I-95 Corridor Coalition

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Vehicle Probe Project: Validation
of INRIX Data

Monthly Report: North Carolina

August 2012

I-95 CORRIDOR COALITION VEHICLE PROBE PROJECT VALIDATION OF INRIX DATA APRIL-MAY 2012

Monthly Report

Evaluation Results for the State of North Carolina

Executive Summary

The data from the Vehicle Probe Project is validated using Bluetooth^{TM} Traffic Monitoring (BTM) technology on a near monthly basis. BTMs sensor were deployed on the beginning and ending points of fourteen different segments along the I-440 corridor (freeway and ramps) and US 1 (arterials). The data was collected between April 26, 2012 and May 10, 2012 with the assistance of North Carolina Department of Transportation personnel. The dataset collected represents approximately 1024 hours of observations along 22.4 miles of roadway, which included 11.5 miles of freeways, 5.8 miles or ramps, and 5.1 miles of arterials. The number of effective travel time samples observed was 12289 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 periods. 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 the AASE in all speed bins.

ES Table 1 - North Carolina Evaluation Summary for Freeways						
	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	**4.50**	5.80	**3.90**	4.60	233	19.4
30-45 MPH	**5.50**	8.40	**4.70**	6.70	226	18.8
45-60 MPH	**1.90**	4.80	**1.60**	4.10	2166	180.5
> 60 MPH	**0.80**	2.80	**-0.10**	-0.30	7616	634.7
All Speeds	1.22	3.41	0.46	0.90	10241	853.4
Based upon data collected from April 26, 2012 through May 10, 2012 across 11.5 miles of roadway.						

ES Table 2, below summarizes the results of the comparison between the validation data and the INRIX data for **ramp segments** during the above noted periods. As shown, the average absolute speed error (AASE) was within freeway specifications for all speed bins (no specifications are currently in effect for ramp data). The Speed Error Bias (SEB) was within freeway specification for all speed bins except the 30-45 mph bin.

ES Table 2 - North Carolina Evaluation Summary for Ramps						
	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	**4.80**	7.50	**3.90**	5.60	84	7.0
30-45 MPH	**7.10**	10.40	**5.90**	8.20	56	4.7
45-60 MPH	**2.30**	4.70	**2.00**	4.20	1078	89.8
> 60 MPH	**0.50**	2.00	**-0.30**	-0.60	80	6.7
All Speeds	2.56	4.96	2.15	4.17	1298	108.2

Based upon data collected from April 26, 2012 through May 10, 2012 across 5.8 miles of roadway.

Data collected on arterial segments are not included in this report. Charts and data tables are available on request. The results from arterials will be included in a more comprehensive review of data quality on arterials planned by the Coalition.

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 North Carolina was validated on five occasions: October 2008, July 2009, March 2010, March 2011 and April/May 2012. These five validations represent more than 4780 hours of observations along approximately 125 miles of freeway segments in North Carolina. ES Table 3 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 3 - North Carolina (Freeways) - Cumulative to Date						
	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	**3.68**	4.71	**2.33**	2.69	1301	108.4
30-45 MPH	**6.86**	9.28	**2.87**	4.08	883	73.6
45-60 MPH	**1.99**	4.55	**1.12**	2.93	5427	452.3
> 60 MPH	**1.83**	4.18	**-1.43**	-2.79	49771	4147.6
All Speeds	1.97	4.30	-1.04	-2.02	57382	4781.8

Data Collection

The data from the Vehicle Probe Project is validated using Bluetooth[TM] Traffic Monitoring (BTM) technology on a near monthly basis. BTMs sensor were deployed on the beginning and ending points of fourteen different segments along I-440 corridor (freeway and ramps) and US 1 (arterials). Of the segments where data was collected, eight were freeway segments, four were ramp segments and two were arterials. The data was collected between April 26th 2012 and May 10th 2012 with the assistance of North Carolina Department of Transportation personnel. The dataset collected represents approximately 1024 hours of observations along 22.4 miles of roadway, which included 11.5 miles of freeways, 5.8 miles of ramps, and 5.1 miles of arterials. The number of effective travel time samples observed was 12289 in total. This round of data collections in North Carolina was designed to capture the traffic data on freeway segments, ramps and arterial segments. Segment locations are chosen with a high-likelihood of observing recurrent and non-recurrent congestions during peak or off-peak periods.

