



I-95 Corridor Coalition

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

Report for South Carolina (#2)
I-85 and I-26



February 2016

I-95 CORRIDOR COALITION VEHICLE PROBE PROJECT VALIDATION OF TOMTOM DATA FEBRUARY 2016

Report for South Carolina (#2) I-85 and I-26

Prepared for:

I-95 Corridor Coalition

Sponsored by:

I-95 Corridor Coalition

Prepared by:

Masoud Hamedi, Ali Haghani, Kiana Roshan Zamir, Zhongxiang Wang
University of Maryland, College Park

Acknowledgements:

The research team would like to express its gratitude for the assistance it received from the state highway officials in South Carolina 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.

February 2016

Evaluation Results for the State of South Carolina

Executive Summary

The data from the Vehicle Probe Project is validated using Bluetooth™ Traffic Monitoring (BTM) technology on a near monthly basis. BTM sensors were deployed at the beginning and ending points of seven different segments along the I-85 and I-26 corridors. The Bluetooth sensor deployment covers the range from US-276 to SC-14 along I-85 and from Bush River Rd. to Harbison Blvd. along I-26. The Average Annual Daily Traffic (AADT) along the I-85 corridor is 82,300 and the speed limit is 60 MPH. The AADT along the I-26 corridor is 37,550 and the speed limit is 55 MPH.

Travel time data was collected for both directions along each freeway, between December 2 and December 15, 2015. The dataset collected represents approximately 4,191 hours of observations along seven freeway segments, totaling approximately 12 miles. The total number of effective five-minute travel time samples observed was 50,287.

ES Table 1, below summarizes the results of the comparison between the BTM reference data and the TomTom data for freeway segments during the above noted time period. As shown, the average absolute speed error (AASE) and Speed Error Bias (SEB) were both within specification in all speed bins.

ES Table 1 – South Carolina Evaluation Summary for Freeway						
Speed Bin	Average Absolute Speed Error (<10mph)		Speed Error Bias (<5mph)		Number of 5 Minute Samples	Hours of Data Collection
	Comparison with SEM Band	Comparison with Mean	Comparison with SEM Band	Comparison with Mean		
0-30 MPH	3.4	5.2	3.2	4.6	1420	118
30-45 MPH	3.7	6.5	3.0	5.1	1354	113
45-60 MPH	0.7	3.0	0.0	0.6	13374	1115
>60 MPH	4.0	7.8	-4.0	-7.8	34139	2845
All Speeds	3.1	6.4	-2.6	-4.9	50287	4191

Based upon data collected from December 2, 2015 through December 15, 2015 across 12 miles of roadway.

Data Collection

Travel time samples were collected along seven freeway segments with the assistance of South Carolina Department of Transportation (SCDOT) personnel. Freeway segments studied were located on the I-85 corridor from US-276 to SC-14 and on I-26 from Bush River Rd. to Harbison Blvd. Travel time data was collected for both directions along I-85 and I-26 between December 2 and December 15, 2015. Segment locations were chosen with a high-likelihood of observing recurrent and non-recurrent congestion during peak and off-peak periods.

Figure 1 and 2 present an overview snapshot of the placement of sensors for the collection of data on the I-85 and I-26 corridors in South Carolina. The Average Annual Daily Traffic (AADT) along the I-85 corridor is 82,300 and the speed limit is 60 MPH. The AADT along the I-26 corridor is 37,550 and the speed limit is 55 MPH. Blue segments represent freeway segments selected for analysis.

