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

Report for North Carolina (#08)
I-240, I-40 and I-26

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Data Collected: December 15 to December 26, 2016
Report Date: July 2017

1. Table of Contents

2. List of Tables

3. List of Figures

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).

- Wi-Fi re-identification sensors were deployed at the beginning and ending points of 15 different segments along the I-240, I-40 and I-26 corridors in both directions.
- Selected segments for the I-240 corridor stretch from Exit 3 to Exit 5B. (Refer to Figure 1 below).
- I-40 segments cover the range from Exit 44 to Exit 47.
- I-26 segments include the stretch between I-40 to Exit 37.
- Travel time data was collected for both directions along the corridors, between December 15 and December 26, 2016.
- The dataset collected represents approximately 2,427 hours of observations along the 15 freeway segments, totaling approximately 22 miles.
- The total number of effective five-minute travel time samples observed was 28,953.
- 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-240, I-40 and I-26 Freeway Description

Corridor Name	Number of Lanes	AADT	Speed Limit
I-240	2 to 4 lanes per direction	80,000	50 *mph*
I-40	2 to 4 lanes per direction	54,250	60 *mph*
I-26	2 to 3 lanes per direction	76,000	60 *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 North Carolina					
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	3.6	6.4	3.3	5.6	425
30-45 MPH	2.8	6.1	1.4	3.0	1226
45-60 MPH	1.9	4.6	-0.3	0.2	10065
>60 MPH	1.7	5.0	-1.5	-3.9	17237
All Speeds	1.8	4.9	-0.9	-2.0	28953
Based upon data collected from December 15, through December 26, 2016 across 22 miles of roadway.					

- As shown for HERE data in ES Table 2, 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.

ES Table 3- INRIX Freeway Evaluation Summary for North Carolina					
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	6.1	9.2	5.4	7.5	425
30-45 MPH	3.8	7.1	2.8	4.9	1226
45-60 MPH	1.4	4	-0.1	0.4	10065
>60 MPH	1.4	4.6	-1.2	-3.5	17237
All Speeds	1.6	4.6	-0.6	-1.6	28953
Based upon data collected from December 15, through December 26, 2016 across 22 miles of roadway.					

- As shown for INRIX data in ES Table 3, 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.

ES Table 4- TOMTOM Freeway Evaluation Summary for North Carolina					
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	2.7	4.8	2.4	3.6	425
30-45 MPH	1.9	4.5	1.0	2.6	1226
45-60 MPH	0.8	2.9	-0.6	-1.0	10065
>60 MPH	2.4	6.0	-2.4	-6.0	17237
All Speeds	1.8	4.8	-1.6	-3.8	28953
Based upon data collected from December 15, through December 26, 2016 across 22 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 15 freeway segments with the assistance of North Carolina Department of Transportation (NCDOT) personnel. Freeway segments studied were located on the I-240 corridor from Exit 3 to Exit 5B, I-40 corridor from Exit 44 to Exit 47, and I-26 corridor between I-40 to Exit 37. Travel time data was collected for both directions along I-240, I-40 and I-26 freeways between December 15 and December 26, 2016. Segment locations were chosen with a high-likelihood of observing recurrent and non-recurrent congestion during peak and off-peak periods.

Figures 1 to 3 present an overview snapshot of the placement of sensors for the collection of data on the I-240, I-40 and I-26 corridors in North Carolina. Blue segments represent freeway segments selected for analysis.