Figure 1 presents an overview snapshot of the roadway segments over which Bluetooth sensors were deployed along the I-95 corridor in North Carolina. Blue segments represent segments selected for analysis.
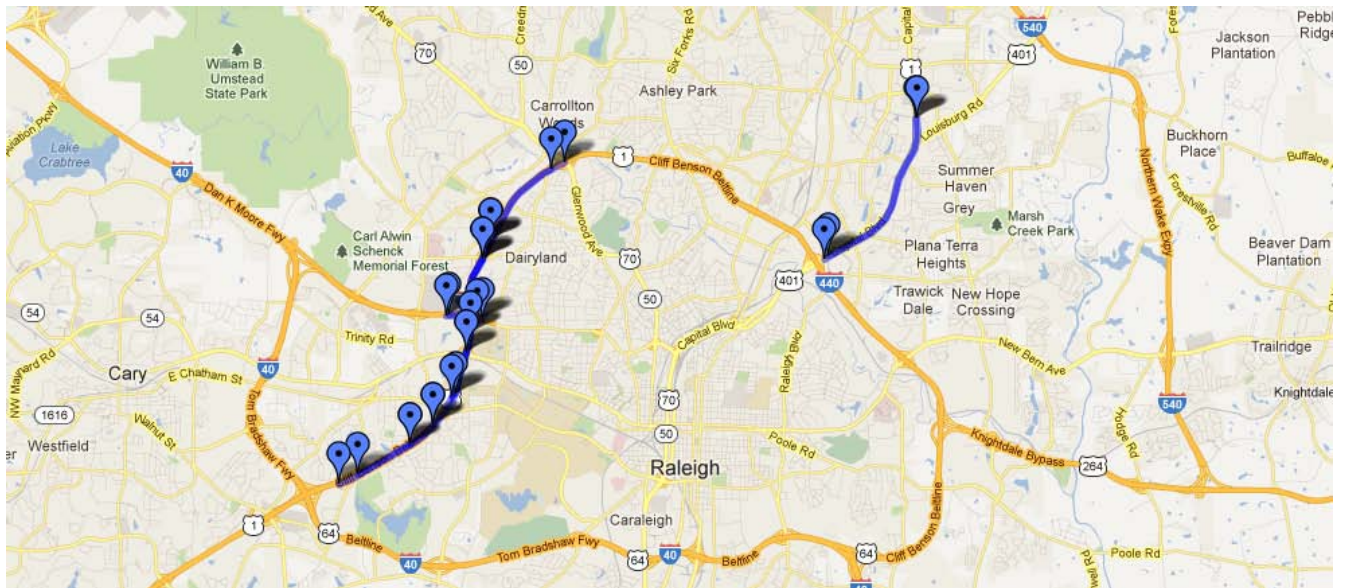

Figure 1 — Locations of all segments selected for analysis in North Carolina

TMC segments selected for validation in North Carolina

Table 1 presents a list of data collection segments from North Carolina. In total, these segments cover a total length of approximately 11.5 freeway miles, 5.8 miles of freeway ramps and 5.1 miles of arterial roads. 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 eight 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 throughout the state of North Carolina 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^{TM} 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 North Carolina

