



## I-95 Corridor Coalition

I-95 Corridor Coalition Vehicle  
Probe Project: Validation of  
INRIX Data  
Monthly Report  
North Carolina



*June 2011*

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# I-95 CORRIDOR COALITION VEHICLE PROBE PROJECT: VALIDATION OF INRIX DATA JUNE 2011

## *Monthly Report*

*Prepared for:*

I-95 Corridor Coalition

*Sponsored by:*

I-95 Corridor Coalition

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*June 2011*

# Evaluation Results for the State of North Carolina

## Executive Summary

Travel time samples were collected along a total length of approximately 16 freeway miles and nearly three ramp miles from Thursday, March 10, 2011 through Thursday, March 24, 2011 in North Carolina. Freeway segments studied were located along I-77 in Mecklenburg County and the ramp segments studied were located at the interchange of I-77 and I-85 in Mecklenburg County. Data collected 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 more than 1200 hours of observations along nine freeway segments, totaling more than 16 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, both the average absolute speed error and speed error bias were within specification for all speed bins.

<b>ES Table 1 - North Carolina Evaluation Summary for Freeways</b>						
<b>Speed Bin</b>	<b>Absolute Speed Error</b> (<10mph)		<b>Speed Error Bias</b> (<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	<b>2.30</b>	3.20	<b>1.30</b>	1.70	305	25.4
30-45 MPH	<b>5.70</b>	8.30	<b>4.90</b>	6.60	218	18.2
45-60 MPH	<b>1.00</b>	2.90	<b>0.70</b>	1.70	1971	164.3
> 60 MPH	<b>1.50</b>	3.80	<b>-1.20</b>	-2.60	11974	997.8
All Speeds	1.51	3.73	-0.80	-1.78	14468	1205.7

Based upon data collected from March 10, 2011 through March 24, 2011 across 16 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 North Carolina was validated on four occasions: October 2008, July 2009, March 2010 and March 2011. These four validations represent nearly than 3930 hours of observations along approximately 114 miles of freeway segments in North Carolina. ES Table 2 provides a summary of the cumulative validation effort for freeway segments. As shown, the absolute average speed error and speed error bias are within specification for all speed bins even when errors are measured against the mean.

<b>ES Table 2 - North Carolina - Cumulative to Date</b>						
<b>Speed Bin</b>	<b>Absolute Speed Error (&lt;10mph)</b>		<b>Speed Error Bias (&lt;5mph)</b>		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	<b>3.50</b>	4.48	<b>1.99</b>	2.27	1068	89.0
30-45 MPH	<b>7.33</b>	9.59	<b>2.24</b>	3.18	657	54.8
45-60 MPH	<b>2.04</b>	4.38	<b>0.81</b>	2.15	3261	271.8
> 60 MPH	<b>2.02</b>	4.43	<b>-1.67</b>	-3.24	42155	3512.9
All Speeds	2.13	4.50	-1.36	-2.65	47141	3928.4

Ramps are anticipated to be included in the Vehicle Probe Project data feed as of July 1, 2011, enabling users to estimate travel time on complex routes that span multiple highways. The data from the freeway ramp segments were analyzed separately from mainline freeway segments. The results are not included in freeway analysis described above because ramps are not subject to the contractual quality specification for freeways. However, results from the ramp analysis, noted in ES Table 3, show that in all speed bins, INRIX data collected on the three ramp segments studied meets the data quality measures set forth in the contract for normal freeway segments. On the three segments studied, only 71.2 hours of data collection were obtained over the study period, considerably less than the mainline freeway segments. The low amount of validation data reflects lower volumes on these ramps as compared to mainline freeway segments, which in turn implies that data from the VPP may rely on historic data a larger percentage of the time.

<b>ES Table 3 - North Carolina Evaluation Summary for Ramps</b>						
<b>Speed Bin</b>	<b>Absolute Speed Error (&lt;10mph)</b>		<b>Speed Error Bias (&lt;5mph)</b>		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	<b>4.60</b>	6.60	<b>3.10</b>	3.80	55	4.6
30-45 MPH	<b>6.30</b>	12.20	<b>4.00</b>	8.60	20	1.7
45-60 MPH	<b>1.90</b>	4.50	<b>1.80</b>	4.00	761	63.4
> 60 MPH	<b>1.20</b>	3.40	<b>-1.00</b>	-3.20	18	1.5
All Speeds	2.16	4.79	1.88	3.94	854	71.2

Based upon data collected from March 10, 2011 through March 24, 2011 across 2.7 miles spanning three interchange ramps.

## **Data Collection**

Bluetooth sensor deployments in North Carolina started on Thursday, March 10, 2011. The actual deployments in North Carolina were performed with the assistance of North Carolina Department of Transportation (NC DOT) personnel. Sensors remained in the same position until they were retrieved 14 days later on Thursday, March 24, 2011. This

round of data collections in North Carolina was designed to cover segments of the highways along which both recurrent and non-recurrent congestions could be expected during both peak and off-peak periods.

Figure 1 and 2 present snapshots of the roadway segments over which Bluetooth sensors were deployed in North Carolina. Table 1 presents a list of specific TMC segments that were selected as the validation sample in North Carolina. These segments cover a total length of approximately 16 freeway miles, and nearly three ramp miles. Since some TMC segments in this corridor are less than one mile long, when appropriate, consecutive TMC segments are combined to form path segments longer than one mile. This document includes the results of validation performed on three ramps and nine freeway segments; four of which are path segments combined from multiple standard TMC segments. The coordinates of the locations at which the Bluetooth sensors were deployed throughout the state of North Carolina are highlighted in Table 2. It should be noted that the configuration of consecutive TMC segments is such that the endpoint of one TMC segment and the start point of the next TMC segment are overlapping, so one Bluetooth sensor in that location is covering both TMC segments.