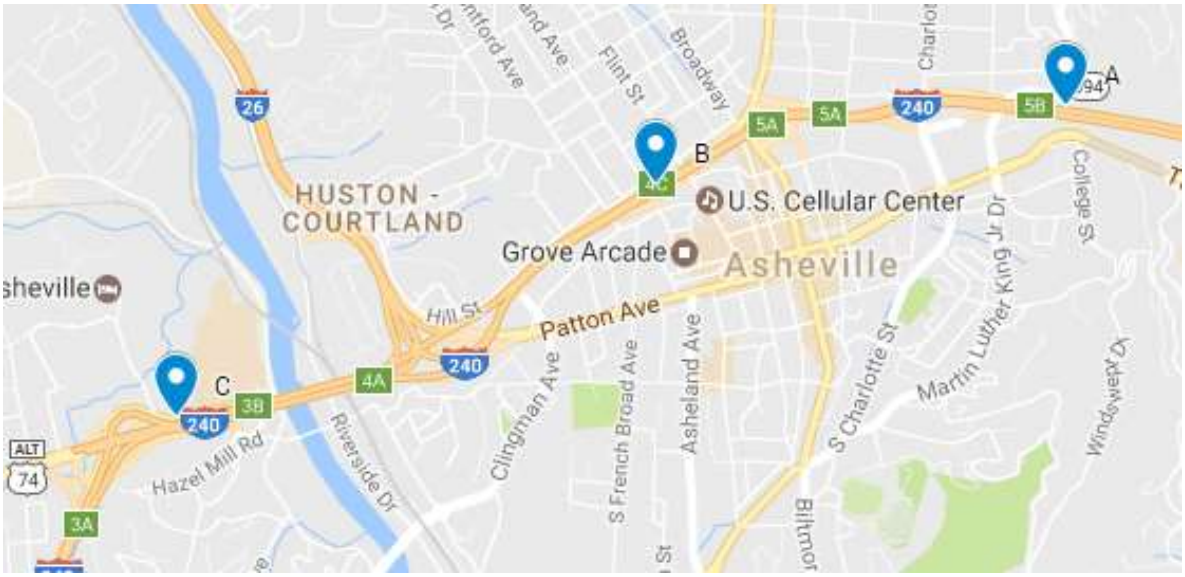

Figure 1- Locations of all segments selected on I-240 for analysis in North Carolina

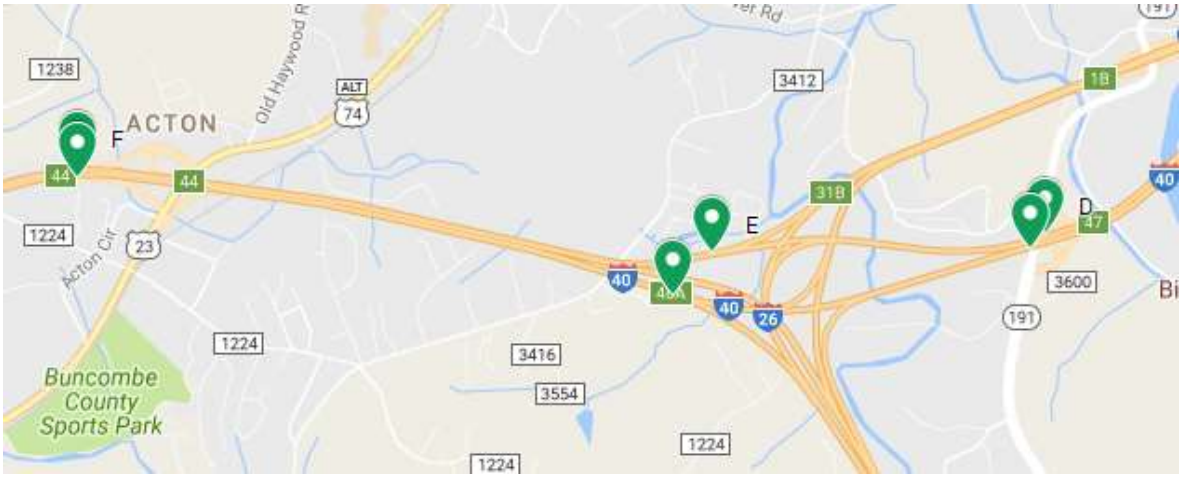

Figure 2- Locations of all segments selected on I-40 for analysis in North Carolina

