.1	174
			30-45	1.9	1.9	3.8	4.0	55
			45-60	1.4	1.5	4.4	5.3	100
			60+	-0.3	0.4	-2.4	3.3	1733
PA10-0014	1.09	1.09	0-30	-	-	-	-	-
			30-45	9.0	9.5	21.4	22.5	18*
			45-60	1.5	3.8	6.5	10.1	614
			60+	-2.2	2.6	-2.0	5.8	2107

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