I-95 Corridor Coalition
Vehicle Probe Project:
HERE, INRIX and TOMTOM
Data Validation

Report for Virginia (#11)
US-50

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Executive Summary

Wireless re-identification traffic monitoring (WRTM) data is collected to validate data from Vehicle Probe Project. WRTM data includes Bluetooth, Wi-Fi and other wireless traffic monitoring devices that collect signals emitted by in-vehicle electronic equipment. The specific device type used for each validation, will be determined based upon applicability and will be defined in the report. The validation of arterial data is similar to that of freeway data, however 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. Specifications used for comparison include the Average Absolute Speed Error (AASE) and the Speed Error Bias (SEB).

- Wi-Fi re-identification sensors were deployed at the beginning and ending points of 38 different segments along the US-50 corridor from George Mason Dr. to Lees Corner Rd (Refer to Figure 1 below).
- Travel time data was collected for both directions along the arterial, between September 26 and October 7, 2016.
- The dataset collected represents approximately 4,823 hours of observations along 38 arterial segments, totaling approximately 35 miles.
- The total number of effective five-minute travel time samples observed was 57,877.
- Due to data quality considerations, 7 segments were dropped from final validation.
- Although the data are compared to the contract specifications, as noted below, caution should be used when using probe data on arterial roadways. Other factors including signal density and traffic volume should be considered.
- 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.

ES Table 1 provides a summary description of the study corridor.

ES Table 1– US-50 Arterial Description

Number of Lanes	Avg. Signal Density	AADT	Speed Limit
2 and 3 per direction	3.3 per mile	52,885	45 mph

ES Table 2, 3 and 4 below summarizes the results of the comparison between the WRTM reference data and the probe data from each vendor for arterial segments during the above noted time period.

ES Table 2- HERE Arterial Evaluation Summary for Virginia					
Speed Bin	**Average Absolute Speed Error (<10mph)**		**Speed Error Bias (<5mph)**		Number of 5 Minute Samples
	Comparison with SEM Band	Comparison with Mean	Comparison with SEM Band	Comparison with Mean	
0-15 MPH	2.9	5.0	2.8	4.6	5367
15-25 MPH	2.4	6.3	2.3	5.2	15029
25-35 MPH	1.2	5.2	0.5	2.0	18990
>35 MPH	1.8	5.8	-1.6	-3.8	18491
All Speeds	1.9	5.7	0.5	1.2	57877
Based upon data collected from September 26, through October 7, 2016 across 35 miles of roadway.					

- As shown for HERE data in ES Table 2, 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 when compared with the Standard Error of the Mean (SEM) Band.

ES Table 3- INRIX Arterial Evaluation Summary for Virginia					
Speed Bin	**Average Absolute Speed Error (<10mph)**		**Speed Error Bias (<5mph)**		Number of 5 Minute Samples
	Comparison with SEM Band	Comparison with Mean	Comparison with SEM Band	Comparison with Mean	
0-15 MPH	4.6	6.9	4.6	6.7	5367
15-25 MPH	3.4	7.5	3.2	6.2	15029
25-35 MPH	2.0	6.6	0.9	2.5	18990
>35 MPH	2.4	6.7	-1.8	-3.4	18491
All Speeds	2.7	6.9	1.0	2.0	57877
Based upon data collected from September 26, through October 7, 2016 across 35 miles of roadway.					

- As shown for INRIX data in ES Table 3, 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 when compared with the Standard Error of the Mean (SEM) Band.

ES Table 4- TOMTOM Arterial Evaluation Summary for Virginia					
Speed Bin	**Average Absolute Speed Error (<10mph)**		**Speed Error Bias (<5mph)**		Number of 5 Minute Samples
	Comparison with SEM Band	Comparison with Mean	Comparison with SEM Band	Comparison with Mean	
0-15 MPH	4.1	6.4	4.1	6.3	5367
15-25 MPH	4.2	8.5	4.1	7.9	15029
25-35 MPH	1.9	6.6	1.4	4.0	18990
>35 MPH	1.9	5.9	-1.5	-3.0	18491
All Speeds	2.7	6.9	1.4	3.0	57877
Based upon data collected from September 26, through October 7, 2016 across 35 miles of roadway.					

- As shown for TOMTOM data in ES Table 4, 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 when compared with the Standard Error of the Mean (SEM) Band.

Methodology

Corridor Description and Data Collection

Travel time samples were collected along 38 arterial segments with the assistance of Virginia Department of Transportation (VDOT) personnel. Arterial segments studied were located on the US-50 corridor from George Mason Dr. to Lees Corner Rd. Travel time data was collected for both directions along the US-50 arterial between September 26 and October 7, 2016. Segment locations were chosen with a high-likelihood of observing recurrent and non-recurrent congestion during peak and off-peak periods.

Figure 1 present an overview snapshot of the placement of sensors for the collection of data on the US-50 corridor in Virginia. Blue segments represent arterial segments selected for analysis.

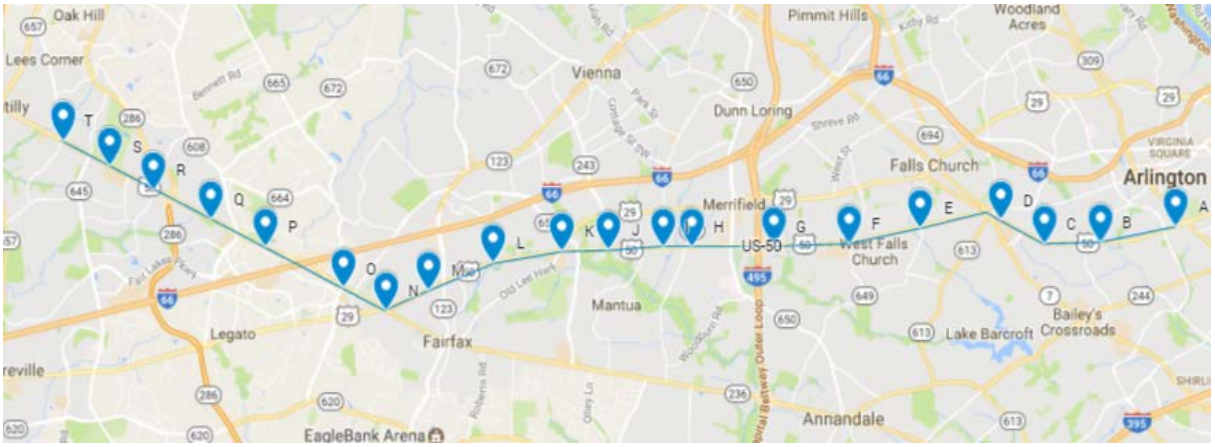

Figure 1- Locations of all segments selected on US-50 for analysis in Virginia

TMC segments selected for validation in Virginia

Table 1 presents the data collection segments from Virginia. As a whole, these segments cover a total length of 35 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, in most cases, one mile 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 38 directional arterial 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 WRTM sensors were deployed along the US-50 in Virginia 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 WRTM sensor covers both data collection segments.