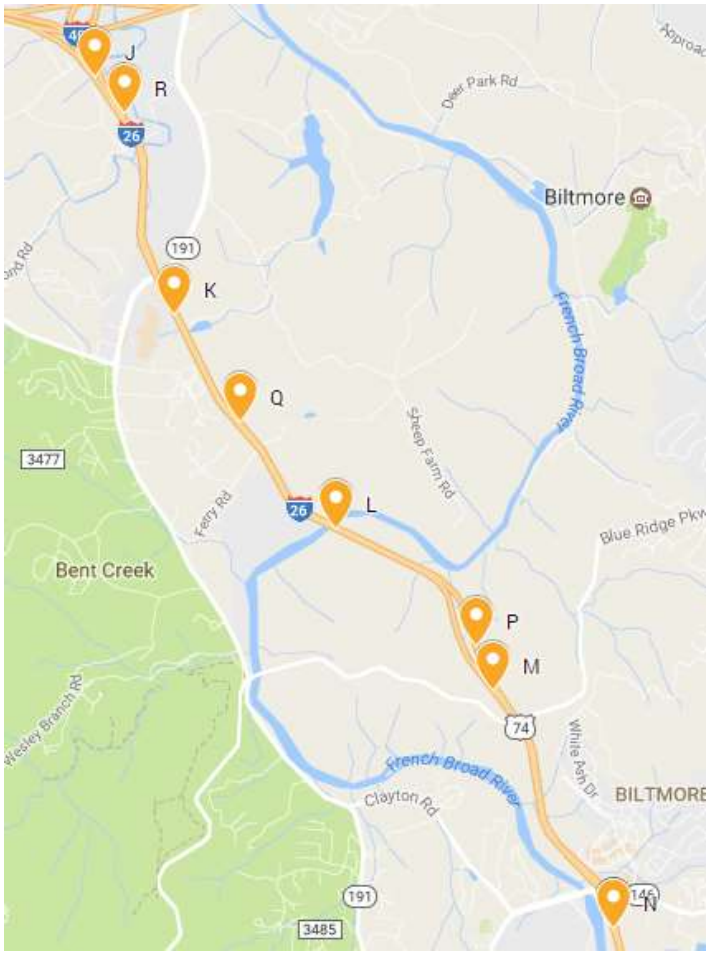

Figure 3- Locations of all segments selected on I-26 for analysis in North Carolina

TMC segments selected for validation in North Carolina

Table 1 presents the data collection segments from North Carolina. As a whole, these segments cover a total length of 22 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 15 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-240, I-40 and I-26 in North Carolina 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 North Carolina

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-240	US-70/Exit 5B	2	77,000	5	35.600168 -82.541236	0.98
NC08-0001	Westbound	Haywood St./Exit 4C	3	78,000	50	35.597625 -82.557832	
A2	I-240	Haywood St./Exit 4C	2	62,000	7	35.597625 -82.557832	1.24
NC08-0002	Westbound	US-23/Exit 3	4	103,000	50	35.589811 -82.577333	
A3	I-40	NC-191/Exit 47	2	36,000	3	35.557230 -82.598800	0.87
NC08-0003	Westbound	I-26/Exit 46	3	48,000	60	35.556580 -82.614100	
A4	I-40	I-26/Exit 46	3	53,000	3	35.556580 -82.614100	1.68
NC08-0004	Westbound	US-23/US-19/Exit 44	4	80,000	60	35.559730 -82.643500	
A5	I-40	US-23/US-19/Exit 44	3	53,000	2	35.559540 -82.643400	1.58
NC08-0005	Eastbound	I-26/Exit 46	4	80,000	60	35.555160 -82.615900	
A6	I-40	I-26/Exit 46	3	36,000	4	35.555160 -82.615900	0.96
NC08-0006	Eastbound	NC-191/Exit 47	4	48,000	55	35.556880 -82.599500	
A7	I-26	I-40/ Exit 46 A/US 74	2	62,000	2	35.550849 -82.609067	1.51
NC08-0007	Westbound	I-26/Exit 33	3	81,000	60	35.530710 -82.600681	
A8	I-26	I-26/Exit 33	2	78,000	0	35.530710 -82.600681	1.60
NC08-0008	Westbound	Old River Rd	3	81,000	60	35.512520 -82.584117	
A9	I-26	Old River Rd	2	78,000	0	35.512520 -82.584117	1.41
NC08-0009	Westbound	Blue Ridge Pkwy	2	78,000	60	35.498820 -82.567674	
A10	I-26	Blue Ridge Pkwy	2	72,000	2	35.498820 -82.567674	1.60
NC08-0010	Westbound	I-26/Exit 37	3	78,000	60	35.478775 -82.555093	
A11	I-26	I-26/Exit 37	2	72,000	2	35.478550 -82.554788	1.90
NC08-0011	Eastbound	Blue Ridge Pkwy	3	78,000	60	35.502600 -82.569413	