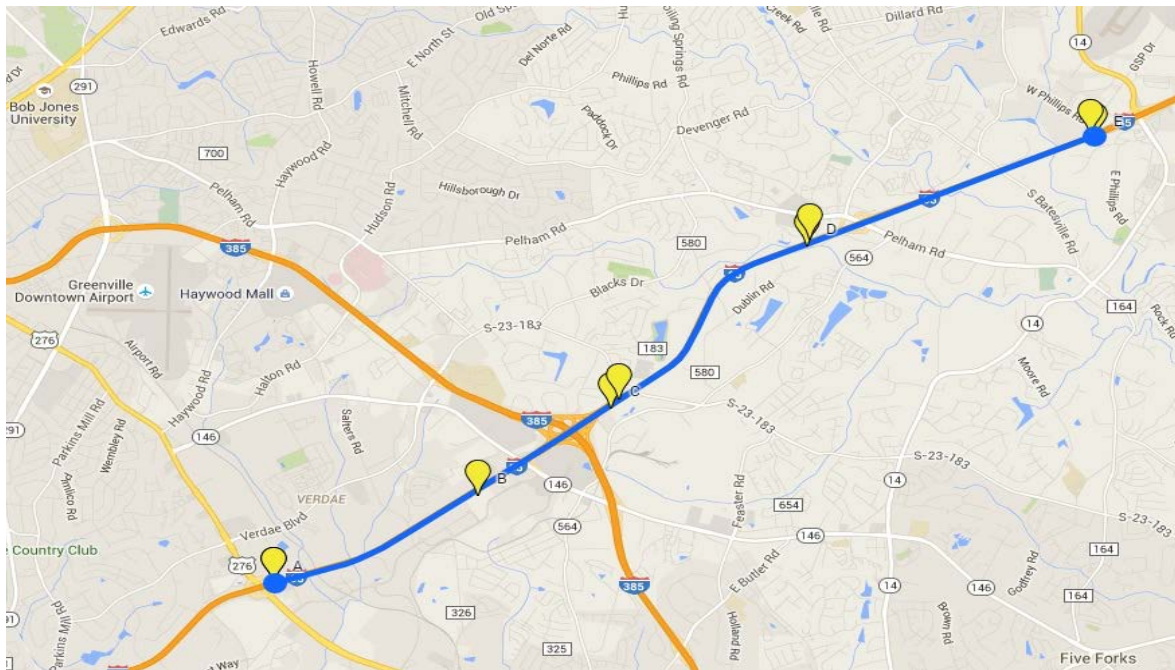


Figure 1 — Locations of all segments selected on I-85 for analysis in South Carolina

