I-95 Corridor Coalition

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

Monthly Report: Pennsylvania

I-95 CORRIDOR COALITION

February 2013

I-95 CORRIDOR COALITION VEHICLE PROBE PROJECT VALIDATION OF INRIX DATA FEBRUARY 2013

Monthly Report

Prepared for:

I-95 Corridor Coalition

Sponsored by:

I-95 Corridor Coalition

Prepared by:

Ali Haghani, Masoud Hamedi, Yang Lu, Yashar Aliari Kardedeh
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 Pennsylvania Department of Transportation (PENNDOT) 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 2013

Evaluation Results for the State of Pennsylvania

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 14 different segments along the I-376 corridor in Allegheny County, Pennsylvania. The Bluetooth sensor deployment covers the range from Exit 64A/I-79 to Exit 81/PA-791 along I-376. Travel time data was collected for both directions along portions of the freeway north of the Monongahela River, and in eastbound lanes for portions of the freeway south of the river. The data was collected between December 20, 2012 and January 6, 2013 with the assistance of Pennsylvania Department of Transportation (PennDOT) personnel. The dataset collected represents approximately 1,467 hours of observations along 14 freeway segments, totaling approximately 26 miles. The total number of effective five-minute travel time samples observed was 17,600.

ES Table 1, below, summarizes the results of the comparison between the validation data and the INRIX data for freeway segments during the above noted period. As shown, the average absolute speed error (AASE) and Speed Error Bias (SEB) were within specification for all speed bins. Even when errors are measured against the mean (rather than the SEM band) the data meets contract specifications for the AASE in all speed bins.

ES Table 1 - Pennsylvania Evaluation Summary for Freeway

	Absolute Speed Error (<10mph)		Speed Error Bias (<5mph)		Number of 5 Minute Samples	Hours of Data Collection
Speed Bin	Comparison with SEM Band	Comparison with Mean	Comparison with SEM Band	Comparison with Mean		
0-30 MPH	**3.8**	5.4	**3.3**	4.3	1920	160.0
30-45 MPH	**3.4**	6.2	**2.4**	4.3	2031	169.3
45-60 MPH	**1.4**	3.7	**0.2**	0.9	9258	771.5
>60 MPH	**1.7**	4.4	**-1.5**	-3.4	4391	365.9
All Speeds	1.9	4.3	0.4	0.6	17600	1466.7

Based upon data collected from December 20th, 2012 through January 6th, 2013 across 26.3 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 Pennsylvania was validated on four occasions: January 2010, August 2010, September 2011, and December 2012. These four validations represent more than 5,845 hours of observations along approximately 76 miles of freeway segments in Pennsylvania. ES Table 2 provides a summary of the cumulative validation effort. As shown, the average absolute speed error and speed error bias are within specification for all speed bins even when errors are measured against the mean.

ES Table 2 - Pennsylvania - Cumulative to Date						
	Absolute Speed Error (<10mph)		**Speed Error Bias** (<5mph)			
Speed Bin	Comparison with SEM Band	Comparison with Mean	Comparison with SEM Band	Comparison with Mean	Number of 5 Minute Samples	Hours of Data Collection
0-30 MPH	**4.35**	5.65	**2.93**	3.54	5148	429.0
30-45 MPH	**4.21**	6.61	**2.18**	3.54	3892	324.3
45-60 MPH	**1.73**	3.76	**0.01**	0.63	29191	2432.6
> 60 MPH	**2.17**	4.54	**-1.98**	-3.87	31910	2659.2
All Speeds	2.26	4.41	-0.56	-1.04	70141	5845.1

Data Collection

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 fourteen different segments along the I-376 corridor. The Bluetooth sensor deployment covers the range from Exit 64A/I-79 to Exit 81/PA-791 along I-376 in Allegheny County, Pennsylvania. Travel time data was collected for both directions along portions of the freeway north of the Monongahela River, and in eastbound lanes for portions of the freeway south of the river. The data was collected between December 20, 2012 and January 6, 2013 with the assistance of Pennsylvania Department of Transportation (PennDOT) personnel. This round of data collection in Pennsylvania was designed to capture the traffic data on a primary freeway route accessing downtown Pittsburgh, and which frequently experiences delays during rush hour periods. Traffic on this corridor is constricted due to tunnels. Segment locations were chosen with a high-likelihood of observing recurrent congestion during peak periods.