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

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-26	Blue Ridge Pkwy	2	78,000	0	35.502600	-82.569413	2.00
NC08-0012	Eastbound	Ferry Rd	2	81,000	60	35.521619	-82.593987	
A13	I-26	Ferry Rd	2	62,000	2	35.521619	-82.593987	1.98
NC08-0013	Eastbound	I-26/Exit 31 A	3	81,000	55	35.547731	-82.606132	
A14	I-240	US-23/Exit 3	2	62,000	4	35.589481	-82.578059	1.14
NC08-0014	Eastbound	Haywood St./Exit 4C	4	103,000	50	35.596122	-82.560630	
A15	I-240	Haywood St./Exit 4C	2	77,000	6	35.596122	-82.560630	1.11
NC08-0015	Eastbound	US-70/Exit 5B	4	78,000	55	35.600069	-82.542252	

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 North Carolina

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	3.6	6.4	3.3	5.6	425
30-45 MPH	2.8	6.1	1.4	3.0	1226
45-60 MPH	1.9	4.6	-0.3	0.2	10065
>60 MPH	1.7	5.0	-1.5	-3.9	17237
All Speeds	1.8	4.9	-0.9	-2.0	28953
Based upon data collected from December 15, through December 26 across 22 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 North Carolina

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	31%	76%	0%	60%	425
30-45	33%	77%	0%	47%	1226
45-60	49%	86%	0%	63%	10065
60+	55%	89%	0%	60%	17237

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 North Carolina

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	6.1	9.2	5.4	7.5	425
30-45 MPH	3.8	7.1	2.8	4.9	1226
45-60 MPH	1.4	4	-0.1	0.4	10065
>60 MPH	1.4	4.6	-1.2	-3.5	17237
All Speeds	1.6	4.6	-0.6	-1.6	28953
Based upon data collected from December 15, through December 26 across 22 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 North Carolina

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	26%	62%	0%	47%	425
30-45	31%	69%	0%	42%	1226
45-60	55%	91%	0%	70%	10065
60+	57%	91%	0%	62%	17237

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 North Carolina

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	2.7	4.8	2.4	3.6	425
30-45 MPH	1.9	4.5	1.0	2.6	1226
45-60 MPH	0.8	2.9	-0.6	-1.0	10065
>60 MPH	2.4	6.0	-2.4	-6.0	17237
All Speeds	1.8	4.8	-1.6	-3.8	28953
Based upon data collected from December 15, through December 26 across 22 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 North Carolina

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	30%	79%	1%	62%	425
30-45	48%	88%	0%	65%	1226
45-60	71%	95%	0%	83%	10065
60+	40%	81%	0%	49%	17237