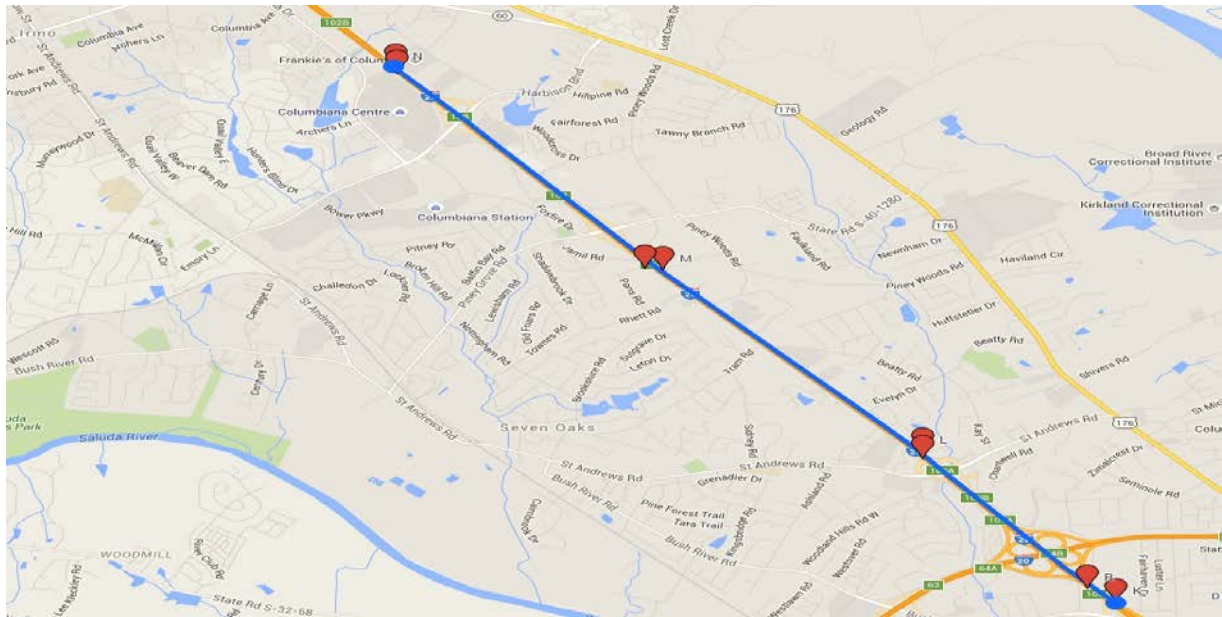


Figure 2 — Locations of all segments selected on I-26 for analysis in South Carolina

TMC segments selected for validation in South Carolina

Table 1 presents the data collection segments from South Carolina. As a whole, these segments cover a total length of 12 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 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 the validation performed on seven bidirectional 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 Bluetooth sensors were deployed along I-85 and I-26 in South 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 Bluetooth sensor covers both data collection segments.

Table 1 also provides data on the precise length of the TMCs comprising the test segment as compared to the measured length between Bluetooth™ Traffic Monitoring (BTM) sensors placed on the roadway. An algorithm was developed and documented in a separate report¹ 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 TomTom data feeds for individual data collection segments are provided in this separate report. This algorithm finds an equivalent TomTom travel time (and therefore travel speed) corresponding to each sample BTM travel time observation on the test segment of interest.

¹ Ali Haghani, Masoud Hamed, 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 South Carolina

SEGMENT (Map Link)	DESCRIPTION			TMC CODES		Deployment		All Lengths in Miles
	Freeway South Carolina	State County	Starting at Ending at	Begin End	Number Length	Begin Lat/Lon End Lat/Lon	Length % Diff	
Freeways								
F1 SC02-0001	I-85 Northbound	South Carolina Greenville	US-276/Exit 48 SC-146/Woodruff Rd/Exit 51	125p04733 125p04733	1 1.7	34.814246 34.826048	-82.33399 -82.308215	1.67 -1.26%
F2 SC02-0002	I-85 Northbound	South Carolina Greenville	SC-146/Woodruff Rd/Exit 51 SC-146/Woodruff Rd/Exit 51	125p04733 125p04733	1 1.1	34.826048 34.835775	-82.308215 -82.292468	1.22 8.94%
F3 SC02-0003	I-85 Northbound	South Carolina Greenville	SC-146/Woodruff Rd/Exit 51 Pelham Rd/Exit 54	125p04735 125p04735	1 2.3	34.835775 34.857171	-82.292468 -82.264182	2.06 -9.24%
F4 SC02-0004	I-85 Northbound	South Carolina Greenville	Pelham Rd/Exit 54 SC-14/Exit 56	125p04735 125p04736	2 2.1	34.857171 34.869354	-82.264182 -82.230867	2.29 10.62%
F5 SC02-0005	I-85 Southbound	South Carolina Greenville	SC-14/Exit 56 Pelham Rd/Exit 54	125n04735 125n04735	1 2.3	34.86958 34.856039	-82.230741 -82.267742	2.23 -3.04%
F6 SC02-0006	I-85 Southbound	South Carolina Greenville	Pelham Rd/Exit 54 I-385/Exit 51	125n04734 125n04734	1 1.8	34.856039 34.837858	-82.267742 -82.289509	2.22 20.79%
F7 SC02-0007	I-85 Southbound	South Carolina Greenville	I-385/Exit 51 SC-146/Woodruff Rd/Exit 51	125n04733 125n04733	1 1.4	34.837858 34.82527	-82.289509 -82.309863	1.85 27.90%
F8 SC02-0008	I-85 Southbound	South Carolina Greenville	SC-146/Woodruff Rd/Exit 51 US-276/Exit 48	125n04732 125n04732	1 1.6	34.82527 34.814403	-82.309863 -82.334008	1.68 6.33%
F9 SC02-0009	I-26 Westbound	South Carolina Richland	Bush River Rd/Exit 108 Saint Andrews Rd/Exit 106	125p05660 125p05661	2 1.27	34.03192 34.046107	-81.105291 -81.119325	1.27 0.00%
F10 SC02-0010	I-26 Westbound	South Carolina Lexington	Saint Andrews Rd/Exit 106 Piney Grove Rd/Exit 104	125p05662 125p05662	1 1.61	34.046107 34.063425	-81.119325 -81.138117	1.60 -0.62%
F11 SC02-0011	I-26 Westbound	South Carolina Richland	Piney Grove Rd/Exit 104 Harbison Blvd/Exit 103	125p05662 125p05664	3 1.59	34.063425 34.081164	-81.138117 -81.155826	1.71 7.55%

