I-95 Corridor Coalition

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

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

I-95 CORRIDOR
COALITION

October 2016

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

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

Prepared for:

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Sponsored by:

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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 2,494 hours of observations along 12 directional freeway segments, totaling approximately 33 miles. The total number of effective five-minute travel time samples observed was 29,922.

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) were within specification in all speed bins, and the Speed Error Bias (SEB) were within specification in all speed bins except for the >60 MPH speed category. TOMTOM puts a cap on the reported speeds equal to the posted speed limit, which may impact the performance measures on the >60 MPH speed category.

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	4.3	6.1	3.8	5.4	544	45
30-45 MPH	2.7	4.9	1.1	2.5	593	49
45-60 MPH	0.8	3.3	-0.7	-2.7	3233	269
>60 MPH	5.3	8.9	-5.3	-8.8	25552	2129
All Speeds	4.8	8.2	-4.5	-7.7	29922	2494

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.

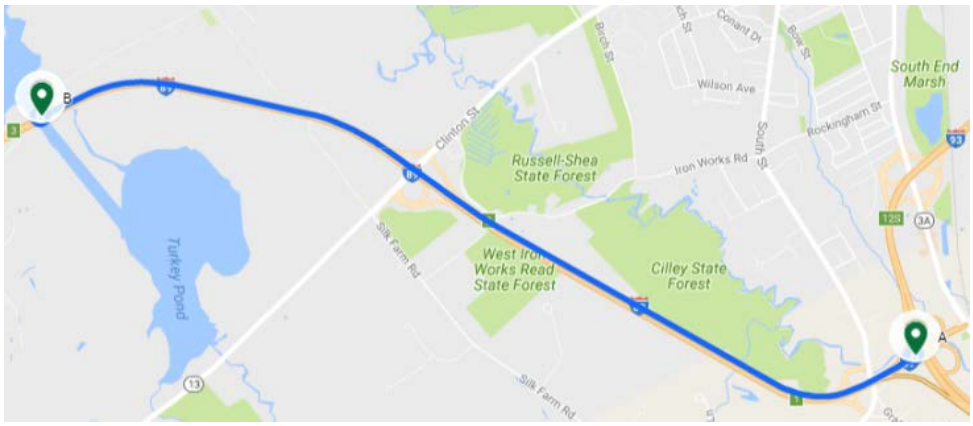

Figure 1 — Locations of segment selected on I-89 for analysis in New Hampshire

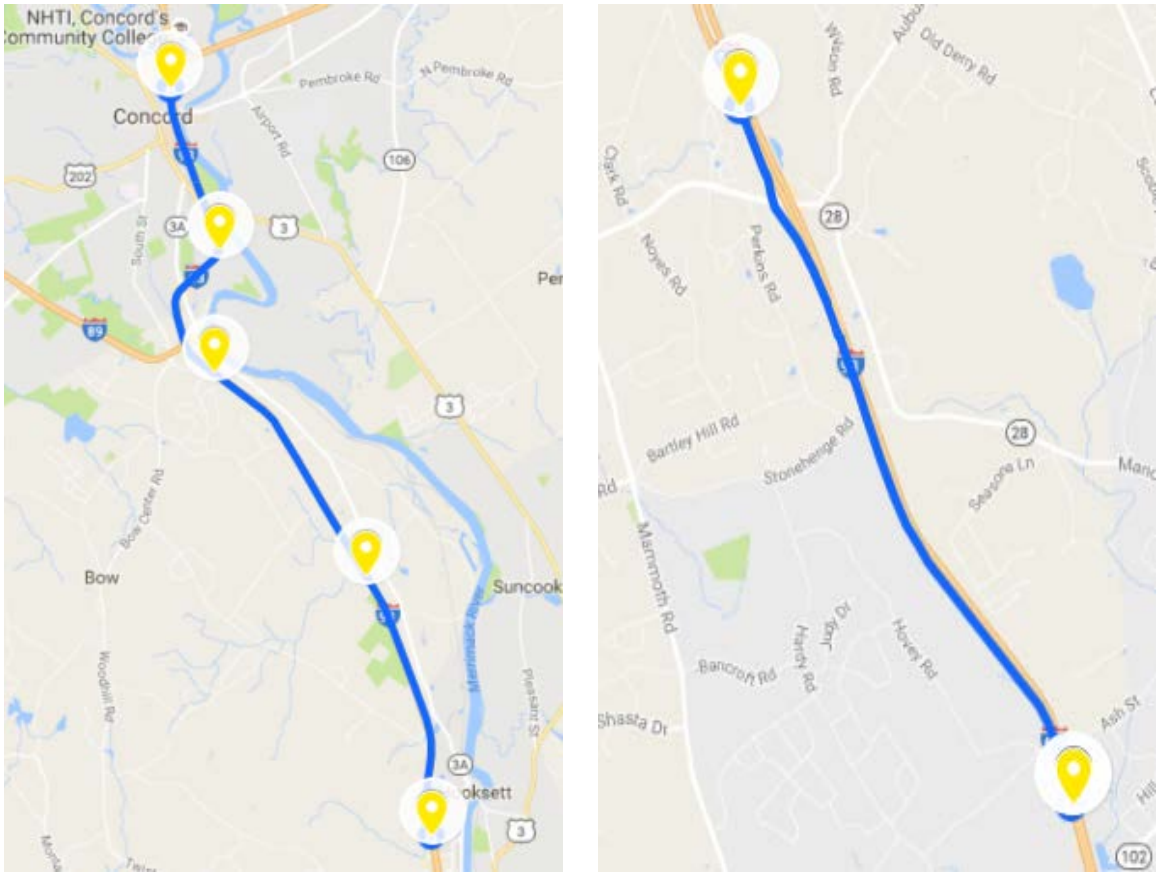

Figure 2 — Locations of segments selected on I-93 for analysis in New Hampshire

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 Bluetooth™ Traffic Monitoring (BTM) sensors placed on the roadway. 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 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 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		
	Freeway NH	State County	Starting at Ending at	Begin End	Number Length	Begin Lat/Lon End Lat/Lon		Length % Diff
Freeways								All Lengths in Miles
F1	I-89	New Hampshire	I-93	129P05141	4	43.1702	-71.5308	3.38
NH01-0001	Northbound	Merrimack	Stickney Hill Rd/Exit 3	129P05144	3.54	43.1828	-71.5941	-4.52%
F2	I-89	New Hampshire	Stickney Hill Rd/Exit 3	129N05143	3	43.1823	-71.595	3.55