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 probe data feeds for individual data collection segments are provided in this separate report. This algorithm finds an equivalent probe travel time (and therefore travel speed) corresponding to each sample WRTM 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 Virginia

Segment (Map Link)	DESCRIPTION							Deployment		Notes
	Highway / Direction	Starting at / Ending at	Lane (Min) / Lane (Max)	AADT (Min) / AADT (Max)	Signals / Signal/mile	Access Points / Speed Limit	Median / Major Junction	Begin Lat/Lon / End Lat/Lon	Length (mile)	
Arterial										
A1	US-50	George Mason Dr	3	56564	3	6	Partial	110P05723	1.18	Signalized intersections: Henderson Rd, Park Dr, Edison St.
VA11-0001	Westbound	Carlin Springs Rd	3	56564	2.5	45	0	110+05724		
A2	US-50	Carlin Springs Rd	3	50662	3	2	Partial	110P05724	0.85	Signalized intersections: Manchester St, Montague St (No turn), Olin Dr.
VA11-0002	Westbound	Olin Dr	3	56564	3.5	45	0	110+05725		
A3	US-50	Olin Dr	2	50662	1	5	Yes	110+05725	0.74	Signalized intersection: Patrick Henry Dr. Major junction with Leesburg pike
VA11-0003	Westbound	VA-7	3	50662	1.4	45	1	110+05725		
A4	US-50	VA-7	2	50479	2	4	Yes	110+05725	1.2	Signalized intersections: Cherry St, and Annandale Rd
VA11-0004	Westbound	Annandale Rd	2	50662	1.6	45	0	110P05726		
A5	US-50	Annandale Rd	2	50479	1	6	Yes	110+05727	1.11	Signalized intersections with Graham Rd at end.
VA11-0005	Westbound	Graham Rd	2	50479	0.9	45	0	110+05727		
A6	US-50	Graham Rd	2	50479	3	6	Yes	110+05728	1.14	Signalized intersections: Allen St, Jaguar Tr. Major Junction with Fairview Park and I-495
VA11-0006	Westbound	I-495	3	50479	2.6	45	2	110+05730		
A7	US-50	I-495	2	41490	3	6	Yes	110+05730	1.24	Signalized intersections with Williams Dr and Javier Rd.
VA11-0007	Westbound	Prosperity Ave	3	50479	2.4	45	0	110+05732		
A8	US-50	Prosperity Ave	2	41490	2	0	Yes	110P05732	0.43	Signalized intersections with Prosperity Ave and Cedar Ln
VA11-0008	Westbound	Cedar Ln	2	41490	4.7	45	0	110+05733		
A9	US-50	Cedar Ln	2	41490	3	3	Yes	110+05734	0.83	Signalized intersections with Barkley Dr, Covington St and Nutley St.
VA11-0009	Westbound	Nutley St	2	41490	3.6	45	0	110+05734		
A10	US-50	Nutley St	2	34041	3	3	Yes	110+05735	0.70	Signalized intersections with Stonehurst Dr, Blake Ln and US-29 at end.
VA11-0010	Westbound	Old Lee Hwy	2	41490	4.3	35	0	110P05736		
A11	US-50	Old Lee Hwy	3	38630	5	6	Yes	110P05736	1.04	Signalized intersections: US-29, Draper Dr, Rebel Run, Stafford Dr, Plantation Pkwy.
VA11-0011	Westbound	Plantation Hwy	3	40719	4.8	35	0	110+05738		

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

Segment (Map Link)	DESCRIPTION							Deployment		Notes
	Highway Direction	Starting at Ending at	Lane (Min) Lane (Max)	AADT (Min) AADT (Max)	Signals Signal/mile	Access Points Speed Limit	Median Major Junction	Begin Lat/Lon End Lat/Lon	Length (mile)	
Arterial										
A12	US-50	Plantation Hwy	2	33977	5	5	Partial	110+05738	1.05	Signalized intersections: Blvd Market Place, Eaton Pl, University Dr, Chian Bridge Rd , McLean Ave.
VA11-0012	Westbound	McLean Ave	3	38852	4.8	35	0	110+05739		
A13	US-50	McLean Ave	2	35153	4	1	No	110+05739	0.7	Signalized intersections with Meredith Dr, Fairchester Dr and Main St at end.
VA11-0013	Westbound	Lee Hwy	2	35153	5.7	35	0	110+05739		
A14	US-50	Lee Hwy	2	35153	3	5	Yes	110+05741	0.70	Signalized intersections with Bevan Dr, Jermantown Rd and Waple Mill Rd at end.
VA11-0014	Westbound	Waples Mill Rd	3	57871	4.3	35	0	110+05741		
A15	US-50	Waples Mill Rd	1	57871	0	5	Yes	110P05741	1.33	Major Junction with 66 W and Fair Oak Shopping Center.
VA11-0015	Westbound	Ox Rd	3	92847	0.0	55	3	110+05743		
A16	US-50	Ox Rd	3	69843	3	5	Yes	110+05743	0.91	Two signalized intersection with Fair Ridge Dr. Major Junction with West Ox Rd.
VA11-0016	Westbound	Fair Ridge Dr	3	92847	3.3	45	1	110+05744		
A17	US-50	Fair Ridge Dr	3	69843	2	5	Yes	110+05744	0.95	Signalized intersections with Alder Woods Dr and Rugby Rd.
VA11-0017	Westbound	Middle Ridge Dr	3	70531	2.1	45	0	110+05745		
A18	US-50	Middle Ridge Dr	3	70531	3	1	Yes	110+05745	0.74	Signalized intersections with Highland Oaks Dr, Muirfield Ln and Plaza Ln.
VA11-0018	Westbound	Plaza Ln	3	70531	4.1	45	0	110+05745		
A19	US-50	Plaza Ln	3	70531	2	0	Yes	110+05745	0.79	Signalized intersections with Stringfellow Rd and Lees Corner Rd.
VA11-0019	Westbound	Lees Corner Rd	3	70531	2.5	45	0	110+05746		
A20	US-50	Lees Corner Rd	3	70531	2	0	Yes	110-05745	0.79	Signalized intersections with Stringfellow Rd and Plaza Ln at end.
VA11-0020	Eastbound	Plaza Ln	3	70531	2.5	45	0	110-05744		
A21	US-50	Plaza Ln	3	70531	3	1	Yes	110-05744	0.74	Signalized intersections with Greenbriar, Majestic Ln and Middle Ridge Dr.
VA11-0021	Eastbound	Middle Ridge Dr	3	70531	4.1	45	0	110-05744		
A22	US-50	Middle Ridge Dr	3	69843	2	2	Yes	110-05744	0.96	Signalized intersections with Doorforth Dr and Fair Ridge Dr.
VA11-0022	Eastbound	Fair Ridge Dr	3	70531	2.1	45	0	110-05743		