Figure 1 presents an overview snapshot of the roadway segments over which Bluetooth sensors were deployed along the I-376 corridor in Pennsylvania. Blue segments represent freeway segments selected for analysis.

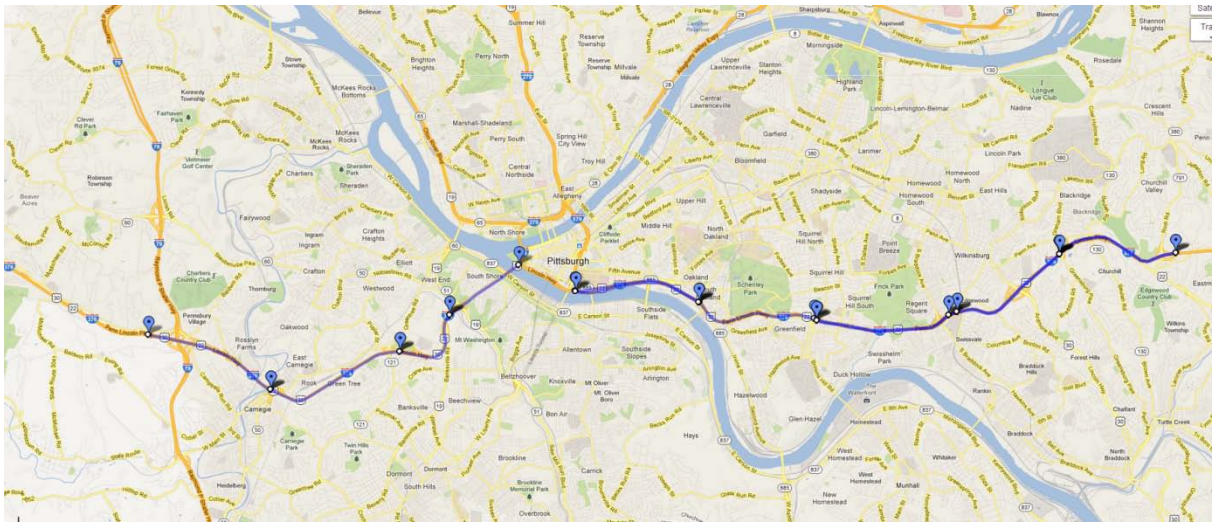

Figure 1 — Locations of all segments selected for analysis in Pennsylvania

TMC segments selected for validation in Pennsylvania

Table 1 presents a list of data collection segments from Pennsylvania. In total, these segments cover a total length of approximately 26 freeway miles. Data collection segments are comprised of one or more Traffic Message Channel (TMC) base segments, such that 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 validation performed on 14 freeway segments are included in this report. Table 1 contains summary information on each data collection segment. The latitude/longitude coordinates of the locations at which the Bluetooth sensors were deployed throughout the state of Pennsylvania 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 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. Details of the algorithm used to estimate equivalent path travel times based on INRIX data feeds for individual data collection segments are provided in a separate report. This algorithm finds an equivalent INRIX travel time (and therefore travel speed) corresponding to each sample BTM travel time observation on the test segment of interest.

