



I-95 Corridor Coalition

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

Report for New Hampshire (#1)
I-89 and I-93



October 2016

I-95 CORRIDOR COALITION VEHICLE PROBE PROJECT VALIDATION OF HERE DATA OCTOBER 2016

*Report for New Hampshire (#1)
I-89 and I-93*

Prepared for:

I-95 Corridor Coalition

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Evaluation Results for the State of New Hampshire

Executive Summary

The data from the Vehicle Probe Project is validated using Bluetooth™ Traffic Monitoring (BTM) technology on a near monthly basis. BTMs sensors were deployed at the beginning and ending points of 12 different segments along the I-89 and I-93 corridors. Average Annual Daily Traffic (AADT) is 33,000 along I-89 and 68,460 along I-93. The speed limit varies between 45 to 65 MPH for both I-89 and I-93.

The Bluetooth sensor deployment covers the range from I-93 to Stickney Hill Rd along I-89, and between exits 4 and 5 and also exits 11 and 15 along I-93. Travel time data was collected for both directions, between July 8 and July 22, 2016. The dataset collected represents approximately 2,484 hours of observations along 12 directional freeway segments, totaling approximately 33 miles. The total number of effective five-minute travel time samples observed was 29,811.

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

ES Table 1 – New Hampshire 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	2.8	4.5	1.7	2.2	544	45
30-45 MPH	3	5.2	0	0.5	593	49
45-60 MPH	1.1	3.5	-0.2	0.4	3218	268
>60 MPH	1.7	4.4	-1.6	-3.7	25456	2121
All Speeds	1.7	4.4	-1.4	-3.1	29811	2484
Based upon data collected between July 8 and July 22, 2016 across 33 miles of roadway.						

Data Collection

Travel time samples were collected along 12 freeway segments with the assistance of New Hampshire Department of Transportation (NHDOT) personnel. Freeway segments studied were located on the I-89 corridor from I-93 to Stickney Hill Rd and on I-93 corridor between exits 4 and 5 and also exits 11 and 15. Travel time data was collected for both directions along I-89 and I-93 corridors between July 8 and July 22, 2016. 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-89 and I-93 corridors in New Hampshire, respectively. Average Annual Daily Traffic (AADT) is 33,000 along I-89 and 68,460 along I-93. The speed limit varies between 45 to 65 MPH for both I-89 and I-93. Blue segments represent freeway segments selected for analysis.