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

Segment (Map Link)	DESCRIPTION							Deployment		Notes
	Highway / Direction	Starting at / Ending at	Lane (Min) / Lane (Max)	AADT (Min) / AADT (Max)	Signals / Signal/mile	Access Points / Speed Limit	Median / Major Junction	Begin Lat/Lon / End Lat/Lon	Length (mile)	
Arterial										
A23	US-50	Fair Ridge Dr	3	69843	1	5	Yes	110-05743	0.90	Second signalized intersection with Fair Ridge Dr. Speed limit change from 45 to 55.
VA11-0023	Eastbound	I-66	3	92847	1.1	55	0	110-05742		
A24	US-50	I-66	2	57871	1	5	Yes	110-05742	1.30	Signalized intersection with Waple Mill Rd. Major Junction with I-66 E and W
VA11-0024	Eastbound	Waples Mill Rd	3	92847	0.8	55	2	110N05741		
A25	US-50	Waples Mill Rd	2	35153	3	4	Yes	110-05740	0.70	Signalized intersection with Jermantown Rd, Baven Dr and Lee Hwy.
VA11-0025	Eastbound	Lee Hwy	2	57871	4.3	35	0	110N05740		
A26	US-50	Lee Hwy	2	35153	4	5	No	110N05739	0.70	Signalized intersection with Walnut St, Oak St and Mclean Ave.
VA11-0026	Eastbound	McLean Ave	2	35153	5.7	35	0	110-05738		
A27	US-50	McLean Ave	2	33977	5	8	Partial	110-05738	1.05	Signalized intersections: Chain Bridge Rd, University Dr, Eaton Pl, Blvd Market Place, Plantation Pkwy.
VA11-0027	Eastbound	Plantation Hwy	3	38852	4.8	35	0	110-05737		
A28	US-50	Plantation Hwy	2	38630	5	7	Yes	110-05737	1.03	Signalized intersection with Stafford Dr, rebel Run, Draper Dr, US-29 and Old Lee Hwy.
VA11-0028	Eastbound	Old Lee Hwy	3	40719	4.9	35	0	110N05736		
A29	US-50	Old Lee Hwy	2	34041	3	3	Yes	110N05736	0.70	Signalized intersections with Pickett Rd, Stinehurst Dr and Nutley St. Speed limit change to 45.
VA11-0029	Eastbound	Nutley St	3	41490	4.3	45	0	110-05734		
A30	US-50	Nutley St	2	41490	3	3	Yes	110-05733	0.83	Signalized intersections with Covington St, Barkley Dr and Cedar Ln.
VA11-0030	Eastbound	Cedar Ln	2	41490	3.6	45	0	110-05733		
A31	US-50	Cedar Ln	2	41490	1	0	Yes	110-05732	0.41	Signalized intersection with Prosperity Ave.
VA11-0031	Eastbound	Prosperity Ave	3	41490	2.4	45	0	110N05732		
A32	US-50	Prosperity Ave	3	41490	3	6	Yes	110-05731	1.28	Signalized intersections: Javier Rd, Williams Dr. Major Junctions with Gallowes Rd and I-495 N and S.
VA11-0032	Eastbound	Fairview Park Dr	4	50479	2.3	45	3	110-05729		
A33	US-50	Fairview Park Dr	3	50479	4	4	Yes	110-05729	1.13	Signalized intersections with Allen St, Jaguar Tr and Graham Rd. Major Junction with Fairview Park.
VA11-0033	Eastbound	Graham Rd	3	50479	3.5	45	1	110-05727		

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

Segment (Map Link)	DESCRIPTION							Deployment		Notes
	Highway / Direction	Starting at / Ending at	Lane (Min) / Lane (Max)	AADT (Min) / AADT (Max)	Signals / Signal/mile	Access Points / Speed Limit	Median / Major Junction	Begin Lat/Lon / End Lat/Lon	Length (mile)	
Arterial										
A34	US-50	Graham Rd	2	50479	2	6	Yes	110-05726	1.11	Signalized intersections with Woodley Ln and Annandale Rd.
VA11-0034	Eastbound	Annandale Rd	2	50479	1.8	45	0	110-05726		
A35	US-50	Annandale Rd	2	50479	1	7	Yes	110N05726	1.22	Signalized intersection with Cherry St.
VA11-0035	Eastbound	VA-7	2	50662	0.8	45	0	110-05724		
A36	US-50	VA-7	2	50662	1	1	Yes	110-05724	0.74	Signalized intersection with Patrick Henry Dr.
VA11-0036	Eastbound	Olin Dr	3	50662	1.4	45	0	110-05724		
A37	US-50	Olin Dr	3	50662	2	2	Yes	110-05724	0.83	Signalized intersection with Manchester St.
VA11-0037	Eastbound	Carlin Springs Rd	3	56564	2.4	45	0	110N05724		
A38	US-50	Carlin Springs Rd	3	56564	3	4	Yes	110-05723	1.20	Signalized intersections with Edison St, Park Dr and Henderson Rd.
VA11-0038	Eastbound	George Mason Dr	3	56564	2.5	45	0	110N05723		

Analysis of Arterials

Following sections summarizes the data quality measures obtained as a result of comparison between WRTM and all reported probe 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: 0-15 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 WRTM 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 bins have proven to be the critical specification (and most difficult) to attain. It is important to consider that the weather ranged from rain to heavy rain during the data collection[2].

[2] The ground-truth data collected for this report as well as detailed daily comparison graphs for all segments are available for download upon request. Please email masoud@umd.edu for such inquiries.

RESULTS

Analysis of Arterial Results for HERE Data

Table 2 shows the results of the comparison between the WRTM reference data and the HERE data. As stated before, 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 when compared with the Standard Error of the Mean (SEM) Band.

Table 2- HERE Data quality measures for arterial segments in Virginia

Speed Bin	Average Absolute Speed Error (<10mph)		Speed Error Bias (<5mph)		Number of 5 Minute Samples
	Comparison with SEM Band	Comparison with Mean	Comparison with SEM Band	Comparison with Mean	
0-15 MPH	2.90	5.00	2.80	4.61	5367
15-25 MPH	2.44	6.32	2.25	5.23	15029
25-35 MPH	1.17	5.24	0.47	2.01	18990
>35 MPH	1.82	5.76	-1.63	-3.78	18491
All Speeds	1.9	5.7	0.5	1.2	57877
Based upon data collected from September 26, through October 7, 2016 across 35 miles of roadway.					

