



I-95 Corridor Coalition

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

Monthly Report: Virginia



June 2015

I-95 CORRIDOR COALITION VEHICLE PROBE PROJECT VALIDATION OF TOMTOM DATA JUNE 2015

Monthly Report

Prepared for:

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Evaluation Results for the State of Virginia

Executive Summary

The data from the Vehicle Probe Project is validated using Bluetooth™ Traffic Monitoring (BTM) technology on a near monthly basis. The validation of arterial data is similar to that of freeway data, however the following should be noted. The boundaries of the speed bins used for arterials are different than those used for freeways to accommodate the lower speeds on this type of corridor.

BTMs sensor were deployed at the beginning and ending points of eight different segments along the US-1 corridor. There are two lanes per direction with average signal density of 1.5 signal per mile. Average Annual Daily Traffic (AADT) along the corridor is 21,500 and the speed limit is 45 MPH.

The Bluetooth sensor deployment covers the range from Joplin Rd to Harrison Rd along US-1. Travel time data was collected for both directions along the arterial, between January 15 and January 28, 2015. The dataset collected represents approximately 1355 hours of observations along eight arterial segments, totaling approximately 34 miles. The total number of effective five-minute travel time samples observed was 16,245.

ES Table 1, below summarizes the results of the comparison between the BTM reference data and the TomTom data for arterial segments during the above noted time period. As shown, the average absolute speed error (AASE) was within specification in all speed bins. The Speed Error Bias (SEB) was within specifications for all speed bins except for 0-15 MPH and 15-25MPH when compared with the Standard Error of the Mean (SEM) Band. Although the data are compared to these specifications, caution should be used when using probe data on arterial roadways. Other factors including signal density and traffic volume should be considered.

ES Table 1 - Virginia Evaluation Summary for Arterial						
Speed Bin	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		
0-15 MPH	6.7	9.6	6.6	9.4	584	49
15-25 MPH	5.4	9.9	5.3	9.6	2868	239
25-35 MPH	3.3	7.9	3.0	6.7	3858	322
>35 MPH	2.5	6.2	-1.1	-1.2	8935	745
All Speeds	3.4	7.3	1.3	3.0	16245	1354

Based upon data collected from Jan 15th, 2015 through Jan 28th, 2015 across 33.8 miles of roadway.

Data Collection

Travel time samples were collected along eight arterial segments with the assistance of Virginia Department of Transportation (VDOT) personnel. Arterial segments studied were located along the US-1 corridor from Joplin Road to Harrison Road. Travel time data was collected for both directions along the US-1 arterial between January 15 and January 28, 2015. Segment locations were chosen with a high-likelihood of observing recurrent and non-recurrent congestion during peak and off-peak periods.

Figure 1 presents an overview snapshot of the placement of sensors for the collection of data on the US-1 corridor in Virginia. Red segments represent arterial segments selected for analysis. There are two lanes per direction with average signal density of 1.5 signal per mile. Average Annual Daily Traffic (AADT) along the corridor is 21,500 and the speed limit is 45 MPH.