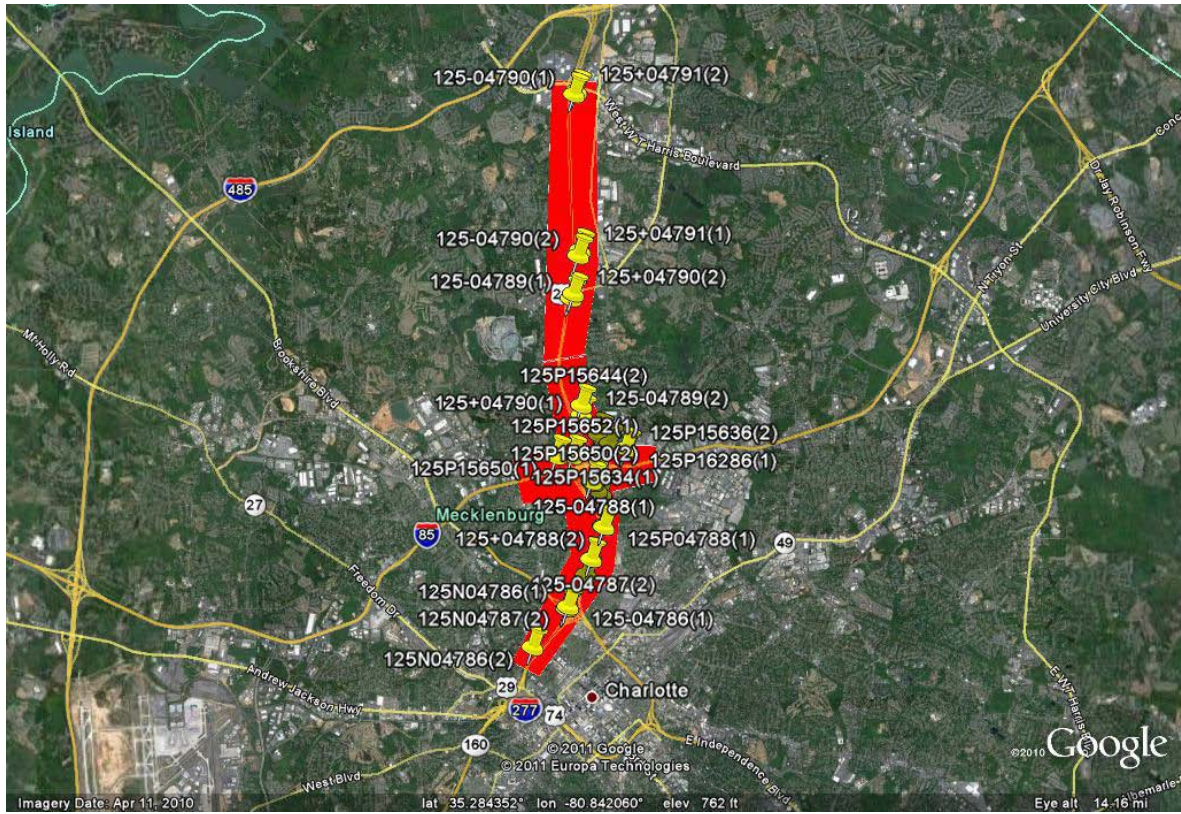
Finally, Table 3 summarizes the segment definitions used in the validation process which also presents the distances that have been used in the estimation of Bluetooth speeds based on travel times. Details of the algorithm used to estimate equivalent path travel times based on INRIX data feeds for individual TMC segments are provided in a separate report. This algorithm finds an equivalent INRIX travel time (and therefore travel speed) corresponding to each sample Bluetooth travel time observation on the path segment of interest.

## ***Analysis of Results***

Table 4 summarizes the data quality measures obtained as a result of comparison between Bluetooth and all reported INRIX speeds. In all speed bins, 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.