NH01-0002	Southbound	Merrimack	I-93	129N05141	3.61	43.1702	-71.5306	-2.22%
F3	I-93	New Hampshire	I-393/US-202/US-4/Exit 15	129N05000	4	43.2127	-71.5340	1.87
NH01-0003	Southbound	Merrimack	US-3/Manchester St/Exit 13	129N04997	1.93	43.1862	-71.5228	-3.11%
F4	I-93	New Hampshire	US-3/Manchester St/Exit 13	129N04997	3	43.1862	-71.5228	2.00
NH01-0004	Southbound	Merrimack	NH-3A/Main St/Exit 12	129N04159	1.77	43.1658	-71.524	12.98%
F5	I-93	New Hampshire	I-89	129N04159	1	43.1658	-71.524	2.88
NH01-0005	Southbound	Merrimack	Hackett Hill Rd/Exit 11	129N04159	6.06	43.1322	-71.4896	-52.47%
F6	I-93	New Hampshire	Hackett Hill Rd/Exit 11	129N04159	1	43.1322	-71.4896	3.03
NH01-0006	Southbound	Merrimack	Hackett Hill Rd/Exit 11	129N04159	6.06	43.0893	-71.4748	-49.99%
F7	I-93	New Hampshire	NH-28/Rockingham Rd/Exit 5	129N04151	1	42.9227	-71.3763	3.49
NH01-0007	Southbound	Hillsborough	NH-102/Nashua Rd/Exit 4	129N04150	3.63	42.8765	-71.3435	-3.85%
F8	I-93	New Hampshire	NH-102/Nashua Rd/Exit 4	129P04151	1	42.8733	-71.3419	3.03
NH01-0008	Northbound	Rockingham	NH-28/Rockingham Rd/Exit 5	129P04151	3.05	42.9123	-71.3684	-0.65%
F9	I-93	New Hampshire	Hackett Hill Rd/Exit 11	129P04159	2	43.0895	-71.4744	2.99
NH01-0009	Northbound	Merrimack	I-89	129P04160	6.03	43.1335	-71.4900	-50.45%
F10	I-93	New Hampshire	I-89	129P04160	1	43.1335	-71.4900	2.8
NH01-0010	Northbound	Merrimack	I-89	129P04160	6.03	43.1657	-71.5235	-53.60%
F11	I-93	New Hampshire	I-89	129P04160	3	43.1657	-71.5235	1.96
NH01-0011	Northbound	Merrimack	US-3/Manchester St/Exit 13	129P04998	1.92	43.1882	-71.5228	2.08%
F12	I-93	New Hampshire	US-3/Manchester St/Exit 13	129P04998	3	43.1882	-71.5228	1.86
NH01-0012	Northbound	Merrimack	I-393/US-202/US-4/Exit 15	129P05000	1.79	43.2128	-71.5338	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 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) were within specification in all speed bins, and the Speed Error Bias (SEB) were within specification in all speed bins except the last speed bin. TOMTOM puts a cap on the reported speeds equal to the posted speed limit, which may impact the performance measures on the >60 MPH speed category.