Table 3 shows the percentage of the time the HERE data falls within 5 mph of the SEM band and the mean for each speed bin for all arterial data segments in this validation report.

Table 3- Percent observations meeting HERE data

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	30%	78%	0%	61%	5367
15-25	48%	80%	0%	47%	15029
25-35	66%	92%	0%	54%	18990
35+	61%	86%	0%	53%	18491

Analysis of Arterial Results for INRIX Data

Table 4 shows the results of the comparison between the WRTM reference data and the INRIX data. As stated before, 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 when compared with the Standard Error of the Mean (SEM) Band.

Table 4- INRIX Data quality measures for arterial segments in Virginia

Speed Bin	Average Absolute Speed Error (<10mph)		Speed Error Bias (<5mph)		Number of 5 Minute Samples
	Comparison with SEM Band	Comparison with Mean	Comparison with SEM Band	Comparison with Mean	
0-15 MPH	4.6	6.9	4.6	6.7	5367
15-25 MPH	3.4	7.5	3.2	6.2	15029
25-35 MPH	2.0	6.6	0.9	2.5	18990
>35 MPH	2.4	6.7	-1.8	-3.4	18491
All Speeds	2.7	6.9	1.0	2.0	57877
Based upon data collected from September 26, through October 7, 2016 across 35 miles of roadway.					

Table 5 shows the percentage of the time the INRIX data falls within 5 mph of the SEM band and the mean for each speed bin for all arterial data segments in this validation report.

Table 5- Percent observations meeting INRIX 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	17%	62%	0%	41%	5367
15-25	41%	71%	0%	40%	15029
25-35	56%	84%	0%	44%	18990
35+	56%	81%	0%	47%	18491

Analysis of Arterial Results for TOMTOM Data

Table 6 shows the results of the comparison between the WRTM reference data and the TOMTOM data. As stated before, 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 when compared with the Standard Error of the Mean (SEM) Band.

Table 6- TOMTOM Data quality measures for arterial segments in Virginia

Speed Bin	Average Absolute Speed Error (<10mph)		Speed Error Bias (<5mph)		Number of 5 Minute Samples
	Comparison with SEM Band	Comparison with Mean	Comparison with SEM Band	Comparison with Mean	
0-15 MPH	4.1	6.4	4.1	6.3	5367
15-25 MPH	4.2	8.5	4.1	7.9	15029
25-35 MPH	1.9	6.6	1.4	4.0	18990
>35 MPH	1.9	5.9	-1.5	-3.0	18491
All Speeds	2.7	6.9	1.4	3.0	57877
Based upon data collected from September 26, through October 7, 2016 across 35 miles of roadway.					

Table 7 shows the percentage of the time the TOMTOM data falls within 5 mph of the SEM band and the mean for each speed bin for all arterial data segments in this validation report.

Table 7- Percent observations meeting TOMTOM 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	20%	67%	0%	48%	5367
15-25	36%	65%	0%	33%	15029
25-35	55%	84%	0%	41%	18990
35+	60%	85%	0%	55%	18491

APPENDIX

Table A.1 to A.3 presents detailed data for individual TMC segments in this validation for all three vendors. 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 A. 1
HERE data quality measures for individual arterial validation segments in the state of Virginia

Path	Standard TMC length	Sensor 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	
VA11-0001	1.15	1.15	0-15	-	-	-	-	-
			15-25	1.6	1.6	3.2	3.2	6*
			25-35	0.9	1.2	3.2	4.4	336
			35+	-1.1	1.2	-3.4	4.7	1548
VA11-0002	0.85	0.85	0-15	1.7	1.7	2.7	2.7	9*
			15-25	2.4	2.9	4.6	6.4	218
			25-35	0.1	1.0	2.0	5.0	985
			35+	-2.7	2.7	-6.2	6.7	630
VA11-0003	0.74	0.74	0-15	5.0	5.0	7.1	7.2	258
			15-25	3.4	3.5	8.3	8.7	710
			25-35	0.3	0.5	3.6	5.2	408
			35+	-2.0	2.0	-6.3	6.8	230
VA11-0004	1.22	1.22	0-15	1.3	1.3	2.5	2.9	272
			15-25	0.8	1.0	4.4	5.5	297
			25-35	-0.1	0.6	-0.1	3.8	554
			35+	-3.2	3.2	-7.4	7.7	190
VA11-0005	1.11	1.11	0-15	2.1	2.3	3.3	3.8	256
			15-25	3.6	3.7	8.4	8.7	821
			25-35	1.0	1.3	4.3	5.7	675
			35+	-1.1	1.5	-2.4	4.2	71
VA11-0006	1.14	1.14	0-15	2.3	2.3	4.8	4.8	26*
			15-25	2.0	2.1	5.5	6.2	414
			25-35	0.5	0.6	1.6	4.0	810
			35+	-2.1	2.1	-7.6	8.0	324
VA11-0007	1.24	1.24	0-15	3.1	3.2	4.5	5.0	184
			15-25	4.5	4.7	8.0	8.4	84
			25-35	1.1	1.6	4.1	5.6	214
			35+	-0.6	1.0	-3.0	5.0	133
VA11-0009	0.83	0.83	0-15	0.6	1.0	0.9	2.0	52
			15-25	0.4	1.1	0.9	3.3	100
			25-35	0.1	1.1	0.9	4.5	347
			35+	-2.2	2.2	-5.6	6.2	1191
VA11-0010	0.7	0.7	0-15	2.7	2.7	4.9	5.0	230
			15-25	1.7	1.8	5.3	5.9	447
			25-35	-0.2	0.3	-1.4	4.7	285
			35+	-3.6	3.7	-10.9	11.1	102
VA11-0011	1.04	1.04	0-15	1.9	1.9	2.8	5.5	18*
			15-25	-0.4	1.1	-0.3	4.5	201
			25-35	-1.6	1.6	-6.2	6.4	769
			35+	-6.1	6.1	-13.3	13.3	334

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

Table A.1 (Cont'd)
HERE data quality measures for individual arterial validation segments in the state of Virginia