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 North Carolina

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	
NC08-0001	0.99	0.98	0-30	2.9	3.0	4.9	5.3	172
			30-45	2.7	3.0	6.0	7.3	105
			45-60	1.0	1.3	2.4	3.6	1063
			60+	-5.6	5.6	-10.1	10.1	1*
NC08-0002	1.24	1.24	0-30	3.0	3.0	5.7	6.7	13*
			30-45	-3.6	3.6	-6.1	6.6	143
			45-60	-6.4	6.4	-10.4	10.4	1253
			60+	-11.4	11.4	-16.6	16.6	131
NC08-0003	0.87	0.87	0-30	-	-	-	-	-
			30-45	-	-	-	-	-
			45-60	0.8	1.0	3.1	4.2	334
			60+	-0.7	0.9	-2.7	4.1	1524
NC08-0004	1.67	1.68	0-30	-	-	-	-	-
			30-45	-	-	-	-	-
			45-60	0.7	0.7	3.1	3.5	634
			60+	-0.2	0.5	-1.3	2.8	1240
NC08-0005	1.58	1.58	0-30	10.0	10.0	19.6	19.7	43
			30-45	3.5	4.1	8.6	11.8	75
			45-60	1.0	1.3	3.3	4.4	463
			60+	-0.2	0.5	-0.8	2.7	1690
NC08-0006	0.96	0.96	0-30	-	-	-	-	-
			30-45	-	-	-	-	-
			45-60	0.6	0.7	4.5	5.0	146
			60+	-2.6	2.6	-7.0	7.6	1269
NC08-0007	1.52	1.51	0-30	0.9	1.2	1.4	2.6	27*
			30-45	3.4	3.7	5.9	6.6	309
			45-60	1.6	1.8	3.8	4.7	2044
			60+	-0.6	1.8	-2.2	4.8	116
NC08-0008	1.6	1.6	0-30	0.9	1.7	1.2	3.2	18*
			30-45	0.1	2.5	0.4	5.0	25*
			45-60	-2.9	3.1	-5.7	6.6	9*
			60+	-3.0	3.0	-7.5	7.6	2743
NC08-0009	1.41	1.41	0-30	2.5	2.9	2.8	4.0	15*
			30-45	0.7	3.3	0.7	5.3	36
			45-60	1.0	1.4	3.1	4.0	502
			60+	-0.1	0.6	-0.4	2.7	2315
NC08-0010	1.59	1.59	0-30	0.5	0.8	0.6	2.8	22*
			30-45	-0.8	1.7	-1.8	4.8	18*
			45-60	-1.9	2.5	-2.9	6.0	68
			60+	-2.3	2.3	-6.2	6.4	2530

*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 North Carolina

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	
NC08-0011	1.9	1.9	0-30	1.5	2.5	2.3	4.3	40
			30-45	0.6	4.2	1.5	6.5	35
			45-60	0.8	1.2	2.6	3.7	516
			60+	0.0	0.4	0.5	2.2	539
NC08-0012	2	2	0-30	6.3	6.5	7.1	7.5	28*
			30-45	2.7	2.7	3.8	4.0	50
			45-60	0.3	1.2	1.1	3.2	195
			60+	-0.4	0.8	-1.2	2.5	1078
NC08-0013	1.98	1.98	0-30	1.9	1.9	4.6	4.6	2*
			30-45	-0.2	2.0	-0.6	3.5	30
			45-60	-1.4	2.1	-2.2	4.3	306
			60+	-2.1	2.2	-5.4	5.6	2056
NC08-0014	1.15	1.14	0-30	2.7	2.7	4.6	5.4	41
			30-45	1.2	1.6	3.3	4.6	312
			45-60	-0.1	0.7	-0.5	2.9	1232
			60+	-4.8	4.8	-8.4	8.4	1*
NC08-0015	1.12	1.11	0-30	1.7	1.7	5.8	5.8	4*
			30-45	1.1	1.7	2.9	4.9	88
			45-60	-0.4	0.8	-1.2	3.1	1300
			60+	-2.2	2.2	-7.2	7.2	4*