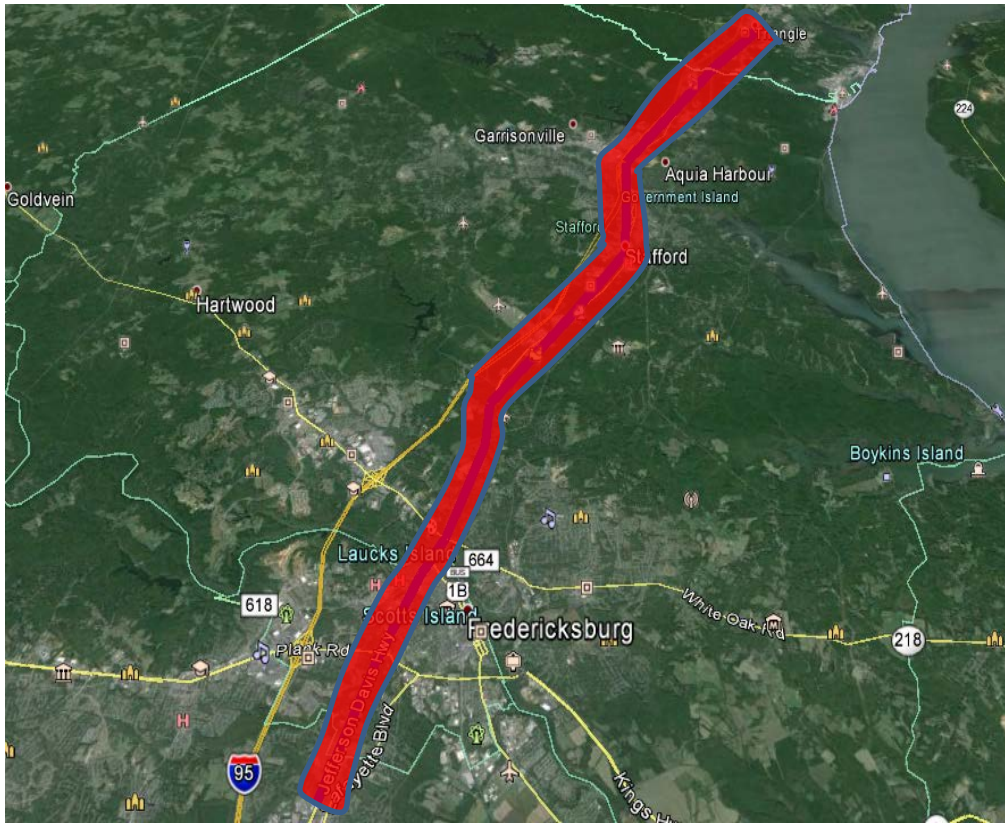


Figure 1 — Locations of all segments selected for analysis in Virginia

TMC segments selected for validation in Virginia

Table 1 presents a list of data collection segments from Virginia. In total, these segments cover a total length of approximately 33.8 arterial 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 arterials. When appropriate, consecutive TMC segments are combined to form a data collection segment longer than one mile. The results of the validation performed on eight arterial segments are included in this report. Table 1 contains the summary information on each data collection segment. The latitude/longitude coordinates of the locations at which the Bluetooth sensors were deployed along the US-1 in Northern Virginia 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 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 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 Virginia

SEGMENT (Map Link)	DESCRIPTION			TMC CODES		Deployment		
	Highway	State	Starting at	Begin	Number	Begin Lat/Lon	Length	
	Pennsylvania	County	Ending at	End	Length	End Lat/Lon	% Diff	
Arterials							<i>All Lengths in Miles</i>	
A1 VA10-0001	US-1 Southbound	Virginia Prince William	Joplin Rd Russell Rd	110-09526 110N09526	2.13 2	38.545472 -77.336879 38.521074 -77.360451	2.19 2.82%	
A2 VA10-0002	US-1 Southbound	Virginia Stafford	Russell Rd VA-610/Garrisonville Rd	110-09525 110-09525	4.65 1	38.521074 -77.360451 38.4637 -77.405727	4.75 2.03%	
A5 VA10-0005	US-1 Southbound	Virginia Stafford	American Legion Rd Mountain View Rd	110-09522 110-09522	2.70 1	38.395746 -77.429713 38.363967 -77.45708	2.74 1.48%	
A6 VA10-0006	US-1 Southbound	Virginia Stafford	Mountain View Rd Forbes St	110-09521 110-09521	0.90 1	38.363967 -77.45708 38.351058 -77.457959	0.86 -4.45%	
A7 VA10-0007	US-1 Southbound	Virginia Stafford	Forbes St US-17/VA-212/Warrenton Rd	110-09520 110-09520	1.97 1	38.351058 -77.457959 38.324019 -77.468435	2.00 1.52%	
A8 VA10-0008	US-1 Southbound	Virginia Stafford	US-17/VA-212/Warrenton Rd Fall Hill Ave	110-09519 110-09519	0.76 1	38.324019 -77.468435 38.314289 -77.474837	0.76 0.00%	
A9 VA10-0009	US-1 Southbound	Virginia Fredericksburg	Fall Hill Ave VA-3/William St	110N09519 110N09518	1.56 3	38.314289 -77.474837 38.293127 -77.484856	1.50 -3.83%	
A10 VA10-0010	US-1 Southbound	Virginia Spotsylvania	VA-3/William St Harrison Rd	110-09517 110N09517	2.08 2	38.293127 -77.484856 38.264219 -77.495507	2.12 1.93%	