Table 1
Segments selected for validation in Pennsylvania

SEGMENT (Map Link)	DESCRIPTION			TMC CODES		Deployment		
	Highway Direction	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-376	Pennsylvania	PA-791/Exit 81	104N04506	6	40.442212	-79.824348	1.84
(PA04-0001)	Westbound	ALLEGHENY	Greensburg Pike/Exit 79A	104-04503	1.9	40.442033	-79.857308	-4.5%
F2	I-376	Pennsylvania	Greensburg Pike/Exit 79A	104N04503	4	40.442033	-79.857308	2.01
(PA04-0002)	Westbound	ALLEGHENY	Braddock Ave/Exit 77	104-04501	1.9	40.429601	-79.885981	8.4%
F3	I-376	Pennsylvania	Braddock Ave/Exit 77	104N04501	2	40.429601	-79.885981	2.23
(PA04-0003)	Westbound	ALLEGHENY	Beechwood Blvd/Exit 74	104-04500	2.2	40.428019	-79.925279	3.4%
F4	I-376	Pennsylvania	Beechwood Blvd/Exit 74	104-04499	4	40.428019	-79.925279	1.88
(PA04-0004)	Westbound	ALLEGHENY	Bates St/Exit 73B	104N04498	1.9	40.431684	-79.958925	-2.9%
F5	I-376	Pennsylvania	Bates St/Exit 73B	104-04496	5	40.431684	-79.958925	2.08
(PA04-0005)	Westbound	ALLEGHENY	Grant St/Exit 71B	104-04494	1.9	40.434107	-79.993888	7.5%
F6	I-376	Pennsylvania	Grant St/Exit 71B	104+04495	5	40.433949	-79.993758	1.88
(PA04-0006)	Eastbound	ALLEGHENY	Bates St/Exit 73B	104+04497	1.9	40.431631	-79.959075	-2.0%
F7	I-376	Pennsylvania	Bates St/Exit 73B	104P04498	4	40.431631	-79.959075	1.79
(PA04-0007)	Eastbound	ALLEGHENY	Beechwood Blvd/Exit 74	104+04500	1.9	40.427906	-79.925595	-7.3%
F8	I-376	Pennsylvania	Beechwood Blvd/Exit 74	104+04501	2	40.427906	-79.925595	2.21
(PA04-0008)	Eastbound	ALLEGHENY	Braddock Ave/Exit 77	104P04501	2.0	40.428904	-79.888405	8.4%
F9	I-376	Pennsylvania	Braddock Ave/Exit 77	104+04502	4	40.428904	-79.888405	1.93
(PA04-0009)	Eastbound	ALLEGHENY	Greensburg Pike /Exit 79A	104P04503	2.0	40.441947	-79.857257	-3.1%

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

SEGMENT (Map Link)	DESCRIPTION			TMC CODES		Deployment		
	Highway	State	Starting at	Begin	Number	Begin Lat/Lon		Length
	Direction	County	Ending at	End	Length	End Lat/Lon		% Diff
FREEWAYS								All Lengths in Miles
F10	I-376	Pennsylvania	Greensburg Pike /Exit 79A	104+04504	6	40.441947	-79.857257	1.88
(PA04-0010)	Eastbound	ALLEGHENY	PA-791/Exit 81	104P04506	2.0	40.442155	-79.82283	-5.6%
F11	I-376	Pennsylvania	I-79/Exit 64A	104P04508	4	40.424631	-80.114198	2.04
(PA04-0011)	Eastbound	ALLEGHENY	Lydia St/Exit 65	104+04510	2.0	40.412895	-80.079691	0.2%
F12	I-376	Pennsylvania	Lydia St/Exit 65	104P04510	5	40.412895	-80.079691	2.12
(PA04-0012)	Eastbound	ALLEGHENY	Greentree Rd/Exit 67	104P04512	2.2	40.421041	-80.043278	-1.5%
F13	I-376	Pennsylvania	Greentree Rd/Exit 67	104+04513	4	40.421041	-80.043278	1.24
(PA04-0013)	Eastbound	ALLEGHENY	US-19/ Exit 69B	104P04514	1.2	40.428925	-80.029242	0.1%
F14	I-376	Pennsylvania	US-19/ Exit 69B	104+04515	8	40.428925	-80.029242	1.21
(PA04-0014)	Eastbound	ALLEGHENY	I-279/ Exit 70A	104P04518	1.2	40.439753	-80.009773	0.8%
TOTALS					63			26.34
					26.3			0.1%

Analysis of Freeway Results

Table 2 summarizes the data quality measures obtained as a result of comparison between Bluetooth and all reported INRIX speeds. Specifications 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, and are highlighted in Table 2. AASE below 10 MPH meets contract specifications. AASE below 5 MPH are considered exceptional quality. As shown, the average absolute speed error (AASE) and Speed Error Bias (SEB) were within specification for all speed bins.

TABLE 2
Data quality measures for freeway segments in Pennsylvania

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	3.3	3.8	4.3	5.4	1920	160
30-45	2.4	3.4	4.3	6.2	2031	169
45-60	0.2	1.4	0.9	3.7	9258	772
60+	-1.5	1.7	-3.4	4.4	4391	366

Table 3 shows the percentage of the time INRIX data falls within 5 mph of the SEM band and the mean for each speed bin for all freeway data segments in Pennsylvania.