SEGMENT (Map Link)	DESCRIPTION			TMC CODES		Deployment		
	Highway	State	Starting at	Begin	Number	Begin Lat/Lon		Length
	Direction	County	Ending at	End	Length	End Lat/Lon		% Diff
FREEWAYS								All Lengths in Miles
F1	I-440	North Carolina	Ridge Rd/Exit 6	125+04978	3	35.835409	-78.669596	1.46
(NC05-0001)	Southbound	WAKE	Lake Boone Trl/Exit 5	125+04979	1.6	35.819126	-78.688505	-8.46%
F2	I-440	North Carolina	Lake Boone Trl/Exit 5	125P04979	3	35.819126	-78.688505	1.41
(NC05-0002)	Southbound	WAKE	Wade Ave/Exit 4	125P04980	1.4	35.799916	-78.693798	1.11%
F3	I-440	North Carolina	Wade Ave/Exit 4	125+04981	4	35.799916	-78.693798	1.52
(NC05-0003)	Southbound	WAKE	Western Blvd/Exit 2	125P04982	1.4	35.786915	-78.698329	5.65%
F4	I-440	North Carolina	Western Blvd/Exit 2	125+04983	4	35.780958	-78.703457	1.22
(NC05-0004)	Southbound	WAKE	Jones Franklin Rd/Exit 1	125P04984	1.3	35.77084	-78.722508	-4.95%
F5	I-440	North Carolina	Jones Franklin Rd/Exit 1	125N04984	2	35.768876	-78.7274	1.12
(NC05-0005)	Northbound	WAKE	NC-54/Hillsborough St/Exit 3	125-04983	1.2	35.776922	-78.709276	-3.55%
F6	I-440	North Carolina	NC-54/Hillsborough St/Exit 3	125N04983	4	35.776922	-78.709276	1.67
(NC05-0006)	Northbound	WAKE	Lake Boone Trl/Exit 5	125-04981	1.6	35.796093	-78.694569	3.30%
F7	I-440	North Carolina	Lake Boone Trl/Exit 5	125N04981	4	35.796093	-78.694569	1.24
(NC05-0007)	Northbound	WAKE	Ridge Rd/Exit 6	125-04979	1.4	35.815336	-78.690704	-9.49%
F8	I-440	North Carolina	Hollins Ferry Rd/Exit 9	125N04979	3	35.815336	-78.690704	1.71
(NC05-0008)	Northbound	WAKE	MD-295/Baltimore Washington Pkwy/Exit 7	125N04978	1.7	35.83389	-78.673154	3.54%
TOTALS				-	27	-	-	11.35
				-	11.5	-	-	-
RAMPS								All Lengths in Miles
R1	I-440/US-1 NORTHBOUND	North Carolina	-	125P15862	2	35.802893	-78.690709	0.96
(NC05-0009)		WAKE		125-04979	1.0	35.807901	-78.69377	0.01%
R2	RALEIGH-CHAPEL	North Carolina	-	125P04979	3	35.80893	-78.693954	1.46

(NC05-0010)	HILL EXPY NORTHBOUND	WAKE		125P15864	1.3	35.803961	-78.699059	12.67%
R3	I-440/US-1 SOUTHBOUND	North Carolina	-	125P15868	5	35.803701	-78.69991	1.96
(NC05-0011)		WAKE		125P04982	1.9	35.799916	-78.693798	3.16%
R4	WADE AVE	North Carolina	-	125N04982	5	35.799465	-78.693678	1.71
(NC05-0012)		WAKE		125P15872	1.6	35.802575	-78.692093	6.87%
TOTALS				-	15	-	-	6.09
				-	5.8	-	-	-
ARTERIALS								All Lengths in Miles
A1	US-1	North Carolina	I-440	125+06598	3	35.815199	-78.603314	2.43
(NC05-0013)	Northbound	WAKE	US-401	125P06601	2.6	35.844493	-78.579802	-6.23%
A2	US-1	North Carolina	US-401	125N06601	3	35.844536	-78.580072	2.35
(NC05-0014)	Southbound	WAKE	I-440	125-06593	2.5	35.815994	-78.602325	-6.00%
TOTALS				-	6	-	-	4.78
				-	5.1	-	-	-

Analysis of Freeway Results

Table 2 summarizes the data quality measures of freeway segments 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) and Speed Error Bias (SEB) were within specification for all speed bins.

TABLE 2
Data quality measures for freeway segments in North Carolina

	Data Quality Measures for		Mean			
	1.96 SEM Band					
	SEB	**AASE**				
	5 mph	10 mph	**SEB**	**AASE**	**No. of 5 Minute Samples**	**Hours of Data Collection**
SPEED BIN	(contract specifications)					
0-30	3.9	4.5	4.6	5.8	233	19
30-45	4.7	5.5	6.7	8.4	226	19
45-60	1.6	1.9	4.1	4.8	2166	181
60+	-0.1	0.8	-0.3	2.8	7616	635

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 North Carolina.

Table 3 Percent observations meeting 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	18%	74%	0%	67%	233
30-45	21%	60%	0%	41%	226
45-60	38%	89%	0%	59%	2166
60+	63%	96%	0%	85%	7616

Tables 5 and 6 present detailed data for individual TMC segments in North Carolina 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 the small number of observations.