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 (contract specifications)	SEB	AASE		
0-30	3.8	4.3	5.4	6.1	544	45
30-45	1.1	2.7	2.5	4.9	593	49
45-60	-0.7	0.8	-2.7	3.3	3233	269
60+	-5.3	5.3	-8.8	8.9	25552	2129

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 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	15%	65%	0%	44%	544
30-45	23%	83%	0%	66%	593
45-60	66%	97%	0%	92%	3233
60+	19%	58%	0%	24%	25552

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	1.0	1.0	3.6	3.6	12*
			60+	-2.5	2.5	-6.2	6.3	1780
NH01-0002	3.52	3.53	0-30	1.7	1.7	5.3	5.4	66
			30-45	1.1	1.1	5.3	5.3	30
			45-60	0.0	0.1	-0.8	1.7	100
			60+	-3.4	3.4	-6.8	6.8	2328
NH01-0003	1.86	1.87	0-30	2.1	2.3	3.1	3.6	42
			30-45	2.0	2.1	3.7	3.9	144
			45-60	-0.4	0.4	-2.5	3.1	807
			60+	-4.2	4.2	-8.3	8.3	1784
NH01-0004	2.00	2.00	0-30	1.6	1.6	5.4	5.4	20*
			30-45	1.6	1.6	3.3	3.6	40
			45-60	-0.4	0.4	-2.7	3.0	771
			60+	-3.8	3.8	-8.3	8.3	1236
NH01-0005	2.88	2.88	0-30	3.9	4.1	5.2	5.5	27*
			30-45	0.1	3.5	1.1	5.3	13*
			45-60	-2.6	2.6	-6.1	6.1	35
			60+	-12.0	12.0	-16.6	16.6	2071
NH01-0006	3.03	3.03	0-30	1.7	1.7	2.5	2.5	11*
			30-45	-4.5	4.6	-4.9	7.1	22*
			45-60	-3.2	3.2	-5.3	6.1	62
			60+	-14.5	14.5	-19.3	19.3	2422
NH01-0007	3.49	3.49	0-30	-0.8	2.1	-1.7	4.2	20*
			30-45	-2.6	2.7	-4.3	4.6	31
			45-60	-6.7	7.1	-7.5	9.3	60
			60+	-2.0	2.0	-4.6	4.7	3384
NH01-0008	3.03	3.03	0-30	-2.3	3.9	-3.5	5.6	12*
			30-45	-0.6	2.7	-0.6	4.0	28*
			45-60	-1.7	2.6	-0.9	4.9	109
			60+	-0.6	0.7	-2.0	2.7	2876
NH01-0009	2.99	2.99	0-30	0.8	3.1	0.9	3.7	33
			30-45	-4.6	8.0	-1.3	13.8	27*
			45-60	-7.0	7.0	-6.4	10.1	26*
			60+	-6.9	6.9	-10.2	10.2	1827
NH01-0010	2.80	2.80	0-30	2.9	3.1	3.6	3.9	74
			30-45	0.3	2.4	-0.1	4.0	36
			45-60	-3.8	3.8	-5.6	5.6	30
			60+	-6.4	6.4	-9.5	9.5	2700
NH01-0011	1.96	1.96	0-30	7.5	7.6	9.1	9.2	163
			30-45	4.6	5.7	6.0	8.0	47
			45-60	-0.5	0.9	-1.9	3.2	175
			60+	-4.5	4.5	-8.5	8.5	2018