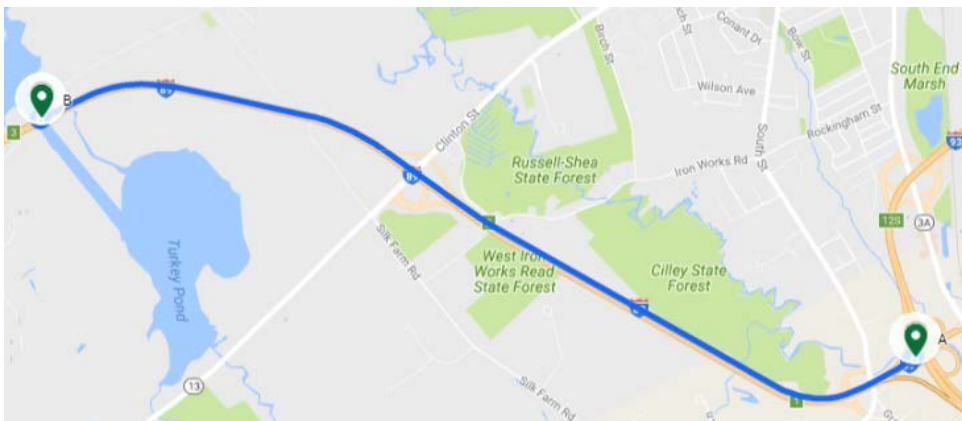


Figure 1 — Locations of segment selected on I-89 for analysis in New Hampshire

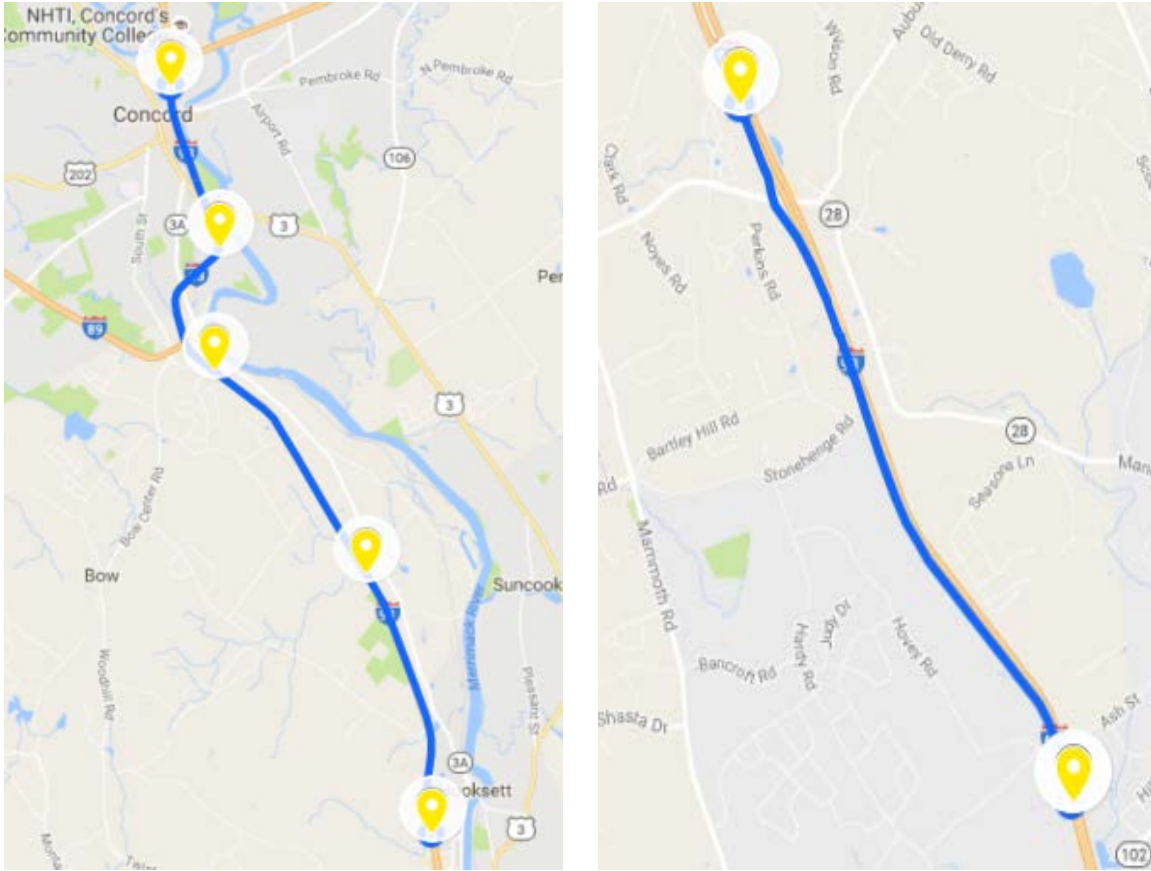


Figure 2 — Locations of segments selected on I-93 for analysis in New Hampshire

TMC segments selected for validation in New Hampshire

Table 1 presents the data collection segments from New Hampshire. As a whole, these segments cover a total length of 33 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 12 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 Bluetooth sensors were deployed along I-89 and I-93 in New Hampshire 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 BluetoothTM 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 VPPH. Details of the algorithm used to estimate equivalent path travel times based on HERE data feeds for individual data collection segments are provided in this separate report. This algorithm finds an equivalent HERE travel time (and therefore travel speed) corresponding to each sample BTM 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 New Hampshire