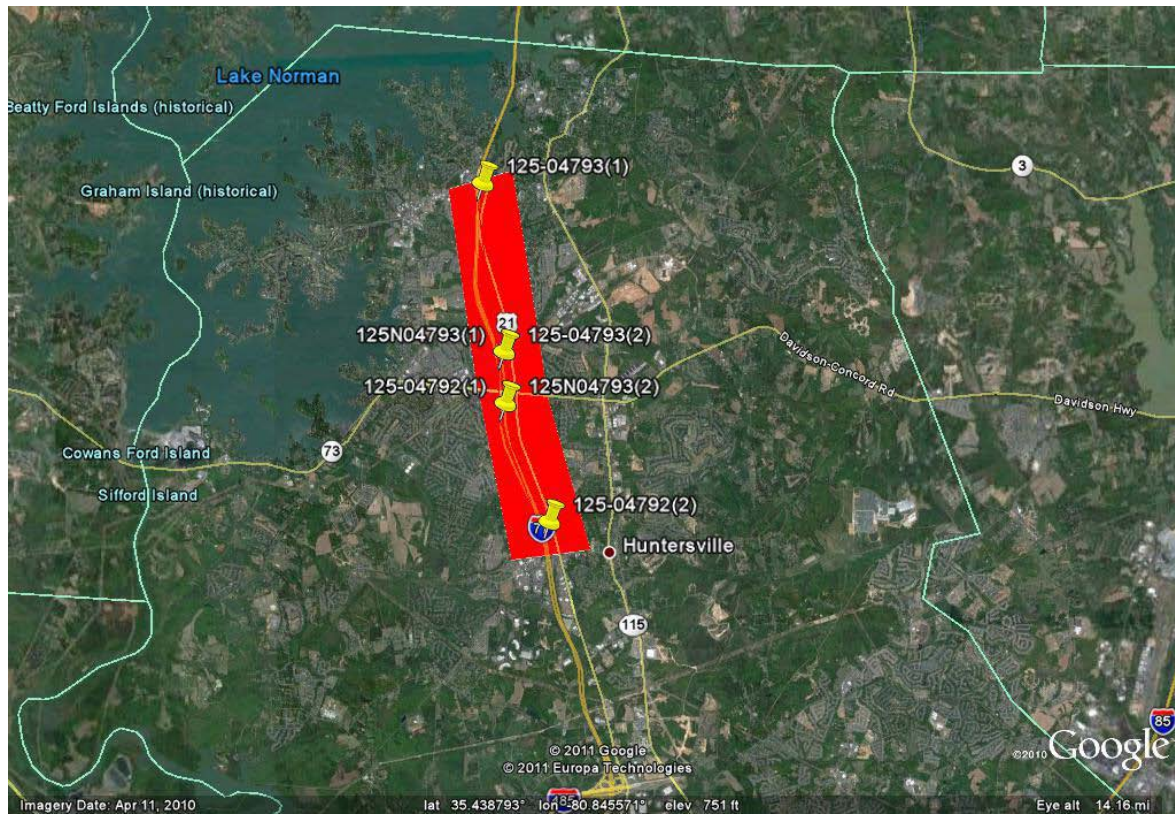
Table 5 shows the percentage of the time intervals that fall within 5 mph of the SEM band and the mean for each speed bin for all TMC segments in North Carolina. Tables 6 and 7 present detailed data for individual TMC segments in North Carolina in similar format as Tables 4 and 5, respectively. Note that for some segments and in some speed bins the comparison results may not be reliable due to small number of observations.

Figures 2 and 3 show the overall speed error biases for different speed bins, and the average absolute speed errors for all validation segments in North Carolina, respectively. These figures correspond to Table 4.



**Figure 1**  
**TMC segments selected for validation in North Carolina**





**Figure 1 (Cont'd)**  
**TMC segments selected for validation in North Carolina**

**Table 1**  
**Traffic Message Channel segments picked for validation in North Carolina**

<b>TYPE</b>	<b>TMC</b>	<b>HIGHWAY</b>	<b>STARTING AT</b>	<b>ENDING AT</b>	<b>COUNTY</b>	<b>DIRECTION</b>	<b>LENGTH (mile)</b>
Freeway	125+04788	I-77	I-277/NC-16/W 11TH ST/BROOKSHIRE FWY/EXIT 11	LASALLE ST/EXIT 12	MECKLENBURG	NORTHBOUND	0.7
Freeway	125P04788	I-77	LASALLE ST/EXIT 12	LASALLE ST/EXIT 12	MECKLENBURG	NORTHBOUND	0.5
Freeway	125+04790	I-77	I-85/STATESVILLE AVE/EXIT 13	US-21/SUNSET RD/EXIT 16	MECKLENBURG	NORTHBOUND	1.6
Freeway	125+04791	I-77	US-21/SUNSET RD/EXIT 16	HARRIS OAK BLVD/REAMES RD/EXIT 18	MECKLENBURG	NORTHBOUND	2.2
Freeway	125-04793	I-77	US-21/EXIT 28	NC-73/EXIT 25	MECKLENBURG	SOUTHBOUND	2.4
Freeway	125N04793	I-77	NC-73/EXIT 25	NC-73/EXIT 25	MECKLENBURG	SOUTHBOUND	0.7
Freeway	125-04792	I-77	NC-73/EXIT 25	GILEAD RD/EXIT 23	MECKLENBURG	SOUTHBOUND	1.7
Freeway	125-04790	I-77	HARRIS OAK BLVD/REAMES RD/EXIT 18	US-21/SUNSET RD/EXIT 16	MECKLENBURG	SOUTHBOUND	2.2
Freeway	125-04789	I-77	US-21/SUNSET RD/EXIT 16	I-85/STATESVILLE AVE/EXIT 13	MECKLENBURG	SOUTHBOUND	1.6
Freeway	125N04788	I-77	LASALLE ST/EXIT 12	LASALLE ST/EXIT 12	MECKLENBURG	SOUTHBOUND	0.5
Freeway	125-04787	I-77	LASALLE ST/EXIT 12	I-277/NC-16/W 11TH ST/BROOKSHIRE FWY/EXIT 11	MECKLENBURG	SOUTHBOUND	0.5
Freeway	125N04787	I-77	I-277/NC-16/W 11TH ST/BROOKSHIRE FWY/EXIT 11	I-277/NC-16/W 11TH ST/BROOKSHIRE FWY/EXIT 11	MECKLENBURG	SOUTHBOUND	0.7
Freeway	125-04786	I-77	I-277/NC-16/W 11TH ST/BROOKSHIRE FWY/EXIT 11	TRADE ST/5TH ST/EXIT 10	MECKLENBURG	SOUTHBOUND	0.0
Freeway	125N04786	I-77	TRADE ST/5TH ST/EXIT 10	TRADE ST/5TH ST/EXIT 10	MECKLENBURG	SOUTHBOUND	0.7
<b>SUBTOTAL</b>							<b>16.1</b>