Path	Standard TMC length	Sensor 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	
VA11-012	1.05	1.05	0-15	3.1	3.1	4.3	4.4	297
			15-25	0.8	1.0	2.3	3.6	756
			25-35	-0.8	0.8	-3.0	3.7	101
			35+	-4.1	4.1	-7.1	7.1	1*
VA11-0013	0.7	0.7	0-15	1.3	1.4	2.6	3.0	523
			15-25	-0.6	0.9	-1.9	3.8	560
			25-35	-2.6	2.6	-7.5	7.6	129
			35+	-7.0	7.0	-14.0	14.0	9*
VA11-0014	0.7	0.7	0-15	3.9	3.9	7.7	7.7	497
			15-25	0.8	0.9	3.1	4.7	754
			25-35	-2.3	2.4	-5.4	6.7	66
			35+	-7.0	7.0	-11.7	11.7	9*
VA11-0015	1.33	1.33	0-15	-	-	-	-	-
			15-25	6.3	6.3	19.2	19.2	15*
			25-35	2.0	2.0	9.3	9.3	261
			35+	-0.2	0.8	0.5	4.2	1103
VA11-0016	0.91	0.91	0-15	-	-	-	-	-
			15-25	13.2	13.2	16.7	16.7	24*
			25-35	3.7	3.7	9.9	10.0	446
			35+	0.0	0.7	1.2	4.4	1656
VA11-0017	0.95	0.95	0-15	5.2	5.2	7.4	7.4	1*
			15-25	2.2	2.2	5.8	6.0	71
			25-35	0.6	0.7	3.1	4.7	623
			35+	-1.5	1.6	-5.2	6.4	1426
VA11-0018	0.74	0.74	0-15	2.8	2.8	4.7	5.0	34
			15-25	2.2	2.3	5.7	6.4	470
			25-35	0.5	1.0	2.3	4.9	1121
			35+	-1.3	1.7	-2.9	5.5	505
VA11-0019	0.79	0.79	0-15	4.2	4.4	5.1	5.6	58
			15-25	3.7	3.7	6.9	7.0	836
			25-35	1.4	1.4	4.4	5.3	891
			35+	-0.5	0.7	-1.3	3.7	299
VA11-0020	0.79	0.79	0-15	4.2	4.2	6.3	6.3	145
			15-25	3.4	3.4	7.3	7.7	775
			25-35	0.9	1.3	4.0	5.6	891
			35+	-1.1	1.2	-2.2	4.2	327
VA11-0022	0.96	0.96	0-15	14.3	14.3	16.5	16.5	1*
			15-25	4.7	4.7	9.1	9.1	22*
			25-35	0.1	1.0	1.5	4.4	390
			35+	-2.9	2.9	-6.5	7.1	1593
VA11-0023	0.9	0.9	0-15	1.0	1.2	1.5	2.1	26*
			15-25	3.2	4.4	5.4	8.4	33
			25-35	2.6	2.8	8.1	8.7	300
			35+	-0.9	1.1	-1.6	4.3	1635

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

Table A.1 (Cont'd)
HERE data quality measures for individual arterial validation segments in the state of Virginia

Path	Standard TMC length	Sensor 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	
VA11-0024	1.31	1.31	0-15	2.7	2.7	4.4	4.9	160
			15-25	2.9	3.1	6.4	7.7	147
			25-35	1.2	1.3	5.8	6.5	481
			35+	-0.6	1.1	-1.6	5.0	632
VA11-0025	0.69	0.69	0-15	1.6	1.7	3.9	4.1	700
			15-25	0.4	0.7	0.7	3.3	513
			25-35	-1.7	1.8	-4.7	5.5	49
			35+	-5.4	5.4	-15.1	15.1	2*
VA11-0026	0.7	0.7	0-15	3.0	3.0	6.3	6.5	235
			15-25	0.4	0.6	1.9	4.3	751
			25-35	-1.2	1.2	-5.0	5.6	182
			35+	-8.1	8.1	-12.7	12.7	20*
VA11-0027	1.05	1.05	0-15	5.1	5.1	8.2	8.3	34
			15-25	0.8	1.1	2.7	3.7	867
			25-35	-0.6	0.6	-2.8	3.4	218
			35+	-7.0	7.0	-9.7	9.7	13*
VA11-0028	1.03	1.03	0-15	8.4	8.4	11.0	11.0	52
			15-25	0.7	0.8	2.6	3.4	352
			25-35	-1.2	1.2	-4.0	4.4	972
			35+	-6.2	6.2	-10.7	10.7	78
VA11-0029	0.7	0.7	0-15	1.6	2.3	2.2	4.1	107
			15-25	1.1	1.2	3.3	4.7	673
			25-35	-0.3	0.6	-2.8	4.9	463
			35+	-4.1	4.1	-10.5	10.8	108
VA11-0030	0.83	0.83	0-15	1.7	2.0	2.2	2.8	140
			15-25	3.1	3.2	7.4	8.0	338
			25-35	0.7	1.1	2.6	4.7	1112
			35+	-1.5	1.7	-3.5	4.8	182
VA11-0032	1.23	1.23	0-15	-	-	-	-	-
			15-25	2.7	2.7	9.7	9.7	10*
			25-35	0.8	0.9	2.4	4.1	206
			35+	-3.9	3.9	-8.2	8.9	542
VA11-0033	1.13	1.13	0-15	2.9	2.9	4.2	4.6	129
			15-25	2.8	2.9	5.2	5.6	894
			25-35	0.6	1.0	1.6	4.0	899
			35+	-1.3	1.5	-3.7	5.0	100
VA11-0034	1.11	1.11	0-15	1.7	1.8	2.4	3.1	427
			15-25	2.6	2.8	6.4	6.9	695
			25-35	0.6	0.9	2.8	4.9	725
			35+	-1.0	1.1	-2.4	4.3	144
VA11-0035	1.22	1.22	0-15	5.0	5.1	7.6	7.9	43
			15-25	3.0	3.0	9.6	9.9	408
			25-35	0.5	0.9	3.3	5.0	908
			35+	-1.8	1.8	-3.5	4.4	184

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

Table A.1 (Cont'd)
HERE data quality measures for individual arterial validation segments in the state of Virginia

Path	Standard TMC length	Sensor 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	
VA11-0036	0.74	0.74	0-15	6.2	6.4	8.3	8.8	89
			15-25	4.8	4.8	9.5	9.7	922
			25-35	1.0	1.0	5.0	5.8	512
			35+	-1.3	1.3	-3.5	4.8	126
VA11-0037	0.83	0.83	0-15	1.0	1.8	1.2	2.7	48
			15-25	1.0	1.7	3.2	4.7	136
			25-35	0.0	0.6	0.4	4.6	728
			35+	-3.5	3.5	-7.9	8.2	891
VA11-0038	1.2	1.2	0-15	0.3	1.8	0.2	2.4	82
			15-25	1.3	2.6	1.7	4.4	48
			25-35	1.7	2.1	5.0	5.8	181
			35+	-1.0	1.3	-2.4	4.6	1690