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

SEGMENT (Map Link)	DESCRIPTION			TMC CODES		Deployment		
	Highway Pennsylvania	State County	Starting at Ending at	Begin End	Number Length	Begin Lat/Lon End Lat/Lon	Length % Diff	
Arterials								All Lengths in Miles
A11 VA10-0011	US-1 Northbound	Virginia Stafford	Harrison Rd VA-3/William St	110-09522 110-09522	2.15 2	38.264113 -77.495391 38.294 -77.484411	2.12 -1.40%	
A12 VA10-0012	US-1 Northbound	Virginia Stafford	VA-3/William St Fall Hill Ave	110-09521 110-09521	1.50 3	38.294 -77.484411 38.314236 -77.474704	1.51 0.67%	
A13 VA10-0013	US-1 Northbound	Virginia Stafford	Fall Hill Ave US-17/VA-212/Warrenton Rd	110-09520 110-09520	0.76 1	38.314236 -77.474704 38.324019 -77.468435	0.76 0.00%	
A14 VA10-0014	US-1 Northbound	Virginia Stafford	US-17/VA-212/Warrenton Rd Forbes St	110-09519 110-09519	1.98 1	38.324019 -77.468435 38.351058 -77.457959	2.01 1.52%	
A15 VA10-0015	US-1 Northbound	Virginia Fredericksburg	Forbes St Mountain View Rd	110N09519 110N09518	0.90 1	38.351058 -77.457959 38.363946 -77.456898	0.86 -4.46%	
A16 VA10-0016	US-1 Northbound	Virginia Spotsylvania	Mountain View Rd American Legion Rd	110-09517 110N09517	2.69 1	38.363946 -77.456898 38.395712 -77.429605	2.73 1.48%	
A19 VA10-0019	US-1 Northbound	Virginia Prince William	VA-610/Garrisonville Rd Russell Rd	110+09526 110+09526	4.84 1	38.661743 -77.247195 38.677623 -77.230068	4.75 -1.86%	
A20 VA10-0020	US-1 Northbound	Virginia Prince William	Russell Rd Joplin Rd	110P09526 110+09527	2.04 2	38.677623 -77.230068 38.705713 -77.205011	2.17 6.36%	

Analysis of Arterial Results

Table 2 summarizes the data quality measures obtained as a result of comparison between Bluetooth and all reported TomTom speeds. Specifications include the Average Absolute Speed Error (AASE) and the Speed Error Bias (SEB). 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: 0-15 MPH, 15-25 MPH, 25-35 MPH, and > 35 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) was within specification for all the speed bins. The Speed Error Bias (SEB) was within specifications for all speed bins except for 0-15 MPH and 15-25 MPH when compared with the Standard Error of the Mean (SEM) Band.

TABLE 2 Data quality measures for arterial segments in Virginia

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		
0-15	6.6	6.7	9.4	9.6	584	49
15-25	5.3	5.4	9.6	9.9	2868	239
25-35	3.0	3.3	6.7	7.9	3858	322
35+	-1.1	2.5	-1.2	6.2	8935	745

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 the arterial data segments in this validation report.

Table 3 Percent observations meeting data quality criteria for arterial segments in Virginia

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	
0-15	2%	35%	6%	40%	584
15-25	6%	32%	13%	39%	2868
25-35	9%	43%	20%	52%	3858
35+	13%	60%	27%	68%	8935

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 arterial validation segments in the state of Virginia