**Table 1 (Cont'd)**  
**Traffic Message Channel segments picked for validation in North Carolina**

<b>TYPE</b>	<b>TMC</b>	<b>STARTING AT</b>	<b>ENDING AT</b>	<b>COUNTY</b>	<b>DIRECTION</b>	<b>LENGTH (mile)</b>
Ramp	125P15650	I-77/US-21/EXIT 38	EXIT 38	MECKLENBURG	I-77/US-21	0.2
Ramp	125P15652	EXIT 38	EXIT 38	MECKLENBURG	I-77/US-21 SOUTHBOUND	0.5
Ramp	125-04788	EXIT 38	LASALLE ST/EXIT 12	MECKLENBURG	SOUTHBOUND	0.1
Ramp	125+04789	I-85/STATESVILLE AVE/EXIT 13	EXIT 13A	MECKLENBURG	NORTHBOUND	0.2
Ramp	125P15634	EXIT 13A	EXIT 13A	MECKLENBURG	I-85 NORTHBOUND AND STATESVILLE AVE	0.4
Ramp	125P15636	EXIT 13A	EXIT 13A	MECKLENBURG	I-85 NORTHBOUND	0.4
Ramp	125P16286	EXIT 38	EXIT 38	MECKLENBURG	I-77/US-21	0.2
Ramp	125P15640	EXIT 38	EXIT 38	MECKLENBURG	I-77/US-21	0.2
Ramp	125P15644	EXIT 38	EXIT 38	MECKLENBURG	I-77/US-21 NORTHBOUND	0.5
<b>SUBTOTAL</b>						<b>2.7</b>
<b>TOTAL</b>						<b>18.8</b>

**Table 2**  
**TMC segment lengths and distances between sensor deployment locations in the state of North Carolina**

SEGMENT TYPE	TMC	STANDARD TMC					SENSOR DEPLOYMENT			
		Endpoint (1)		Endpoint (2)		Length (mile)	Endpoint (1)		Endpoint (2)	
		Lat	Long	Lat	Long		Lat	Long	Lat	Long
Freeway	125+04788	35.247933	-80.8458	35.25735	-80.8415	0.7	35.24726	-80.84667		
Freeway	125P04788	35.257354	-80.8415	35.26404	-80.8422	0.5			35.26425	-80.8422
Freeway	125+04790	35.281475	-80.847	35.30359	-80.8489	1.6	35.28064	-80.84636	35.30404	-80.8487
Freeway	125+04791	35.31217	-80.8473	35.34374	-80.8482	2.2	35.31114	-80.84663	35.34357	-80.8483
Freeway	125-04793	35.480381	-80.875	35.44697	-80.8698	2.4	35.47997	-80.87509	35.4473	-80.87
Freeway	125N04793	35.446971	-80.8698	35.43676	-80.8695	0.7				
Freeway	125-04792	35.436757	-80.8695	35.4133	-80.8588	1.7			35.41326	-80.8585
Freeway	125-04790	35.343091	-80.8488	35.31112	-80.8478	2.2	35.34243	-80.84805	35.31126	-80.8479
Freeway	125-04789	35.302664	-80.8495	35.2796	-80.8469	1.6	35.29537	-80.85124	35.28094	-80.8475
Freeway	125N04788	35.264756	-80.8432	35.2576	-80.8417	0.5	35.26571	-80.84621		
Freeway	125-04787	35.257597	-80.8417	35.25096	-80.8446	0.5			35.25053	-80.8459
Freeway	125N04787	35.250962	-80.8446	35.24153	-80.8503	0.7				
Freeway	125-04786	35.24153	-80.8503	35.24115	-80.8507	0.0				
Freeway	125N04786	35.241152	-80.8507	35.2335	-80.8589	0.7			35.235	-80.8585
<b>SUBTOTAL</b>						<b>16.1</b>				
Ramp	125P15650	35.271358	-80.8531	35.27143	-80.8492	0.2	35.27262	-80.85197		
Ramp	125P15652	35.271431	-80.8492	35.26605	-80.8442	0.5				
Ramp	125-04788	35.266385	-80.8445	35.26476	-80.8432	0.1				
Ramp	125+04789	35.264038	-80.8422	35.26677	-80.8442	0.2				
Ramp	125P15634	35.266774	-80.8442	35.27166	-80.8435	0.4				
Ramp	125P15636	35.271657	-80.8435	35.27272	-80.8361	0.4			35.27243	-80.8344
Ramp	125P16286	35.272914	-80.8362	35.27386	-80.84	0.2	35.27302	-80.83559		
Ramp	125P15640	35.273856	-80.84	35.27565	-80.8428	0.2				
Ramp	125P15644	35.275652	-80.8428	35.28148	-80.847	0.5				
<b>SUBTOTAL</b>						<b>2.7</b>				
<b>TOTAL</b>						<b>18.8</b>				