*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 North Carolina

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	
NC08-0001	0.99	0.98	0-30	2.5	3.5	2.9	5.7	175
			30-45	1.3	4.4	3.6	8.9	105
			45-60	0.4	1.4	1.6	3.6	1067
			60+	-3.6	3.6	-8.1	8.1	1*
NC08-0002	1.24	1.24	0-30	5.0	5.0	8.1	9.2	13*
			30-45	-0.8	1.3	-1.7	3.9	146
			45-60	-3.3	3.3	-6.7	6.8	1258
			60+	-7.5	7.5	-12.6	12.6	133
NC08-0003	0.87	0.87	0-30	-	-	-	-	-
			30-45	-	-	-	-	-
			45-60	1.3	1.5	4.6	5.1	337
			60+	-0.4	0.7	-1.6	3.6	1532
NC08-0004	1.67	1.68	0-30	-	-	-	-	-
			30-45	-	-	-	-	-
			45-60	0.8	0.9	3.7	3.8	638
			60+	-0.1	0.4	-1.0	2.8	1247
NC08-0005	1.58	1.58	0-30	10.2	10.2	20.2	20.6	44
			30-45	4.9	5.1	11.6	12.9	76
			45-60	0.8	1.4	3.2	4.2	468
			60+	-0.2	0.5	-1.2	2.8	1695
NC08-0006	0.96	0.96	0-30	-	-	-	-	-
			30-45	-	-	-	-	-
			45-60	1.2	1.2	6.0	6.2	146
			60+	-1.3	1.3	-4.5	5.6	1278
NC08-0007	1.52	1.51	0-30	5.4	6.1	7.0	8.4	28*
			30-45	4.8	4.9	7.8	8.1	312
			45-60	0.6	0.9	1.4	3.3	2053
			60+	-2.1	2.3	-5.4	5.8	116
NC08-0008	1.6	1.6	0-30	6.3	6.4	7.3	8.6	18*
			30-45	3.8	5.2	4.5	8.3	26*
			45-60	-2.1	4.0	-3.6	7.4	10*
			60+	-2.6	2.6	-7.2	7.3	2755
NC08-0009	1.41	1.41	0-30	7.5	8.0	8.4	9.4	16*
			30-45	4.6	7.9	5.1	10.0	38
			45-60	1.3	1.7	3.9	4.5	504
			60+	0.0	0.5	-0.2	2.5	2323
NC08-0010	1.59	1.59	0-30	8.4	8.8	9.6	11.0	24*
			30-45	0.0	9.6	0.0	14.0	18*
			45-60	-1.7	3.3	-0.3	7.3	70
			60+	-1.8	1.9	-5.5	5.7	2538
NC08-0011	1.9	1.9	0-30	8.0	8.1	9.6	9.8	42
			30-45	5.5	5.5	7.9	7.9	35
			45-60	1.0	1.4	3.3	4.0	519
			60+	0.2	0.5	0.7	2.3	541

*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 North Carolina

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	
NC08-0012	2	2	0-30	7.2	8.9	7.8	10.0	30
			30-45	6.3	7.1	7.3	8.5	50
			45-60	0.6	1.6	1.9	3.5	195
			60+	-0.2	0.6	-0.9	2.4	1083
NC08-0013	1.98	1.98	0-30	23.5	23.5	28.1	28.1	2*
			30-45	3.4	4.2	4.1	5.7	31
			45-60	-1.2	3.1	-1.3	5.0	308
			60+	-2.6	2.6	-6.1	6.2	2064
NC08-0014	1.15	1.14	0-30	4.8	5.2	8.2	9.3	41
			30-45	1.3	1.8	3.3	4.6	316
			45-60	-0.5	0.7	-1.5	2.9	1238
			60+	-2.8	2.8	-6.4	6.4	1*
NC08-0015	1.12	1.11	0-30	8.4	8.4	11.8	11.8	4*
			30-45	2.6	3.1	5.5	6.7	88
			45-60	0.0	0.7	0.0	3.0	1311
			60+	-0.9	0.9	-5.9	5.9	4*