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

Table A.2 presents detailed data for individual TMC segments for INRIX. 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 A. 2
INRIX data quality measures for individual arterial validation segments in the state of Virginia

Path	Standard TMC length	Sensor 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	
VA11-0001	1.15	1.15	0-15	-	-	-	-	-
			15-25	-	-	-	-	-
			25-35	1.3	2.3	3.9	7.0	42
			35+	-1.7	2.1	-3.6	6.6	146
VA11-0002	0.85	0.85	0-15	-	-	-	-	-
			15-25	2.2	2.2	4.0	5.2	19*
			25-35	-0.5	1.8	-1.3	6.6	99
			35+	-3.9	3.9	-8.1	9.0	67
VA11-0003	0.74	0.74	0-15	8.8	8.8	10.7	10.7	24*
			15-25	2.3	2.4	6.5	7.4	76
			25-35	0.4	0.7	1.4	6.0	49
			35+	-3.2	3.3	-6.5	9.1	27*
VA11-0004	1.22	1.22	0-15	4.6	4.6	6.8	6.8	32
			15-25	1.4	1.4	3.7	4.8	29*
			25-35	0.0	1.2	-0.4	5.4	61
			35+	-3.4	3.4	-7.5	8.0	21*
VA11-0005	1.11	1.11	0-15	6.4	6.4	9.1	9.1	19*
			15-25	6.1	6.1	10.8	11.0	90
			25-35	2.4	2.8	7.1	8.0	55
			35+	-0.5	0.8	0.8	3.9	4*
VA11-0006	1.14	1.14	0-15	3.6	3.6	6.1	6.1	4*
			15-25	3.9	3.9	7.5	7.8	35
			25-35	1.7	1.7	5.0	6.8	80
			35+	0.0	0.0	-2.8	5.3	24*
VA11-0007	1.24	1.24	0-15	4.4	4.4	6.1	6.1	24*
			15-25	5.6	5.7	7.9	8.7	20*
			25-35	1.8	2.1	5.5	6.9	25*
			35+	-2.6	2.6	-4.6	8.4	17*
VA11-0009	0.83	0.83	0-15	1.6	1.6	4.2	4.2	1*
			15-25	2.2	2.9	2.5	4.8	18*
			25-35	2.4	3.0	4.3	6.5	41
			35+	-0.5	1.0	-1.5	3.7	117
VA11-0010	0.7	0.7	0-15	5.0	5.0	7.3	7.4	29*
			15-25	3.6	3.6	8.1	8.6	46
			25-35	0.4	0.5	2.1	7.1	28*
			35+	-3.8	4.0	-9.9	10.5	10*
VA11-0011	1.04	1.04	0-15	-	-	-	-	-
			15-25	0.8	1.4	1.2	5.0	13*
			25-35	-1.4	1.4	-5.0	5.7	85
			35+	-4.8	4.8	-10.9	10.9	29*
VA11-0014	0.7	0.7	0-15	6.4	6.4	9.6	10.3	37
			15-25	1.4	1.8	4.4	6.9	43
			25-35	3.8	3.8	2.7	6.1	2*
			35+	-	-	-	-	-

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

Table A.2 (Cont'd)
INRIX data quality measures for individual arterial validation segments in the state of Virginia

Path	Standard TMC length	Sensor 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	
VA11-0015	1.33	1.33	0-15	-	-	-	-	-
			15-25	16.3	16.3	21.3	21.3	1*
			25-35	5.6	5.6	14.8	14.8	15*
			35+	0.6	0.8	4.2	5.4	57
VA11-0016	0.91	0.91	0-15	-	-	-	-	-
			15-25	6.9	6.9	11.2	11.2	3*
			25-35	3.8	3.8	9.5	9.9	37
			35+	0.1	1.5	1.6	6.0	116
VA11-0017	0.95	0.95	0-15	-	-	-	-	-
			15-25	2.5	2.5	4.7	4.7	4*
			25-35	0.6	1.0	1.4	4.7	58
			35+	-1.8	1.9	-5.2	6.9	137
VA11-0018	0.74	0.74	0-15	11.3	11.3	12.8	12.8	2*
			15-25	3.6	3.6	7.6	8.2	60
			25-35	1.3	1.7	3.9	6.3	106
			35+	-1.1	2.1	-1.5	5.9	47
VA11-0019	0.79	0.79	0-15	8.8	8.8	11.1	11.1	4*
			15-25	6.2	6.3	9.5	9.8	95
			25-35	3.4	3.4	6.9	7.2	60
			35+	-0.2	0.8	1.1	3.9	19*
VA11-0020	0.79	0.79	0-15	9.0	9.0	11.3	11.3	21*
			15-25	5.8	5.8	10.0	10.1	78
			25-35	2.4	3.2	6.7	8.6	52
			35+	-0.5	2.3	0.4	6.0	30*
VA11-0022	0.96	0.96	0-15	-	-	-	-	-
			15-25	3.3	3.3	6.0	6.0	1*
			25-35	0.7	2.0	1.7	6.0	28*
			35+	-3.3	3.3	-6.0	7.2	161
VA11-0023	0.9	0.9	0-15	-	-	-	-	-
			15-25	1.9	1.9	6.6	6.6	2*
			25-35	3.8	4.1	9.4	10.0	32
			35+	0.0	1.4	0.7	4.9	115
VA11-0024	1.31	1.31	0-15	6.1	6.1	8.6	8.6	27*
			15-25	2.4	2.4	5.4	5.9	15*
			25-35	1.9	2.8	6.2	9.1	27*
			35+	0.1	0.5	-1.5	6.5	20*
VA11-0025	0.69	0.69	0-15	4.2	4.2	7.5	7.6	39
			15-25	1.3	1.5	3.7	5.4	40
			25-35	-0.6	0.6	-4.3	5.7	5*
			35+	-	-	-	-	-
VA11-0028	1.03	1.03	0-15	9.2	9.2	12.6	12.6	10*
			15-25	3.5	3.5	7.8	7.8	36
			25-35	-0.3	0.9	-0.7	3.5	90
			35+	-0.8	0.8	-4.6	4.6	3*

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

Table A.2 (Cont'd)
INRIX data quality measures for individual arterial validation segments in the state of Virginia