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

SEGMENT (Map Link)	DESCRIPTION			TMC CODES		Deployment		
	Freeway South Carolina	State County	Starting at Ending at	Begin End	Number Length	Begin Lat/Lon End Lat/Lon	Length % Diff	
Freeways								All Lengths in Miles
F12 SC02-0012	I-26 Eastbound	South Carolina Richland	Harbison Blvd/Exit 103 Piney Grove Rd/Exit 104	125n05663 125n05662	2 1.60	34.080458 34.062617	-81.155335 -81.137442	1.63 1.87%
F13 SC02-0013	I-26 Eastbound	South Carolina Lexington	Piney Grove Rd/Exit 104 Saint Andrews Rd/Exit 106	125n05662 125n05661	2 1.49	34.062617 34.046545	-81.137442 -81.119958	1.68 12.71%
F14 SC02-0014	I-26 Eastbound	South Carolina Richland	Saint Andrews Rd/Exit 106 Bush River Rd/Exit 108	125n05661 125n05659	3 1.18	34.046545 34.033232	-81.119958 -81.106988	1.08 -8.46%

Analysis of Freeway Results

Table 2 summarizes the data quality measures obtained as a result of a comparison between Bluetooth and all reported TomTom 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 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. As shown, the average absolute speed error (AASE) and the Speed Error Bias (SEB) were both within specification for all the speed bins.

TABLE 2 Data quality measures for freeway segments in South Carolina

SPEED BIN	Data Quality Measures for				No. of 5 Minute Samples	Hours of Data Collection
	1.96 SEM Band		Mean			
	SEB 5 mph (contract specifications)	AASE 10 mph	SEB	AASE		
0-30	3.2	3.4	4.6	5.2	1420	118
30-45	3.0	3.7	5.1	6.5	1354	113
45-60	0.0	0.7	0.6	3.0	13374	1115
60+	-4.0	4.0	-7.8	7.8	34139	2845

Table 3 shows the percentage of the time 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 3 Percent observations meeting data quality criteria for freeway segments in South 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	25%	69%	0%	57%	1420
30-45	23%	67%	0%	38%	1354
45-60	70%	97%	0%	85%	13374
60+	22%	64%	0%	30%	34139