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	
VA10-0001	2.13	2.13	0-15	-	-	-	-	-
			15-25	-	-	-	-	-
			25-35	-	-	-	-	-
			35+	-8.4	8.4	-14.0	14.0	816
VA10-0002	4.77	4.77	0-15	10.6	12.7	11.0	15.4	8*
			15-25	3.0	3.0	6.6	6.7	83
			25-35	4.2	4.5	9.7	10.3	77
			35+	1.0	1.4	2.8	4.1	274
VA10-0005	2.70	2.70	0-15	-	-	-	-	-
			15-25	-	-	-	-	-
			25-35	11.7	11.7	20.4	20.4	12*
			35+	2.5	3.2	5.4	6.8	698
VA10-0006	0.90	0.90	0-15					
			15-25	21.9	21.9	26.2	26.2	3*
			25-35	5.6	5.6	13.1	13.3	71
			35+	-0.3	1.1	0.1	4.5	1235
VA10-0007	1.97	1.97	0-15	4.2	4.2	5.9	5.9	58
			15-25	7.4	7.5	11.2	11.4	142
			25-35	3.0	3.4	7.5	8.9	339
			35+	-0.9	1.6	-0.4	4.5	142
VA10-0008	0.76	0.76	0-15	10.0	10.0	12.4	12.5	68
			15-25	4.6	4.7	8.5	8.7	841
			25-35	0.2	0.8	1.5	3.9	351
			35+	-2.5	2.5	-9.8	9.8	53
VA10-0009	1.57	1.57	0-15	15.5	15.5	22.4	22.4	6*
			15-25	4.9	5.1	9.7	9.8	42
			25-35	0.7	0.9	2.8	3.7	311
			35+	-1.9	1.9	-4.8	4.8	218
VA10-0010	2.08	2.08	0-15	-	-	-	-	-
			15-25	8.9	9.0	12.8	12.9	70
			25-35	6.7	6.7	11.6	11.7	672
			35+	1.2	1.4	4.4	5.2	521

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

Table 4 (Cont'd)
Data quality measures for individual arterial validation segments in the state of Virginia

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	
VA10-0011	2.15	2.15	0-15	-	-	-	-	-
			15-25	8.8	8.8	20.3	20.8	12*
			25-35	6.1	6.1	10.8	10.8	161
			35+	0.7	1.3	2.4	4.0	1025
VA10-0012	1.49	1.49	0-15	11.0	11.0	18.2	18.2	13*
			15-25	5.4	5.5	9.4	9.5	255
			25-35	1.5	1.9	4.0	5.1	189
			35+	-1.3	1.3	-5.1	5.1	22*
VA10-0013	0.76	0.76	0-15	5.0	5.0	7.6	7.7	392
			15-25	2.5	2.6	5.5	6.4	669
			25-35	-0.8	1.1	-1.4	3.9	164
			35+	-3.6	3.6	-11.8	11.8	13*
VA10-0014	1.98	1.98	0-15	19.4	19.4	22.6	22.6	2*
			15-25	0.0	0.0	10.2	10.2	2*
			25-35	0.1	0.3	-0.2	2.0	23*
			35+	-7.7	7.7	-11.9	11.9	505
VA010-0015	0.90	0.90	0-15	22.7	22.7	34.7	34.7	2*
			15-25	16.4	16.4	25.8	25.8	17*
			25-35	6.8	6.8	15.4	15.4	131
			35+	0.4	1.2	2.9	5.5	1177
VA010-0016	2.69	2.69	0-15	-	-	-	-	-
			15-25	-	-	-	-	-
			25-35	15.9	15.9	19.4	19.4	1*
			35+	1.1	1.8	3.3	5.1	563
VA010-0019	4.84	4.84	0-15	33.6	33.6	34.8	34.8	5*
			15-25	14.2	14.2	24.0	24.0	9*
			25-35	3.2	3.2	14.4	14.4	25*
			35+	-0.9	1.2	-2.0	3.6	334
VA010-0020	2.04	2.04	0-15	-	-	-	-	-
			15-25	-	-	-	-	-
			25-35	1.4	1.6	5.2	5.9	91
			35+	-1.5	1.6	-4.5	4.9	653

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

Table 5
Observations meeting data quality criteria for individual arterial validation segments
in the state of Virginia