Table 5
Data quality measures for individual freeway validation segments in the state of North Carolina

| 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	
NC05-0001	1.6	1.46	0-30	3.1	3.8	3.2	4.5	48
			30-45	4.1	5.1	5.2	7.3	49
			45-60	1.5	2.9	3.3	6.0	101
			60+	0.1	0.7	0.2	2.5	1200
NC05-0002	1.4	1.41	0-30	3.1	4.0	3.6	5.1	80
			30-45	3.6	4.6	4.9	7.5	39
			45-60	1.5	1.9	3.9	4.7	531
			60+	0.0	0.6	0.2	2.2	624
NC05-0003	1.4	1.52	0-30	3.0	3.2	3.5	4.4	40
			30-45	6.2	6.6	8.1	8.8	58
			45-60	1.4	1.6	3.6	4.1	566

TMC			SPEED BIN					No. of Obs.
			60+	-0.3	0.6	-0.6	2.4	696
NC05-0004	1.3	1.22	0-30	--	--	--	--	0
			30-45	10.1	10.1	15.7	15.7	7*
			45-60	1.6	1.9	5.3	5.9	231
			60+	-1.0	1.3	-2.1	3.6	1513
NC05-0005	1.2	1.12	0-30	0.9	0.9	2.6	2.6	2*
			30-45	2.7	5.8	3.6	8.4	9*
			45-60	2.7	2.8	5.5	6.3	64
			60+	0.0	0.7	0.1	2.6	675
NC05-0006	1.6	1.67	0-30	7.9	8.7	9.8	11.3	35
			30-45	5.5	7.0	8.2	10.3	30
			45-60	1.6	1.7	4.1	4.5	584
			60+	-0.1	0.5	0.1	2.2	731
NC05-0007	1.4	1.24	0-30	3.9	4.7	0.6	5.2	14*
			30-45	2.3	2.3	0.8	10.7	12*
			45-60	0.4	2.5	0.8	3.6	30
			60+	-0.6	0.9	1.0	-1.2	805
NC05-0008	1.7	1.71	0-30	3.5	3.7	0.8	4.5	14*
			30-45	3.0	3.4	0.8	3.8	22*
			45-60	3.8	3.8	0.7	6.5	59
			60+	0.7	1.0	1.0	1.6	1372

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

Table 6
Observations meeting data quality criteria for individual freeway validation segments in the state of North Carolina

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	
NC05-0001	0-30	11	23%	40	83%	0	0%	39	81%	48
	30-45	12	24%	27	55%	0	0%	25	51%	49
	45-60	28	28%	81	80%	0	0%	48	48%	101
	60+	791	66%	1167	97%	0	0%	1064	89%	1200
NC05-0002	0-30	17	21%	58	73%	0	0%	56	70%	80
	30-45	9	23%	28	72%	0	0%	21	54%	39
	45-60	199	37%	468	88%	1	0%	318	60%	531

	60+	448	72%	609	98%	0	0%	572	92%	624
NC05-0003	0-30	9	23%	32	80%	0	0%	29	73%	40
	30-45	10	17%	30	52%	0	0%	20	34%	58
	45-60	233	41%	526	93%	0	0%	389	69%	566
	60+	475	68%	681	98%	1	0%	622	89%	696
NC05-0004	0-30	0	0%	0	0%	0	0%	0	0%	0
	30-45	1	14%	1	14%	0	0%	0	0%	7*
	45-60	99	43%	205	89%	0	0%	114	49%	231
	60+	857	57%	1405	93%	0	0%	1143	76%	1513
NC05-0005	0-30	1	50%	2	100%	0	0%	2	100%	2*
	30-45	1	11%	6	67%	0	0%	5	56%	9*
	45-60	18	28%	50	78%	0	0%	24	38%	64
	60+	452	67%	661	98%	6	1%	594	88%	675
NC05-0006	0-30	2	6%	21	60%	0	0%	15	43%	35
	30-45	4	13%	15	50%	0	0%	4	13%	30
	45-60	225	39%	531	91%	0	0%	361	62%	584
	60+	534	73%	719	98%	0	0%	678	93%	731
NC05-0007	0-30	0	0%	9	64%	0	0%	8	57%	14*
	30-45	3	25%	10	83%	0	0%	4	33%	12*
	45-60	14	47%	24	80%	0	0%	10	33%	30
	60+	510	63%	770	96%	1	0%	648	81%	805
NC05-0008	0-30	3	21%	11	79%	0	0%	8	57%	14*
	30-45	7	32%	18	82%	0	0%	13	59%	22*
	45-60	7	12%	39	66%	0	0%	13	22%	59
	60+	754	55%	1329	97%	0	0%	1185	86%	1372