Tables 4 and 5 present detailed data for individual TMC segments in this validation 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 4
Data quality measures for individual freeway validation segments in the state of South 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	
SC02-0001	1.69	1.67	0-30	4.8	5.0	6.7	7.0	26*
			30-45	0.3	6.4	1.0	9.5	59
			45-60	0.7	1.2	2.6	3.2	2981
			60+	-0.1	0.1	-1.6	1.6	702
SC02-0002	1.12	1.22	0-30	7.7	7.9	10.0	10.6	71
			30-45	0.9	2.2	4.1	6.3	21*
			45-60	-2.1	2.3	-3.4	5.2	37
			60+	-6.7	6.7	-10.8	10.8	3629
SC02-0003	2.27	2.06	0-30	6.1	6.3	7.6	8.2	180
			30-45	3.6	4.5	5.1	7.0	91
			45-60	-0.9	1.7	-1.0	3.8	146
			60+	-3.9	3.9	-6.6	6.6	3466
SC02-0004	2.07	2.29	0-30	7.7	7.8	9.2	10.1	48
			30-45	5.9	5.9	8.7	8.9	27*
			45-60	-4.3	4.8	-5.0	7.1	389
			60+	-4.6	4.6	-8.3	8.3	3363
SC02-0005	2.30	2.23	0-30	0.0	0.4	-0.2	1.2	323
			30-45	-0.4	0.9	-1.1	2.6	163
			45-60	-2.2	2.3	-4.1	4.9	85
			60+	-8.1	8.1	-12.4	12.4	3220
SC02-0006	1.84	2.22	0-30	6.1	6.1	9.2	9.3	206
			30-45	4.6	4.7	7.8	8.0	452
			45-60	0.0	0.4	-0.3	2.5	2955
			60+	-2.9	2.9	-7.8	7.8	203
SC02-0007	1.45	1.85	0-30	-1.0	1.3	-2.1	3.3	15*
			30-45	-1.2	8.6	-1.3	14.5	5*
			45-60	-0.9	3.0	3.4	10.6	9*
			60+	-6.3	6.3	-11.7	11.8	3662
SC02-0008	1.58	1.68	0-30	1.8	1.8	2.8	2.8	29*
			30-45	1.1	1.6	1.7	3.2	8*
			45-60	-0.1	0.2	0.5	1.2	217
			60+	-1.5	1.5	-4.6	4.6	3552
SC02-0009	1.26	1.27	0-30	1.5	1.6	3.0	3.1	277
			30-45	2.4	2.4	5.3	5.8	54
			45-60	-0.2	0.2	-1.8	2.8	1765
			60+	-3.0	3.0	-7.5	7.5	1096
SC02-0010	1.61	1.60	0-30	1.2	3.2	1.3	5.0	23*
			30-45	3.5	4.0	5.0	6.1	166
			45-60	0.2	0.8	0.5	2.2	497
			60+	-2.1	2.1	-5.1	5.1	2873
SC02-0011	1.59	1.71	0-30	5.0	5.0	7.3	7.3	42
			30-45	3.4	3.4	6.3	6.7	39
			45-60	-0.3	0.4	-0.2	1.9	813
			60+	-1.1	1.1	-3.7	3.7	2454

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

Table 4 (Cont'd)
Data quality measures for individual freeway validation segments in the state of South 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	
SC02-0012	1.60	1.63	0-30	3.1	3.2	4.2	4.4	108
			30-45	2.6	2.6	4.7	5.0	51
			45-60	0.2	0.3	1.6	1.9	545
			60+	-0.6	0.6	-4.6	4.6	2490
SC02-0013	1.49	1.68	0-30	2.3	2.3	4.7	4.9	54
			30-45	4.1	4.1	7.6	7.7	118
			45-60	0.4	0.4	3.1	3.3	2456
			60+	-0.4	0.4	-3.2	3.2	770
SC02-0014	1.18	1.08	0-30	1.1	1.1	4.2	4.9	18*
			30-45	0.8	1.0	2.4	4.0	100
			45-60	-0.7	0.7	-3.1	3.7	479
			60+	-5.6	5.6	-10.9	10.9	2659