Table 3 Percent observations meeting data quality criteria for freeway segments in Pennsylvania

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	29%	78%	0%	68%	1920
30-45	31%	72%	0%	49%	2031
45-60	58%	92%	0%	73%	9258
60+	50%	89%	0%	64%	4391

Tables 4 and 5 present detailed data for individual TMC segments in Pennsylvania 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 small number of observations.

Table 4
Data quality measures for individual freeway validation segments greater than one mile in the state of Pennsylvania

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	
PA04-0001	1.9	1.84	0-30	11.4	11.4	13.0	13.0	18*
			30-45	4.9	4.9	12.9	12.9	6*
			45-60	0.3	0.8	1.5	3.2	412
			60+	-1.2	1.4	-3.5	4.1	376
PA04-0002	1.9	2.01	0-30	2.9	3.5	3.7	5.1	123
			30-45	2.0	4.3	4.3	8.2	63
			45-60	0.4	1.7	1.2	4.1	1000
			60+	-2.3	2.7	-4.3	5.3	200
PA04-0003	2.2	2.23	0-30	3.4	4.1	4.4	5.8	492
			30-45	2.5	3.4	4.2	6.1	392
			45-60	-0.4	1.7	-0.4	4.0	1116
			60+	-5.9	5.9	-9.9	9.9	10
PA04-0004	1.9	1.88	0-30	4.4	5.4	5.4	7.6	32
			30-45	4.4	4.4	8.7	8.7	24*
			45-60	0.3	0.6	1.2	2.6	829
			60+	-1.3	1.4	-3.9	4.3	708
PA04-0005	1.9	2.08	0-30	3.9	4.3	6.5	8.2	121
			30-45	3.4	3.9	8.4	10.8	45
			45-60	0.4	1.0	1.2	3.1	841
			60+	-1.5	1.6	-3.9	4.5	582
PA04-0006	1.9	1.88	0-30	5.1	5.3	6.2	6.7	119
			30-45	2.5	5.1	7.3	11.1	31
			45-60	1.1	1.3	3.5	4.3	480
			60+	-0.3	0.8	-1.0	2.7	365
PA04-0007	1.9	1.79	0-30	2.9	3.0	3.8	4.3	193
			30-45	2.5	5.4	5.5	10.7	40
			45-60	-0.4	1.4	-0.5	4.0	391
			60+	-2.6	2.7	-5.0	5.7	316
PA04-0008	2.0	2.21	0-30	5.6	5.7	6.5	6.7	84
			30-45	4.9	6.0	6.3	8.1	44
			45-60	0.9	1.5	2.1	3.5	628
			60+	-1.1	1.3	-2.8	3.6	214
PA04-0009	2.0	1.93	0-30	1.6	2.0	1.6	3.2	32
			30-45	0.9	2.1	1.2	3.8	64
			45-60	0.3	1.0	1.1	3.4	488
			60+	-1.8	2.2	-4.0	5.1	492

*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 greater than one mile in the state of Pennsylvania

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	
PA04-0010	2.0	1.88	0-30	1.2	1.6	2.8	3.5	29*
			30-45	3.4	4.2	5.0	6.7	24*
			45-60	1.8	2.0	4.4	5.1	289
			60+	-0.1	0.8	-0.3	3.0	195
PA04-0011	2.0	2.04	0-30	3.1	3.2	3.9	4.4	70
			30-45	3.5	3.9	5.8	6.8	53
			45-60	1.1	1.4	3.0	4.0	317
			60+	-0.8	1.0	-2.5	3.5	439
PA04-0012	2.2	2.12	0-30	2.2	2.7	4.0	4.9	109
			30-45	2.7	4.1	6.3	8.6	95
			45-60	0.2	1.2	0.9	3.4	826
			60+	-2.1	2.4	-4.1	5.0	434
PA04-0013	1.2	1.24	0-30	1.6	2.2	2.0	3.3	257
			30-45	2.1	3.0	4.2	5.7	270
			45-60	-0.6	1.7	-1.1	4.1	1077
			60+	-4.4	4.7	-6.5	7.3	60
PA04-0014	1.2	1.21	0-30	3.8	4.3	4.9	5.9	241
			30-45	2.1	3.0	3.5	5.2	880
			45-60	0.1	1.6	0.1	3.9	564
			60+	-	-	-	-	0