*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 North Carolina

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	
NC08-0001	0.99	0.98	0-30	1.8	1.9	3.2	3.7	79
			30-45	1.9	2.2	4.5	6.4	31
			45-60	0.1	0.3	0.9	1.9	507
			60+	-	-	-	-	-
NC08-0002	1.24	1.24	0-30	3.6	3.6	6.7	6.7	12*
			30-45	0.0	0.8	-0.5	3.1	75
			45-60	-3.1	3.1	-6.9	6.9	603
			60+	-8.4	8.4	-13.3	13.3	52
NC08-0003	0.87	0.87	0-30	-	-	-	-	-
			30-45	-	-	-	-	-
			45-60	0.1	0.1	2.1	2.2	165
			60+	-1.1	1.1	-4.9	4.9	732
NC08-0004	1.67	1.68	0-30	-	-	-	-	-
			30-45	-	-	-	-	-
			45-60	0.1	0.2	1.5	2.0	358
			60+	-0.5	0.5	-3.5	3.5	543
NC08-0005	1.58	1.58	0-30	-	-	-	-	-
			30-45	6.2	6.2	14.3	14.3	8*
			45-60	0.1	0.2	1.5	1.8	264
			60+	-0.6	0.6	-3.5	3.5	937
NC08-0006	0.96	0.96	0-30	-	-	-	-	-
			30-45	-	-	-	-	-
			45-60	0.2	0.2	2.3	2.4	86
			60+	-2.4	2.4	-8.2	8.2	676
NC08-0007	1.52	1.51	0-30	0.0	0.6	0.7	3.3	10*
			30-45	2.7	2.7	5.8	5.9	70
			45-60	0.0	0.2	0.1	2.1	1033
			60+	-2.8	2.8	-7.7	7.7	29*
NC08-0008	1.6	1.6	0-30	-1.8	1.8	-2.2	5.3	3*
			30-45	6.3	6.3	9.0	9.9	9*
			45-60	-4.9	5.2	-5.8	8.0	5*
			60+	-5.4	5.4	-10.5	10.5	1308
NC08-0009	1.41	1.41	0-30	4.7	4.7	5.3	6.4	4*
			30-45	4.3	4.4	6.0	6.3	8*
			45-60	-0.2	0.4	0.4	1.7	287
			60+	-0.9	0.9	-3.4	3.4	1055
NC08-0010	1.59	1.59	0-30	6.0	7.2	3.8	11.1	3*
			30-45	-2.6	6.9	-1.5	11.1	4*
			45-60	-1.6	1.6	-1.8	3.3	35
			60+	-3.8	3.8	-8.5	8.5	1215
NC08-0011	1.9	1.9	0-30	3.3	3.4	4.1	5.0	40
			30-45	-0.7	5.7	-0.7	8.0	34
			45-60	-0.2	0.5	0.9	2.2	483
			60+	-0.4	0.4	-2.3	2.3	509

*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 North Carolina

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	
NC08-0012	2	2	0-30	3.3	4.7	3.7	5.8	22*
			30-45	1.3	2.2	2.0	3.4	41
			45-60	-0.4	0.7	0.1	1.9	181
			60+	-1.2	1.2	-3.4	3.4	1043
NC08-0013	1.98	1.98	0-30	8.5	8.5	13.1	13.1	2*
			30-45	0.3	1.7	-0.1	2.9	11*
			45-60	-2.6	3.0	-3.6	4.9	127
			60+	-3.5	3.5	-7.4	7.4	973
NC08-0014	1.15	1.14	0-30	1.5	1.5	2.4	5.3	13*
			30-45	0.4	0.5	2.3	3.0	152
			45-60	-0.5	0.5	-1.9	2.5	637
			60+	-10.8	10.8	-14.4	14.4	1*
NC08-0015	1.12	1.11	0-30	1.8	1.8	4.3	4.3	2*
			30-45	0.2	0.9	2.2	3.6	37
			45-60	-0.9	0.9	-3.1	3.3	661
			60+	-	-	-	-	-

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