SEGMENT (Map Link)	DESCRIPTION			TMC CODES		Deployment		All Lengths in Miles
	Freeway NH	State County	Starting at Ending at	Begin End	Number Length	Begin Lat/Lon End Lat/Lon	Length % Diff	
Freeways								
F1 NH01-0001	I-89 Northbound	New Hampshire Merrimack	I-93 Stickney Hill Rd/Exit 3	129P05141 129P05144	4 3.54	43.1702 -71.5308 43.1828 -71.5941	3.38 -4.52%	
F2 NH01-0002	I-89 Southbound	New Hampshire Merrimack	Stickney Hill Rd/Exit 3 I-93	129N05143 129N05141	3 3.61	43.1823 -71.595 43.1702 -71.5306	3.55 -2.22%	
F3 NH01-0003	I-93 Southbound	New Hampshire Merrimack	I-393/US-202/US-4/Exit 15 US-3/Manchester St/Exit 13	129N05000 129N04997	4 1.93	43.2127 -71.5340 43.1862 -71.5228	1.87 -3.11%	
F4 NH01-0004	I-93 Southbound	New Hampshire Merrimack	US-3/Manchester St/Exit 13 NH-3A/Main St/Exit 12	129N04997 129N04159	3 1.77	43.1862 -71.5228 43.1658 -71.524	2.00 12.98%	
F5 NH01-0005	I-93 Southbound	New Hampshire Merrimack	I-89 Hackett Hill Rd/Exit 11	129N04159 129N04159	1 6.06	43.1658 -71.524 43.1322 -71.4896	2.88 -52.47%	
F6 NH01-0006	I-93 Southbound	New Hampshire Merrimack	Hackett Hill Rd/Exit 11 Hackett Hill Rd/Exit 11	129N04159 129N04159	1 6.06	43.1322 -71.4896 43.0893 -71.4748	3.03 -49.99%	
F7 NH01-0007	I-93 Southbound	New Hampshire Hillsborough	NH-28/Rockingham Rd/Exit 5 NH-102/Nashua Rd/Exit 4	129N04151 129N04150	1 3.63	42.9227 -71.3763 42.8765 -71.3435	3.49 -3.85%	
F8 NH01-0008	I-93 Northbound	New Hampshire Rockingham	NH-102/Nashua Rd/Exit 4 NH-28/Rockingham Rd/Exit 5	129P04151 129P04151	1 3.05	42.8733 -71.3419 42.9123 -71.3684	3.03 -0.65%	
F9 NH01-0009	I-93 Northbound	New Hampshire Merrimack	Hackett Hill Rd/Exit 11 I-89	129P04159 129P04160	2 6.03	43.0895 -71.4744 43.1335 -71.4900	2.99 -50.45%	
F10 NH01-0010	I-93 Northbound	New Hampshire Merrimack	I-89 I-89	129P04160 129P04160	1 6.03	43.1335 -71.4900 43.1657 -71.5235	2.8 -53.60%	
F11 NH01-0011	I-93 Northbound	New Hampshire Merrimack	I-89 US-3/Manchester St/Exit 13	129P04160 129P04998	3 1.92	43.1657 -71.5235 43.1882 -71.5228	1.96 2.08%	
F12 NH01-0012	I-93 Northbound	New Hampshire Merrimack	US-3/Manchester St/Exit 13 I-393/US-202/US-4/Exit 15	129P04998 129P05000	3 1.79	43.1882 -71.5228 43.2128 -71.5338	1.86 3.91%	

Analysis of Freeway Results

Table 2 summarizes the data quality measures obtained as a result of a comparison between Bluetooth and all reported HERE 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 Speed Error Bias (SEB) were within specification for all the speed bins.

TABLE 2 Data quality measures for freeway segments in New Hampshire

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	1.7	2.8	2.2	4.5	544	45
30-45	0	3	0.5	5.2	593	49
45-60	-0.2	1.1	0.4	3.5	3218	268
60+	-1.6	1.7	-3.7	4.4	25456	2121

Table 3 shows the percentage of the time 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 data quality criteria for freeway segments in New Hampshire

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%	84%	0%	72%	544
30-45	30%	79%	0%	64%	593
45-60	67%	94%	0%	78%	3218
60+	51%	89%	0%	65%	25456

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
New Hampshire

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	
NH01-0001	3.38	3.38	0-30	-	-	-	-	-
			30-45	-	-	-	-	-
			45-60	0.3	0.6	1.5	2.7	12*
			60+	-3.3	3.3	-7.1	7.2	1772
NH01-0002	3.52	3.53	0-30	3.7	4.3	4.6	7.5	66
			30-45	3.7	4.5	6.9	8.9	30
			45-60	-0.1	0.9	0.0	3.3	99
			60+	-1.6	1.6	-3.9	4.2	2318
NH01-0003	1.86	1.87	0-30	2.2	3.6	2.8	5.1	42
			30-45	0.3	2.4	0.7	4.1	144
			45-60	-0.2	0.7	0.0	3.1	801
			60+	-1.8	1.8	-4.2	4.7	1778
NH01-0004	2.00	2.00	0-30	1.9	2.3	3.7	5.5	20*
			30-45	-0.5	2.0	-0.9	4.0	40
			45-60	0.0	0.7	0.2	2.9	766
			60+	-1.5	1.6	-4.2	4.7	1233
NH01-0005	2.88	2.88	0-30	0.9	2.1	0.9	3.3	27*
			30-45	-2.6	4.3	-3.6	5.9	13*
			45-60	1.4	2.7	3.3	5.8	35
			60+	-1.5	1.7	-3.6	4.6	2059
NH01-0006	3.03	3.03	0-30	0.6	2.2	-0.3	3.4	11*
			30-45	-2.2	6.7	-1.2	10.4	22*
			45-60	-0.3	3.4	2.4	7.5	62
			60+	-3.1	3.1	-6.4	6.7	2410
NH01-0007	3.49	3.49	0-30	0.4	4.2	0.2	6.4	20*
			30-45	-5.0	5.8	-6.3	7.4	31
			45-60	-4.9	5.9	-5.4	8.2	63
			60+	-1.5	1.6	-3.2	4.0	3383
NH01-0008	3.03	3.03	0-30	0.6	2.3	0.2	3.6	12*
			30-45	0.3	2.6	0.9	4.0	28*
			45-60	-0.4	2.1	0.3	4.3	109
			60+	-0.4	0.7	-1.0	2.8	2864
NH01-0009	2.99	2.99	0-30	0.2	2.7	0.2	3.4	33
			30-45	0.1	6.8	4.2	13.0	27*
			45-60	-3.7	6.5	-0.2	11.5	26*
			60+	-1.7	1.7	-3.7	4.2	1824
NH01-0010	2.80	2.80	0-30	-0.1	1.7	-0.3	2.5	74
			30-45	-0.9	3.8	-1.5	5.3	36
			45-60	-0.8	3.2	-0.3	5.7	30
			60+	-1.3	1.4	-3.1	3.7	2688
NH01-0011	1.96	1.96	0-30	2.8	3.2	3.6	4.6	163
			30-45	2.5	3.5	3.5	5.7	47
			45-60	0.0	1.3	1.1	3.7	174
			60+	-1.0	1.1	-3.0	3.8	2008