**Table 3  
Path segments identified for validation in North Carolina**

Type	Validation Segment	STANDARD SEGMENTS INCLUDED			STARTING AT	ENDING AT	LENGTH (MILE)		Error (%)
		TMC(1)	TMC(2)	TMC(3)			Standard	Deployment	
Freeway	NC04-0001	125+04788	125P04788		I-277/NC-16/W 11TH ST/BROOKSHIRE FWY/EXIT 11	LASALLE ST/EXIT 12	1.2	1.30	10.05%
Freeway	125+04790	125+04790			I-85/STATESVILLE AVE/EXIT 13	US-21/SUNSET RD/EXIT 16	1.6	1.68	6.58%
Freeway	125+04791	125+04791			US-21/SUNSET RD/EXIT 16	HARRIS OAK BLVD/REAMES RD/EXIT 18	2.2	2.20	0.80%
Freeway	125-04793	125-04793			US-21/EXIT 28	NC-73/EXIT 25	2.4	2.31	-2.35%
Freeway	NC04-0002	125N04793	125-04792		NC-73/EXIT 25	GILEAD RD/EXIT 23	2.4	2.46	0.55%
Freeway	125-04790	125-04790			HARRIS OAK BLVD/REAMES RD/EXIT 18	US-21/SUNSET RD/EXIT 16	2.2	2.20	-0.47%
Freeway	125-04789	125-04789			US-21/SUNSET RD/EXIT 16	I-85/STATESVILLE AVE/EXIT 13	1.6	1.09	-33.67%
Freeway	NC04-0003	125N04788	125-04787		LASALLE ST/EXIT 12	I-277/NC-16/W 11TH ST/BROOKSHIRE FWY/EXIT 11	1.0	1.16	13.55%
Freeway	NC04-0004	125N04787	125-04786	125N04786	I-277/NC-16/W 11TH ST/BROOKSHIRE FWY/EXIT 11	TRADE ST/5TH ST/EXIT 10	1.5	1.35	-8.05%
Ramp	NC04-0005	125P15650	125P15652	125-04788	I-77/US-21/EXIT 38	LASALLE ST/EXIT 12	0.8	0.65	-21.68%
Ramp	NC04-0006	125+04789	125P15634	125P15636	I-85/STATESVILLE AVE/EXIT 13	EXIT 13A	1.0	1.10	7.58%
Ramp	NC04-0007	125P16286	125P15640	125P15644	EXIT 38	EXIT 38	0.9	0.86	-3.78%
<b>TOTAL</b>							<b>18.84</b>	<b>18.36</b>	<b>-2.56%</b>

**Table 4**  
**Data quality measures for freeway segments greater than one mile in North Carolina**

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	1.3	2.3	1.7	3.2	305
30-45	4.9	5.7	6.6	8.3	218
45-60	0.7	1.0	1.7	2.9	1971
60+	-1.2	1.5	-2.6	3.8	11974

**Table 5**  
**Percent observations meeting data quality criteria for freeway segments greater than one mile in North Carolina**

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	21%	87%	0%	81%	305
30-45	20%	55%	0%	39%	218
45-60	61%	94%	0%	83%	1971
60+	49%	91%	0%	71%	11974

**Table 6**  
**Data quality measures for individual freeway validation segments greater than one mile in the state of North Carolina**

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	
125+04790	1.65	1.68	0-30					6*
			30-45	10.0	12.0	15.7	18.4	26*
			45-60	1.6	2.0	5.1	5.9	1180
			60+	-1.8	2.0	-4.0	4.7	
125+04791	2.25	2.20	0-30					
			30-45					
			45-60	1.6	1.6	6.3	6.3	2*
			60+	-1.5	1.7	-3.7	4.5	1108
125-04789	1.65	1.09	0-30					
			30-45					
			45-60	3.1	3.1	6.4	6.4	41
			60+	-0.7	1.3	-1.6	3.5	1815
125-04790	2.32	2.20	0-30					
			30-45					
			45-60	1.2	1.2	5.9	5.9	26*
			60+	-0.4	0.9	-1.2	3.1	1424
125-04793	2.37	2.31	0-30	1.2	1.8	1.5	2.5	115
			30-45	4.5	5.8	5.5	8.5	46
			45-60	1.9	3.0	4.0	6.4	72
			60+	0.0	0.8	-0.1	2.6	1305
NC04-0001	1.17	1.30	0-30	2.8	3.8	3.8	5.4	56
			30-45	6.6	7.3	8.4	9.4	53
			45-60	0.9	1.0	1.9	2.7	991
			60+	-0.7	1.0	-1.9	3.0	1208
NC04-0002	2.42	2.46	0-30	0.6	2.0	0.7	2.9	131
			30-45	3.9	4.8	5.8	7.2	75
			45-60	1.8	3.2	3.2	6.0	64
			60+	-1.6	1.7	-3.4	4.0	1387
NC04-0003	0.98	1.16	0-30	3.9	3.9	8.4	8.4	3*
			30-45	3.6	4.2	5.4	6.9	35
			45-60	0.2	0.9	0.3	2.8	151
			60+	-2.8	2.8	-5.2	5.4	1592
NC04-0004	1.50	1.35	0-30					
			30-45	8.1	8.1	11.1	11.1	3*
			45-60	0.2	0.4	0.4	1.8	598
			60+	-0.9	0.9	-2.5	2.9	955