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

Analysis of Results for Ramps

Table 7 summarizes the data quality measures obtained as a result of comparison between Bluetooth and all reported INRIX speeds on four ramp segments considered in this round of validations. In all but one speed bin, 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. However, in "30-45 mph" speed bin, INRIX data just barely fails to meet these data quality criteria.

Table 8 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 North Carolina. Tables 9 and 10 present detailed data for individual ramp segments in North Carolina in similar format as Tables 5 and 6, respectively. 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 7
Data quality measures for ramps in North Carolina

SPEED BIN	Data Quality Measures for				No. of 5 Minute Samples	Hours of Data Collection
	1.96 SEM Band		Mean			
	SEB 5 mph	AASE 10 mph	SEB	AASE		
	(contract specifications)					
0-30	3.9	4.8	5.6	7.5	84	7
30-45	5.9	7.1	8.2	10.4	56	5
45-60	2.0	2.3	4.2	4.7	1078	90
60+	-0.3	0.5	-0.6	2.0	80	7

Table 8 Percent observations meeting data quality criteria for ramps 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	24%	65%	0%	54%	84
30-45	21%	36%	0%	23%	56
45-60	35%	84%	0%	59%	1078
60+	76%	100%	0%	91%	80

Table 9
Data quality measures for individual ramps in the state of North Carolina

TMC	Standard TMC length	Bluetooth distance	SPEED BIN	1.96 SEM Band		Mean		No. of Obs.
				Speed Error Bias	Average Absolute Speed Error	Speed Error Bias	Average Absolute Speed Error	
NC05-0009	1.0	0.96	0-30	--	--	--	--	0
			30-45	--	--	--	--	0
			45-60	3.7	3.7	8.2	8.2	4*
			60+	--	--	--	--	0
NC05-0010	1.3	1.46	0-30	3.8	4.8	5.5	7.5	80
			30-45	5.6	7.0	7.7	10.2	49
			45-60	2.2	2.5	4.4	4.9	925
			60+	0.0	0.4	0.2	2.0	47
NC05-0011	1.9	1.96	0-30	11.6	11.6	13.7	13.7	2*
			30-45	7.4	7.4	10.2	10.2	3*
			45-60	1.7	1.9	4.5	4.9	29*
			60+	--	--	--	--	0
NC05-0012	1.6	1.71	0-30	1.0	1.0	2.3	2.3	2*
			30-45	8.2	8.2	12.7	12.7	4*
			45-60	0.8	0.9	2.6	3.2	124
			60+	-0.6	0.6	-1.8	2.1	33

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

Table 10
Observations meeting data quality criteria for individual ramps in the state of North Carolina

TMC	SPEED BIN	1.96 SEM Band				Mean				No. of Obs.
		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	
NC05-0009	0-30	--	--	--	--	--	--	--	--	0
	30-45	--	--	--	--	--	--	--	--	0
	45-60	1	25%	2	50%	0	0%	0	0%	4*
	60+	--	--	--	--	--	--	--	--	0
NC05-0010	0-30	19	24%	52	65%	0	0%	42	53%	80
	30-45	11	22%	19	39%	0	0%	12	24%	49
	45-60	283	31%	765	83%	0	0%	523	57%	925
	60+	35	74%	47	100%	0	0%	45	96%	47

NC05-0011	0-30	1	50%	1	50%	0	0%	1	50%	2*
	30-45	0	0%	0	0%	0	0%	0	0%	3*
	45-60	10	34%	26	90%	0	0%	18	62%	29
	60+	--	--	--	--	--	--	--	--	0
NC05-0012	0-30	0	0%	2	100%	0	0%	2	100%	2*
	30-45	1	25%	1	25%	0	0%	1	25%	4*
	45-60	80	65%	119	96%	0	0%	94	76%	124
	60+	26	79%	33	100%	0	0%	28	85%	33

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