*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
New Hampshire

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	
NH01-0012	1.88	1.86	0-30	1.0	1.6	1.4	3.4	76
			30-45	0.0	1.7	0.1	3.6	175
			45-60	0.1	0.8	0.9	3.2	1041
			60+	-0.7	0.9	-2.3	3.6	1119

*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 New Hampshire

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	
NH01-0001	0-30	-	-	-	-	-	-	-	-	-
	30-45	-	-	-	-	-	-	-	-	-
	45-60	3	25%	11	92%	0	0%	10	83%	12*
	60+	64	4%	724	41%	0	0%	508	29%	1772
NH01-0002	0-30	12	18%	42	64%	0	0%	34	52%	66
	30-45	5	17%	18	60%	0	0%	10	33%	30
	45-60	19	19%	83	84%	0	0%	79	80%	99
	60+	354	15%	1768	76%	0	0%	1531	66%	2318
NH01-0003	0-30	2	5%	25	60%	0	0%	23	55%	42
	30-45	13	9%	111	77%	0	0%	100	69%	144
	45-60	272	34%	715	89%	0	0%	654	82%	801
	60+	352	20%	1306	73%	0	0%	1122	63%	1778
NH01-0004	0-30	4	20%	10	50%	0	0%	8	40%	20*
	30-45	4	10%	32	80%	0	0%	31	78%	40
	45-60	217	28%	689	90%	2	0%	641	84%	766
	60+	199	16%	905	73%	0	0%	750	61%	1233
NH01-0005	0-30	5	19%	22	81%	0	0%	20	74%	27*
	30-45	2	15%	10	77%	0	0%	10	77%	13*
	45-60	5	14%	21	60%	0	0%	19	54%	35
	60+	404	20%	1556	76%	2	0%	1339	65%	2059
NH01-0006	0-30	1	9%	10	91%	0	0%	10	91%	11*
	30-45	0	0%	7	32%	0	0%	5	23%	22*
	45-60	9	15%	36	58%	0	0%	24	39%	62
	60+	356	15%	1363	57%	1	0%	976	41%	2410
NH01-0007	0-30	1	5%	12	60%	0	0%	10	50%	20*
	30-45	3	10%	14	45%	0	0%	12	39%	31
	45-60	10	16%	35	56%	0	0%	28	44%	63
	60+	795	24%	2762	82%	0	0%	2443	72%	3383
NH01-0008	0-30	1	8%	11	92%	0	0%	11	92%	12*
	30-45	3	11%	23	82%	0	0%	22	79%	28*
	45-60	12	11%	83	76%	0	0%	71	65%	109
	60+	860	30%	2623	92%	0	0%	2423	85%	2864
NH01-0009	0-30	2	6%	27	82%	0	0%	25	76%	33
	30-45	0	0%	12	44%	0	0%	8	30%	27*
	45-60	0	0%	10	38%	0	0%	6	23%	26*
	60+	340	19%	1425	78%	0	0%	1238	68%	1824
NH01-0010	0-30	9	12%	71	96%	0	0%	70	95%	74
	30-45	8	22%	24	67%	0	0%	22	61%	36
	45-60	4	13%	22	73%	0	0%	16	53%	30
	60+	590	22%	2250	84%	0	0%	1989	74%	2688
NH01-0011	0-30	28	17%	127	78%	0	0%	120	74%	163
	30-45	8	17%	33	70%	0	0%	27	57%	47
	45-60	53	30%	142	82%	0	0%	130	75%	174
	60+	499	25%	1642	82%	1	0%	1437	72%	2008

*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 New Hampshire

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	
NH01-0012	0-30	10	13%	63	83%	0	0%	60	79%	76
	30-45	22	13%	145	83%	0	0%	133	76%	175
	45-60	283	27%	922	89%	2	0%	844	81%	1041
	60+	279	25%	946	85%	1	0%	825	74%	1119

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