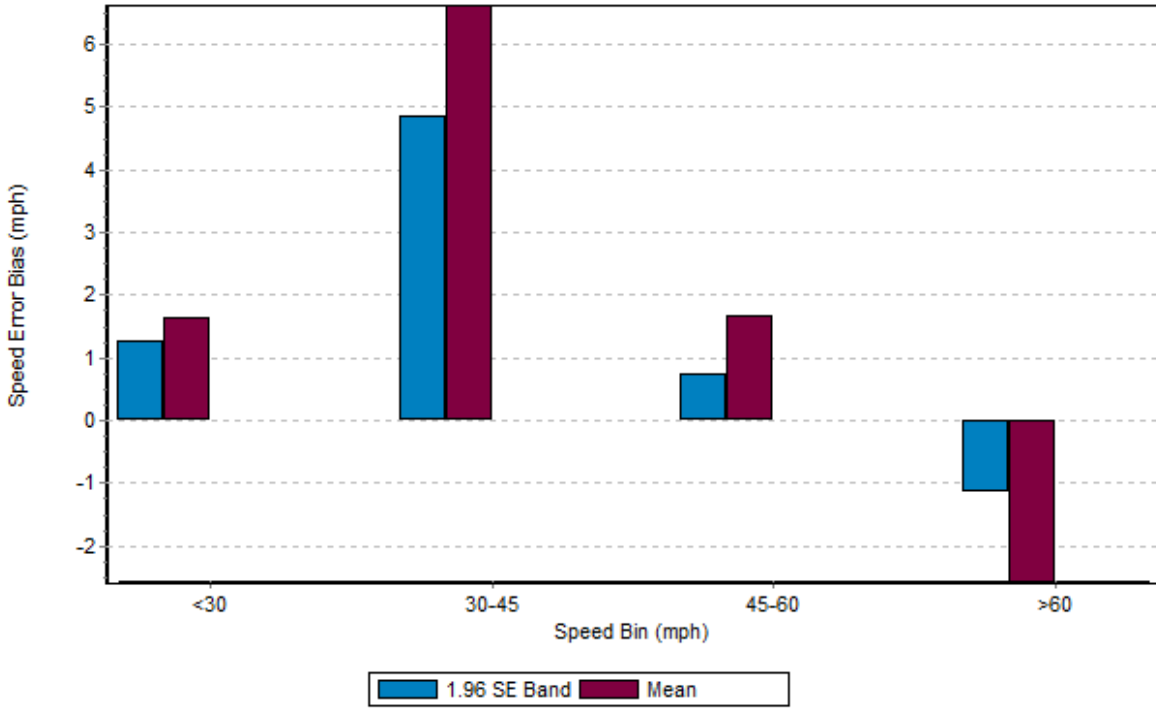
\*Results in the specified row may not be reliable due to small number of observations

**Table 7**  
**Observations meeting data quality criteria for individual freeway validation segments**  
**greater than one mile in the state of North Carolina**

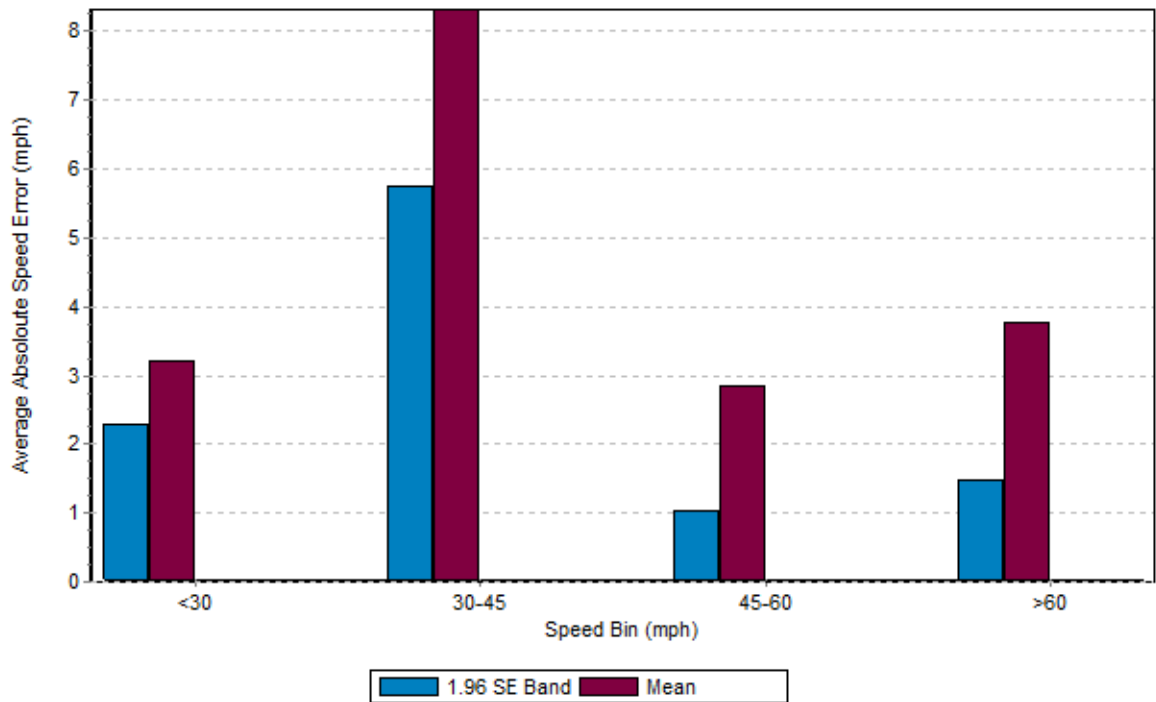
TMC	SPEED BIN	Data Quality Measures for								No. of Obs.
		1.96 SE Band				Mean				
		Speed Error Bias		Average Absolute Speed Error		Speed Error Bias		Average Absolute Speed Error		
		No. falling inside the band	% falling inside the band	No. falling within 5 mph of the band	% falling within 5 mph 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	
125+04790	0-30									
	30-45	0	0%	0	0%	0	0%	0	0%	
	45-60	14	54%	23	88%	0	0%	13	50%	
	60+	503	43%	1018	86%	0	0%	677	57%	
125+04791	0-30									
	30-45									
	45-60	0	0%	2	100%	0	0%	1	50%	
	60+	530	48%	977	88%	0	0%	677	61%	
125-04789	0-30									
	30-45									
	45-60	15	37%	29	71%	0	0%	17	41%	
	60+	981	54%	1677	92%	0	0%	1350	74%	
125-04790	0-30									
	30-45									
	45-60	13	50%	24	92%	0	0%	9	35%	
	60+	903	63%	1350	95%	2	0%	1144	80%	
125-04793	0-30	24	21%	105	91%	0	0%	101	88%	
	30-45	7	15%	26	57%	0	0%	19	41%	
	45-60	18	25%	56	78%	0	0%	30	42%	
	60+	836	64%	1262	97%	8	1%	1142	88%	
NC04-0001	0-30	13	23%	40	71%	0	0%	36	64%	
	30-45	5	9%	22	42%	0	0%	10	19%	
	45-60	585	59%	940	95%	3	0%	833	84%	
	60+	644	53%	1166	97%	2	0%	995	82%	
NC04-0002	0-30	28	21%	119	91%	0	0%	109	83%	
	30-45	20	27%	48	64%	0	0%	38	51%	
	45-60	15	23%	44	69%	0	0%	26	41%	
	60+	550	40%	1246	90%	1	0%	933	67%	
NC04-0003	0-30	0	0%	2	67%	0	0%	1	33%	
	30-45	11	31%	22	63%	0	0%	17	49%	
	45-60	94	62%	144	95%	1	1%	131	87%	
	60+	367	23%	1274	80%	0	0%	779	49%	
NC04-0004	0-30									
	30-45	0	0%	1	33%	0	0%	0	0%	
	45-60	444	74%	594	99%	0	0%	577	96%	
	60+	506	53%	927	97%	0	0%	807	85%	