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	
VA10-0001	0-15	-	-	-	-	-	-	-	--	-
	15-25	-	-	-	-	-	-	-	--	-
	25-35	-	-	-	-	-	-	-	--	-
	35+	3	0%	25	3%	5	1%	47	6%	816
VA10-0002	0-15	0	0%	4	50%	2	25%	4	50%	8*
	15-25	3	4%	59	71%	3	4%	64	77%	83
	25-35	1	1%	11	14%	3	4%	15	19%	77
	35+	31	11%	197	72%	74	27%	224	82%	274
VA10-0005	0-15	-	-	-	-	-	-	-	--	-
	15-25	-	-	-	-	-	-	-	--	-
	25-35	0	0%	0	0%	0	0%	0	0%	12*
	35+	52	7%	321	46%	110	16%	382	55%	698
VA10-0006	0-15	-	-	-	-	-	-	-	--	-
	15-25	0	0%	0	0%	0	0%	0	0%	3*
	25-35	3	4%	8	11%	6	8%	12	17%	71
	35+	271	22%	934	76%	482	39%	1040	84%	1235
VA10-0007	0-15	1	2%	31	53%	2	3%	33	57%	58
	15-25	8	6%	43	30%	19	13%	47	33%	142
	25-35	24	7%	102	30%	47	14%	144	42%	339
	35+	15	11%	108	76%	41	29%	117	82%	142
VA10-0008	0-15	0	0%	5	7%	2	3%	8	12%	68
	15-25	57	7%	253	30%	110	13%	336	40%	841
	25-35	73	21%	293	83%	142	40%	317	90%	351
	35+	3	6%	25	47%	9	17%	34	64%	53
VA10-0009	0-15	0	0%	0	0%	0	0%	0	0%	6*
	15-25	1	2%	7	17%	1	2%	10	24%	42
	25-35	73	23%	245	79%	128	41%	269	87%	311
	35+	11	5%	149	68%	42	19%	165	76%	218
VA10-0010	0-15	-	-	-	-	-	-	-	--	-
	15-25	2	3%	18	26%	3	4%	20	29%	70
	25-35	17	3%	59	9%	32	5%	76	11%	672
	35+	46	9%	319	61%	94	18%	405	78%	521

*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 arterial validation segments
in the state of Virginia

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	
VA10-0011	0-15	-	-	-	-	-	-	-	-	-
	15-25	0	0%	2	17%	0	0%	2	17%	12*
	25-35	2	1%	9	6%	4	2%	18	11%	161
	35+	152	15%	789	77%	306	30%	875	85%	1025
VA10-0012	0-15	0	0%	0	0%	0	0%	0	0%	13*
	15-25	4	2%	76	30%	20	8%	88	35%	255
	25-35	16	8%	111	59%	40	21%	130	69%	189
	35+	4	18%	16	73%	7	32%	16	73%	22*
VA10-0013	0-15	13	3%	165	42%	30	8%	187	48%	392
	15-25	82	12%	350	52%	173	26%	412	62%	669
	25-35	51	31%	139	85%	84	51%	141	86%	164
	35+	0	0%	3	23%	0	0%	5	38%	13*
VA10-0014	0-15	0	0%	0	0%	0	0%	0	0%	2*
	15-25	0	0%	1	50%	0	0%	2	100%	2*
	25-35	11	48%	23	100%	17	74%	23	100%	23*
	35+	2	0%	39	8%	7	1%	68	13%	505
VA10-0015	0-15	0	0%	0	0%	0	0%	0	0%	2*
	15-25	0	0%	0	0%	0	0%	0	0%	17*
	25-35	1	1%	8	6%	4	3%	9	7%	131
	35+	192	16%	777	66%	405	34%	922	78%	1177
VA10-0016	0-15	-	-	-	-	-	-	-	-	-
	15-25	-	-	-	-	-	-	-	-	-
	25-35	0	0%	0	0%	0	0%	0	0%	1*
	35+	70	12%	371	66%	167	30%	419	74%	563
VA10-0019	0-15	0	0%	0	0%	0	0%	0	0%	5*
	15-25	0	0%	0	0%	0	0%	0	0%	9*
	25-35	0	0%	1	4%	1	4%	7	28%	25*
	35+	50	15%	274	82%	110	33%	289	87%	334
VA10-0020	0-15	-	-	-	-	-	-	-	-	-
	15-25	-	-	-	-	-	-	-	-	-
	25-35	3	3%	64	70%	18	20%	74	81%	91
	35+	120	18%	459	70%	223	34%	510	78%	653

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