*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 greater than one mile in the state of Pennsylvania

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	
PA04-0001	0-30	4	22%	10	56%	0	0%	7	39%	18*
	30-45	1	17%	3	50%	0	0%	1	17%	6*
	45-60	262	64%	402	98%	0	0%	320	78%	412
	60+	200	53%	342	91%	0	0%	249	66%	376
PA04-0002	0-30	39	32%	101	82%	0	0%	89	72%	123
	30-45	17	27%	42	67%	0	0%	19	30%	63
	45-60	539	54%	893	89%	0	0%	678	68%	1000
	60+	68	34%	165	83%	0	0%	106	53%	200
PA04-0003	0-30	138	28%	386	78%	0	0%	348	71%	492
	30-45	121	31%	281	72%	0	0%	187	48%	392
	45-60	568	51%	989	89%	0	0%	775	69%	1116
	60+	1	10%	4	40%	0	0%	0	0%	10*
PA04-0004	0-30	10	31%	24	75%	0	0%	18	56%	32*
	30-45	8	33%	15	63%	0	0%	8	33%	24*
	45-60	608	73%	808	97%	0	0%	715	86%	829
	60+	359	51%	653	92%	1	0%	447	63%	708
PA04-0005	0-30	57	47%	91	75%	0	0%	67	55%	121
	30-45	19	42%	30	67%	0	0%	12	27%	45
	45-60	561	67%	794	94%	0	0%	670	80%	841
	60+	303	52%	525	90%	0	0%	380	65%	582
PA04-0006	0-30	20	17%	66	55%	0	0%	59	50%	119
	30-45	7	23%	19	61%	0	0%	8	26%	31
	45-60	271	56%	446	93%	0	0%	325	68%	480
	60+	244	67%	355	97%	0	0%	310	85%	365
PA04-0007	0-30	57	30%	161	83%	0	0%	148	77%	193
	30-45	11	28%	26	65%	0	0%	13	33%	40
	45-60	241	62%	357	91%	0	0%	280	72%	391
	60+	123	39%	252	80%	0	0%	149	47%	316
PA04-0008	0-30	13	15%	53	63%	0	0%	48	57%	84
	30-45	5	11%	23	52%	0	0%	16	36%	44
	45-60	331	53%	568	90%	0	0%	477	76%	628
	60+	116	54%	199	93%	0	0%	157	73%	214

*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 greater than one mile in the state of Pennsylvania

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	
PA04-0009	0-30	16	50%	28	88%	0	0%	27	84%	32
	30-45	26	41%	54	84%	0	0%	45	70%	64
	45-60	314	64%	459	94%	0	0%	375	77%	488
	60+	209	42%	416	85%	0	0%	287	58%	492
PA04-0010	0-30	14	48%	26	90%	0	0%	22	76%	29*
	30-45	8	33%	16	67%	0	0%	11	46%	24*
	45-60	126	44%	249	86%	0	0%	152	53%	289
	60+	132	68%	191	98%	0	0%	160	82%	195
PA04-0011	0-30	25	36%	56	80%	0	0%	54	77%	70
	30-45	16	30%	36	68%	0	0%	27	51%	53
	45-60	180	57%	285	90%	0	0%	216	68%	317
	60+	283	64%	416	95%	0	0%	329	75%	439
PA04-0012	0-30	31	28%	89	82%	0	0%	77	71%	109
	30-45	27	28%	63	66%	0	0%	40	42%	95
	45-60	487	59%	773	94%	0	0%	635	77%	826
	60+	144	33%	363	84%	0	0%	235	54%	434
PA04-0013	0-30	73	28%	223	87%	0	0%	210	82%	257
	30-45	88	33%	207	77%	0	0%	143	53%	270
	45-60	529	49%	955	89%	0	0%	727	68%	1077
	60+	14	23%	33	55%	0	0%	21	35%	60
PA04-0014	0-30	55	23%	174	72%	0	0%	141	59%	241
	30-45	284	32%	657	75%	1	0%	472	54%	880
	45-60	306	54%	504	89%	0	0%	423	75%	564
	60+	-	-	-	-	-	-	-	-	0

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