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





**Figure 2**  
**Speed error bias for freeway segments greater than one mile in North Carolina**



**Figure 3**  
**Average absolute speed error for freeway segments greater than one mile in North Carolina**

## ***Analysis of Results for Ramps***

Ramps are anticipated to be included in the Vehicle Probe Project data feed as of July 1, 2011, enabling users to estimate travel time on complex routes that span multiple highways. The data from the freeway ramp segments were analyzed separately from mainline freeway segments.

The results from the ramp analysis, noted in Table 8, show that in all speed bins, INRIX data collected on the three ramp segments studied meets the data quality measures set forth in the contract for normal freeway segments. However, it should be noted that ramps are not subject to the contractual quality specification for freeways.

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 all ramp segments in North Carolina. Tables 10 and 11 present detailed data for individual ramp segments in North Carolina in similar format as Tables 8 and 9, respectively. Note that for some segments and in some speed bins the comparison results may not be reliable due to small number of observations.

Figures 4 and 5 show the overall speed error biases for different speed bins, and the average absolute speed errors for all considered ramp segments in North Carolina, respectively. These figures correspond to Table 8.

**Table 8**  
**Data quality measures for ramp segments greater than one mile in North Carolina**

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	3.1	4.6	3.8	6.6	55
30-45	4.0	6.3	8.6	12.2	20*
45-60	1.8	1.9	4.0	4.5	761
60+	-1.0	1.2	-3.2	3.4	18*

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

**Table 9**  
**Percent observations meeting data quality criteria for ramp segments greater than one mile in North Carolina**

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	33%	73%	0%	53%	55
30-45	20%	35%	0%	15%	20*
45-60	42%	87%	0%	59%	761
60+	39%	100%	0%	89%	18*

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

**Table 10**  
**Data quality measures for individual ramp validation segments greater than one mile in the**  
**state of North Carolina**

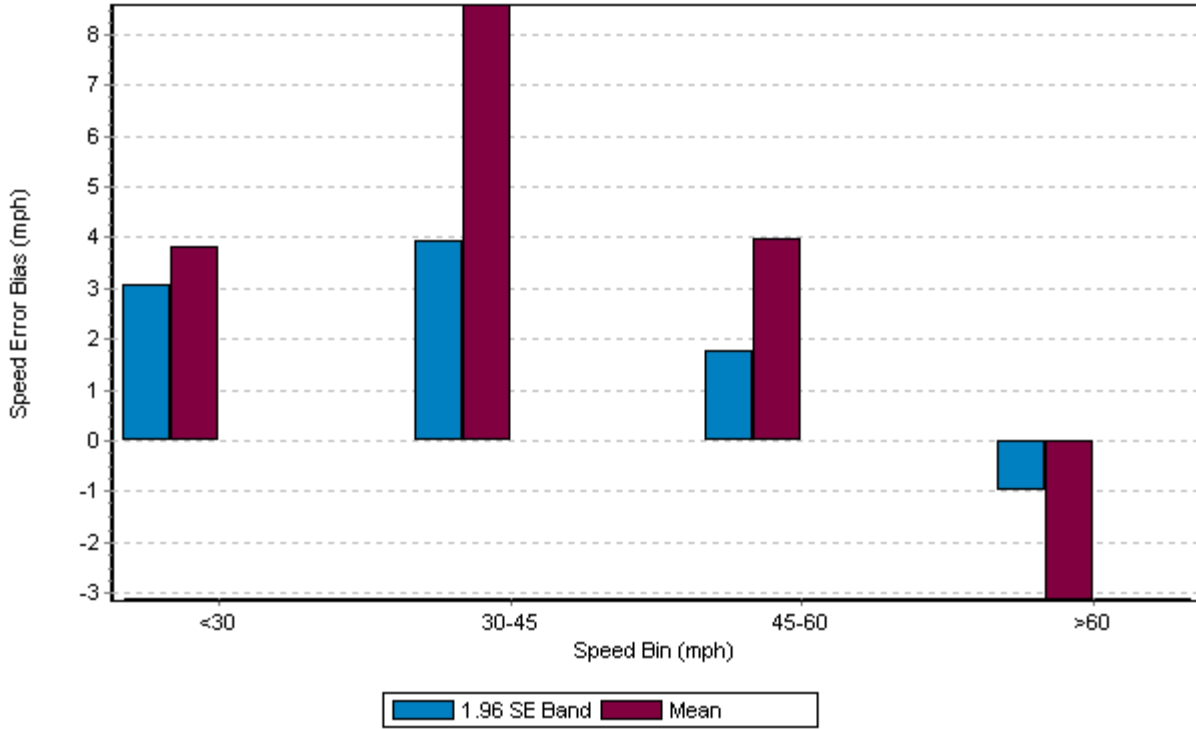
TMC	Standard TMC length	Bluetooth distance	SPEED BIN	Data Quality Measures for				No. of Obs.
				1.96 SE Band		Mean		
				Speed Error Bias	Average Absolute Speed Error	Speed Error Bias	Average Absolute Speed Error	
NC04-0005	0.83	0.65	0-30					1*
			30-45	0.0	0.0	5.2	5.2	50
			45-60	0.2	0.5	0.7	3.0	17*
			60+	-2.6	2.6	-6.0	6.0	
NC04-0006	1.06	1.10	0-30	3.1	4.6	3.8	6.6	55
			30-45	4.0	6.3	8.6	12.2	20*
			45-60	1.8	1.9	4.0	4.5	761
			60+	-1.0	1.2	-3.2	3.4	18*
NC04-0007	0.89	0.86	0-30	0.0	0.0	14.6	14.6	1*
			30-45	-0.1	4.3	4.4	12.1	11*
			45-60	-0.7	0.8	-1.0	3.4	93
			60+	-5.3	5.3	-7.1	7.1	3*