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

Table 5
Observations meeting data quality criteria for individual freeway validation segments
in the state of South 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	
SC02-0001	0-30	6	23%	15	58%	0	0%	13	50%	26*
	30-45	4	7%	15	25%	0	0%	11	19%	59
	45-60	702	24%	2705	91%	0	0%	2505	84%	2981
	60+	388	55%	697	99%	0	0%	689	98%	702
SC02-0002	0-30	4	6%	16	23%	0	0%	13	18%	71
	30-45	3	14%	16	76%	0	0%	7	33%	21*
	45-60	11	30%	30	81%	0	0%	21	57%	37
	60+	6	0%	328	9%	0	0%	130	4%	3629
SC02-0003	0-30	3	2%	33	18%	0	0%	18	10%	180
	30-45	10	11%	45	49%	0	0%	26	29%	91
	45-60	63	43%	131	90%	0	0%	118	81%	146
	60+	25	1%	1679	48%	0	0%	915	26%	3466
SC02-0004	0-30	1	2%	18	38%	0	0%	14	29%	48
	30-45	3	11%	10	37%	0	0%	5	19%	27*
	45-60	68	17%	231	59%	0	0%	204	52%	389
	60+	10	0%	892	27%	0	0%	322	10%	3363
SC02-0005	0-30	111	34%	321	99%	0	0%	320	99%	323
	30-45	43	26%	154	94%	0	0%	143	88%	163
	45-60	25	29%	65	76%	0	0%	52	61%	85
	60+	4	0%	164	5%	0	0%	53	2%	3220
SC02-0006	0-30	4	2%	38	18%	0	0%	15	7%	206
	30-45	15	3%	169	37%	0	0%	74	16%	452
	45-60	1096	37%	2866	97%	0	0%	2626	89%	2955
	60+	2	1%	61	30%	0	0%	0	0%	203
SC02-0007	0-30	2	13%	13	87%	0	0%	11	73%	15*
	30-45	0	0%	0	0%	0	0%	0	0%	5*
	45-60	2	22%	5	56%	0	0%	2	22%	9*
	60+	59	2%	484	13%	0	0%	211	6%	3662
SC02-0008	0-30	1	3%	28	97%	0	0%	27	93%	29*
	30-45	4	50%	7	88%	0	0%	7	88%	8*
	45-60	149	69%	214	99%	1	0%	208	96%	217
	60+	290	8%	2843	80%	0	0%	2202	62%	3552
SC02-0009	0-30	29	10%	257	93%	0	0%	240	87%	277
	30-45	9	17%	36	67%	0	0%	29	54%	54
	45-60	542	31%	1744	99%	0	0%	1683	95%	1765
	60+	1	0%	461	42%	0	0%	0	0%	1096
SC02-0010	0-30	5	22%	17	74%	0	0%	15	65%	23*
	30-45	5	3%	96	58%	1	1%	61	37%	166
	45-60	236	47%	471	95%	0	0%	451	91%	497
	60+	50	2%	2110	73%	0	0%	1522	53%	2873
SC02-0011	0-30	1	2%	19	45%	0	0%	16	38%	42
	30-45	3	8%	20	51%	0	0%	13	33%	39
	45-60	360	44%	788	97%	2	0%	760	93%	813
	60+	235	10%	2162	88%	0	0%	1855	76%	2454

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

Table 5 (Cont'd)
Observations meeting data quality criteria for individual freeway validation segments
in the state of South 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	
SC02-0012	0-30	15	14%	78	72%	0	0%	65	60%	108
	30-45	14	27%	37	73%	0	0%	32	63%	51
	45-60	309	57%	532	98%	0	0%	511	94%	545
	60+	569	23%	2104	85%	0	0%	1571	63%	2490
SC02-0013	0-30	8	15%	35	65%	0	0%	30	56%	54
	30-45	6	5%	61	52%	0	0%	41	35%	118
	45-60	1023	42%	2183	89%	0	0%	1905	78%	2456
	60+	219	28%	721	94%	0	0%	638	83%	770
SC02-0014	0-30	4	22%	15	83%	0	0%	13	72%	18*
	30-45	34	34%	86	86%	1	1%	69	69%	100
	45-60	151	32%	441	92%	0	0%	373	78%	479
	60+	0	0%	407	15%	0	0%	51	2%	2659

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