Path	Standard TMC length	Sensor 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	
VA11-0029	0.7	0.7	0-15	2.3	2.3	3.3	3.5	14*
			15-25	1.9	2.1	3.3	6.1	84
			25-35	-0.7	1.0	-3.0	5.3	47
			35+	-4.7	4.7	-9.3	10.2	5*
VA11-0030	0.83	0.83	0-15	3.2	3.2	4.1	4.1	18*
			15-25	4.7	5.7	8.5	10.7	20*
			25-35	2.5	3.0	5.9	7.3	117
			35+	-0.5	1.5	-1.3	4.8	24*
VA11-0032	1.23	1.23	0-15	-	-	-	-	-
			15-25	4.9	4.9	22.1	22.1	1*
			25-35	2.4	2.5	6.3	7.5	24*
			35+	-1.7	1.8	-3.3	6.1	62
VA11-0033	1.13	1.13	0-15	4.5	4.5	7.7	7.7	4*
			15-25	4.6	4.8	6.7	7.3	87
			25-35	2.3	2.5	4.6	5.7	76
			35+	-0.8	0.8	-3.7	3.9	10*
VA11-0034	1.11	1.11	0-15	3.3	3.3	4.8	5.0	51
			15-25	4.0	4.2	7.6	8.4	56
			25-35	0.7	1.7	2.9	6.0	56
			35+	-2.7	2.7	-6.2	6.3	16*
VA11-0035	1.22	1.22	0-15	12.9	12.9	17.5	17.5	2*
			15-25	2.4	2.4	9.1	9.3	43
			25-35	0.7	1.2	2.5	5.5	98
			35+	-1.1	1.3	-3.4	4.2	21*
VA11-0036	0.74	0.74	0-15	12.7	12.7	17.9	17.9	7*
			15-25	4.6	4.7	8.4	9.0	96
			25-35	1.8	1.8	5.2	6.9	50
			35+	-4.3	4.3	-7.2	8.5	12*
VA11-0037	0.83	0.83	0-15	5.9	5.9	7.0	7.0	2*
			15-25	4.1	4.1	7.3	7.4	18*
			25-35	0.0	1.2	0.5	5.6	68
			35+	-4.3	4.3	-9.2	9.7	100
VA11-0038	1.2	1.2	0-15	3.2	3.2	3.7	3.7	6*
			15-25	2.8	2.8	3.4	3.5	9*
			25-35	2.1	3.3	6.2	7.8	9*
			35+	-0.9	1.8	-1.2	5.1	178

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

Table A.3 presents detailed data for individual TMC segments for TomTom. 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 A. 3
TOMTOM data quality measures for individual arterial validation segments in the state of Virginia

Path	Standard TMC length	Sensor 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	
VA11-0001	1.15	1.15	0-15	-	-	-	-	-
			15-25	8.6	8.6	12.2	12.2	6*
			25-35	4.2	4.3	8.9	9.2	338
			35+	0.0	0.5	0.9	3.8	1549
VA11-0002	0.85	0.85	0-15	5.3	5.3	7.1	7.1	9*
			15-25	4.0	4.2	7.1	7.8	218
			25-35	1.0	1.8	4.4	6.8	986
			35+	-1.7	1.7	-3.5	5.3	632
VA11-0003	0.74	0.74	0-15	5.9	5.9	8.1	8.1	258
			15-25	5.8	5.8	11.2	11.4	710
			25-35	1.2	1.2	7.1	7.9	409
			35+	-1.4	1.4	-3.9	5.3	230
VA11-0004	1.22	1.22	0-15	1.5	1.5	3.0	3.2	272
			15-25	2.4	2.5	6.6	7.5	297
			25-35	1.1	1.5	4.3	6.2	556
			35+	-1.6	1.6	-3.5	4.9	190
VA11-0005	1.11	1.11	0-15	3.5	3.5	5.0	5.1	256
			15-25	7.7	7.7	13.2	13.3	822
			25-35	3.2	3.3	9.3	9.7	676
			35+	-0.3	0.4	0.3	2.7	71
VA11-0006	1.14	1.14	0-15	5.7	5.7	8.5	8.5	26*
			15-25	5.0	5.1	10.0	10.2	414
			25-35	1.9	2.0	6.3	7.3	812
			35+	-0.9	0.9	-3.4	5.0	324
VA11-0007	1.24	1.24	0-15	1.9	1.9	3.4	3.5	184
			15-25	3.7	3.9	6.9	7.4	84
			25-35	0.6	1.0	2.4	4.1	214
			35+	-1.7	1.7	-6.6	6.7	133
VA11-0009	0.83	0.83	0-15	2.7	2.7	3.5	3.9	52
			15-25	2.9	3.1	4.7	5.5	100
			25-35	2.7	3.0	7.0	8.0	347
			35+	-0.6	0.6	-2.1	3.6	1193
VA11-0010	0.7	0.7	0-15	2.1	2.2	4.1	4.3	230
			15-25	0.1	0.4	-1.1	3.0	447
			25-35	-1.5	1.5	-10.4	10.4	285
			35+	-10.7	10.7	-20.5	20.5	102
VA11-0011	1.04	1.04	0-15	3.3	3.3	6.0	7.1	18*
			15-25	0.2	1.1	1.0	4.9	201
			25-35	-1.4	1.5	-4.5	5.4	769
			35+	-5.1	5.1	-12.0	12.0	334
VA11-0012	1.05	1.05	0-15	6.2	6.2	7.6	7.6	297
			15-25	3.1	3.2	6.3	6.7	757
			25-35	0.0	0.3	0.6	2.9	101
			35+	-3.1	3.1	-6.1	6.1	1*

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

Table A.3 (Cont'd)
TOMTOM data quality measures for individual arterial validation segments in the state of Virginia