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

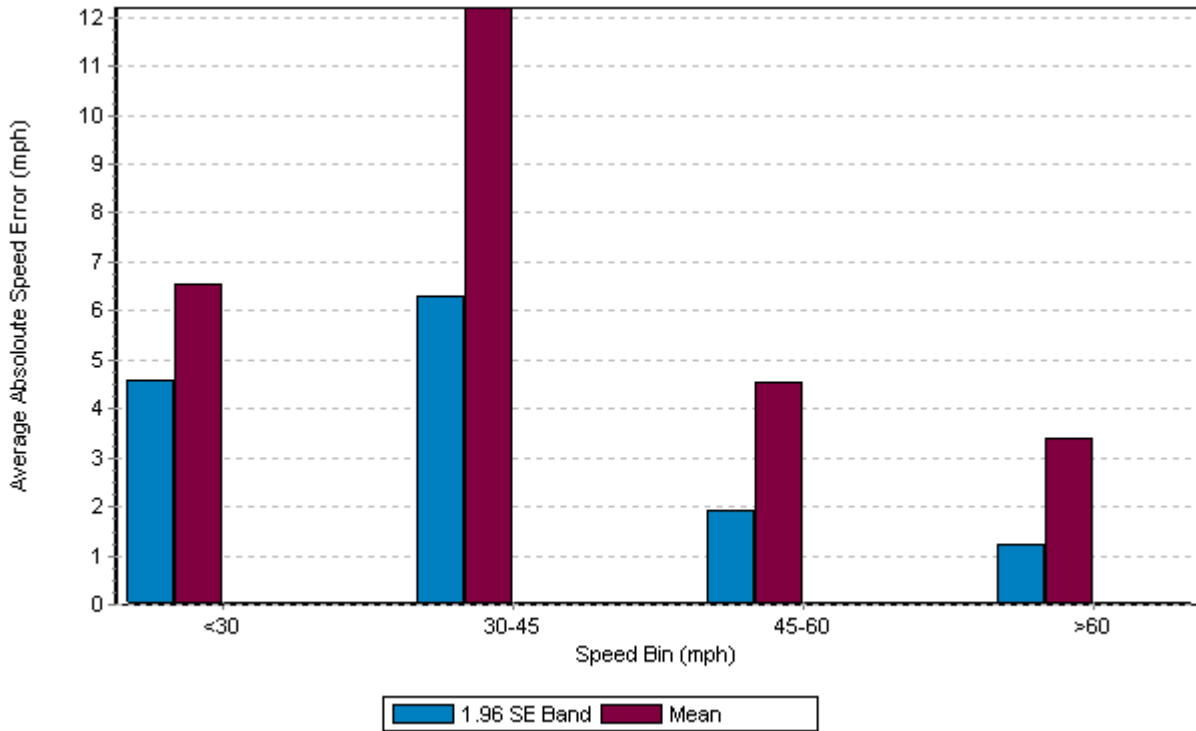
**Table 11**  
**Observations meeting data quality criteria for individual ramp validation segments greater than one mile in the state of North Carolina**

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	
NC04-0005	0-30									
	30-45	1	100%	1	100%	0	0%	0	0%	
	45-60	39	78%	49	98%	0	0%	41	82%	
	60+	7	41%	13	76%	0	0%	6	35%	
NC04-0006	0-30	18	33%	40	73%	0	0%	29	53%	
	30-45	4	20%	7	35%	0	0%	3	15%	
	45-60	323	42%	664	87%	0	0%	451	59%	
	60+	7	39%	18	100%	0	0%	16	89%	
NC04-0007	0-30	1	100%	1	100%	0	0%	0	0%	
	30-45	4	36%	5	45%	0	0%	1	9%	
	45-60	67	72%	87	94%	0	0%	77	83%	
	60+	1	33%	2	67%	0	0%	1	33%	

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



**Figure 4**  
**Speed error bias for ramp segments greater than one mile in North Carolina**



**Figure 5**  
**Average absolute speed error for ramp segments greater than one mile in North Carolina**