*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	1046
			60+	-0.7	0.9	-2.3	3.6	1126

*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	1	8%	10	83%	0	0%	8	67%	12*
	60+	80	4%	879	49%	0	0%	582	33%	1780
NH01-0002	0-30	5	8%	45	68%	0	0%	25	38%	66
	30-45	6	20%	23	77%	0	0%	12	40%	30
	45-60	35	35%	98	98%	0	0%	96	96%	100
	60+	2	0%	964	41%	0	0%	521	22%	2328
NH01-0003	0-30	5	12%	36	86%	0	0%	36	86%	42
	30-45	9	6%	128	89%	0	0%	113	78%	144
	45-60	157	19%	795	99%	0	0%	776	96%	807
	60+	0	0%	432	24%	0	0%	0	0%	1784
NH01-0004	0-30	0	0%	15	75%	0	0%	12	60%	20*
	30-45	1	3%	34	85%	0	0%	33	83%	40
	45-60	115	15%	762	99%	0	0%	751	97%	771
	60+	0	0%	283	23%	0	0%	0	0%	1236
NH01-0005	0-30	0	0%	15	56%	0	0%	12	44%	27*
	30-45	1	8%	8	62%	0	0%	8	62%	13*
	45-60	1	3%	20	57%	0	0%	9	26%	35
	60+	0	0%	0	0%	0	0%	0	0%	2071
NH01-0006	0-30	4	36%	9	82%	0	0%	8	73%	11*
	30-45	1	5%	8	36%	0	0%	6	27%	22*
	45-60	13	21%	40	65%	0	0%	30	48%	62
	60+	0	0%	6	0%	0	0%	0	0%	2422
NH01-0007	0-30	2	10%	15	75%	0	0%	13	65%	20*
	30-45	1	3%	24	77%	0	0%	23	74%	31
	45-60	6	10%	26	43%	0	0%	23	38%	60
	60+	447	13%	2613	77%	0	0%	2185	65%	3384
NH01-0008	0-30	0	0%	7	58%	0	0%	7	58%	12*
	30-45	4	14%	23	82%	0	0%	23	82%	28*
	45-60	7	6%	84	77%	0	0%	61	56%	109
	60+	922	32%	2643	92%	0	0%	2467	86%	2876
NH01-0009	0-30	4	12%	26	79%	0	0%	24	73%	33
	30-45	1	4%	3	11%	0	0%	2	7%	27*
	45-60	7	27%	14	54%	0	0%	11	42%	26*
	60+	6	0%	184	10%	0	0%	101	6%	1827
NH01-0010	0-30	5	7%	52	70%	0	0%	48	65%	74
	30-45	3	8%	28	78%	0	0%	27	75%	36
	45-60	8	27%	15	50%	1	3%	14	47%	30
	60+	9	0%	296	11%	0	0%	149	6%	2700
NH01-0011	0-30	3	2%	36	22%	0	0%	29	18%	163
	30-45	6	13%	19	40%	0	0%	15	32%	47
	45-60	42	24%	161	92%	1	1%	156	89%	175
	60+	0	0%	572	28%	0	0%	233	12%	2018

*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	0	0%	36	47%	0	0%	27	36%	76
	30-45	14	8%	145	83%	0	0%	128	73%	175
	45-60	171	16%	1044	100%	0	0%	1035	99%	1046
	60+	0	0%	342	30%	0	0%	0	0%	1126

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