Path	Standard TMC length	Sensor 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	
VA11-0013	0.7	0.7	0-15	3.3	3.3	5.1	5.2	523
			15-25	0.4	0.7	1.9	3.2	562
			25-35	-1.5	1.5	-6.3	6.3	130
			35+	-7.8	7.8	-14.7	14.7	9*
VA11-0014	0.7	0.7	0-15	4.5	4.5	9.0	9.0	497
			15-25	0.5	0.5	3.5	4.1	756
			25-35	-1.9	1.9	-6.1	6.1	66
			35+	-9.7	9.7	-14.5	14.5	9*
VA11-0015	1.33	1.33	0-15					*
			15-25	6.7	6.7	20.4	20.4	15*
			25-35	3.3	3.3	11.5	11.6	262
			35+	0.1	0.5	2.1	4.0	1105
VA11-0016	0.91	0.91	0-15					*
			15-25	17.4	17.4	20.9	20.9	24*
			25-35	9.2	9.2	16.2	16.2	446
			35+	1.6	1.8	5.6	6.7	1659
VA11-0017	0.95	0.95	0-15	13.2	13.2	15.4	15.4	1*
			15-25	5.6	5.6	10.2	10.2	71
			25-35	1.7	1.7	6.8	7.4	624
			35+	-1.3	1.3	-3.8	5.5	1428
VA11-0018	0.74	0.74	0-15	5.7	5.8	8.1	8.4	34
			15-25	1.9	2.0	5.7	6.4	470
			25-35	-0.1	0.3	-1.2	3.2	1123
			35+	-4.2	4.2	-10.2	10.2	506
VA11-0019	0.79	0.79	0-15	8.9	9.0	10.2	10.4	58
			15-25	5.2	5.2	9.0	9.0	836
			25-35	0.3	0.3	1.5	2.8	894
			35+	-3.2	3.2	-8.7	8.7	299
VA11-0020	0.79	0.79	0-15	8.3	8.3	10.4	10.4	145
			15-25	4.8	4.8	9.6	9.6	776
			25-35	0.4	0.5	2.8	3.6	893
			35+	-2.4	2.5	-6.6	6.7	327
VA11-0022	0.96	0.96	0-15	6.3	6.3	8.5	8.5	1*
			15-25	8.6	8.7	12.7	13.2	22*
			25-35	1.7	2.0	5.2	6.5	390
			35+	-1.6	1.8	-3.6	5.4	1596
VA11-0023	0.9	0.9	0-15	1.6	1.7	2.9	3.1	26*
			15-25	2.2	2.3	4.7	5.6	33
			25-35	1.3	1.6	5.7	7.2	302
			35+	-2.2	2.2	-4.7	5.6	1636
VA11-0024	1.31	1.31	0-15	3.7	3.7	6.0	6.0	160
			15-25	2.7	2.7	6.3	6.9	147
			25-35	-0.9	1.1	-3.8	6.0	482
			35+	-9.6	9.6	-16.6	16.6	634

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

Table A.3 (Cont'd)
TOMTOM data quality measures for individual arterial validation segments in the state of Virginia

Path	Standard TMC length	Sensor 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	
VA11-0025	0.69	0.69	0-15	2.6	2.6	5.1	5.4	700
			15-25	0.2	0.4	1.2	3.2	513
			25-35	-2.0	2.0	-7.3	7.3	49
			35+	-6.7	6.7	-16.6	16.6	2*
VA11-0026	0.7	0.7	0-15	5.3	5.4	9.1	9.2	235
			15-25	2.1	2.1	6.4	7.4	752
			25-35	-0.8	0.9	-1.3	5.1	183
			35+	-3.9	3.9	-8.3	8.3	20*
VA11-0027	1.05	1.05	0-15	8.8	8.8	12.1	12.2	35
			15-25	3.3	3.6	6.6	7.4	867
			25-35	-0.1	0.4	0.9	3.4	219
			35+	-5.5	5.5	-8.2	8.2	13*
VA11-0028	1.03	1.03	0-15	4.6	4.6	7.2	7.2	52
			15-25	3.2	3.2	7.3	7.6	352
			25-35	-0.2	0.6	0.4	3.2	972
			35+	-2.9	2.9	-7.0	7.0	78
VA11-0029	0.7	0.7	0-15	3.8	3.9	5.5	5.9	107
			15-25	2.6	2.6	7.1	7.9	674
			25-35	-0.1	0.4	-0.2	4.0	463
			35+	-2.6	2.6	-8.8	8.8	108
VA11-0030	0.83	0.83	0-15	2.9	2.9	3.8	3.9	140
			15-25	8.8	8.8	14.3	14.4	338
			25-35	3.8	3.8	9.0	9.2	1113
			35+	-0.3	0.3	0.1	2.7	182
VA11-0032	1.23	1.23	0-15	-	-	-	-	-
			15-25	9.1	9.1	18.0	18.0	10*
			25-35	2.0	2.0	7.5	7.9	206
			35+	-2.0	2.0	-4.1	6.1	543
VA11-0033	1.13	1.13	0-15	3.6	3.6	5.4	5.4	129
			15-25	4.8	4.9	7.2	7.7	894
			25-35	1.5	2.0	3.8	5.7	900
			35+	-1.3	1.3	-4.2	4.6	101
VA11-0034	1.11	1.11	0-15	1.9	1.9	3.1	3.3	427
			15-25	1.5	1.5	4.1	4.3	695
			25-35	-0.1	0.8	-2.8	4.3	726
			35+	-6.2	6.2	-12.7	12.7	144
VA11-0035	1.22	1.22	0-15	6.6	6.7	9.4	9.6	43
			15-25	7.5	7.5	15.5	15.5	408
			25-35	2.9	2.9	9.2	9.3	909
			35+	-0.1	0.4	1.2	2.6	184
VA11-0036	0.74	0.74	0-15	6.6	6.7	8.8	9.1	89
			15-25	8.4	8.4	13.5	13.6	922
			25-35	3.1	3.1	9.3	9.7	513
			35+	-0.5	0.5	-0.3	3.8	126

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

Table A.3 (Cont'd)
TOMTOM data quality measures for individual arterial validation segments in the state of Virginia

Path	Standard TMC length	Sensor 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	
VA11-0037	0.83	0.83	0-15	1.6	1.8	2.2	2.8	48
			15-25	2.8	3.0	6.0	6.7	136
			25-35	1.0	1.5	4.3	6.7	729
			35+	-2.3	2.3	-4.7	6.1	891
VA11-0038	1.2	1.2	0-15	0.5	0.7	0.8	1.3	82
			15-25	0.3	0.7	0.4	2.1	48
			25-35	1.3	1.5	5.1	5.7	181
			35+	-1.1	1.1	-3.2	4.0	1692

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

Slowdown Analysis

The slowdown analysis is an offshoot of the traditional analysis, developed to provide a more intuitive measure of probe data's ability to capture congestion events. The slowdown analysis is effective in quantifying the ability of probe data to capture significant disruptions in traffic. The definition of a slowdown in this context is when traffic speed reduces by at least 15 mph for a period of one hour or more. For each observed slowdown in each 24-hour data plot, the analyst rates the performance of the probe data base on the reported speed reduction and duration on slowdown. Each slowdown is classified as either 'Fully Captured', 'Partially Captured', or 'Failed to Capture' as explained below[3].

- A Fully Captured slowdown indicates that the probe data accurately characterized both the reduction in speed, and duration of the slowdown. The error in speed reduction or duration cannot exceed 20%.
- A Partially Captured slowdown indicates that the probe data reported a significant disruption to traffic, but the extent of speed reduction or duration of time were in error by more than 20%.
- Failed to Capture indicates that the probe data either completely missed the slowdown, or the extent of speed reduction or duration of the event were significant in error such that the slowdown would not be interpreted as a significant disruption to traffic.

Throughout the entire VA11 validation, there were about 402 days of observation. (Note, each 24-hour period for each segment counts as a single day of observation.) Through these 402 days, about 140 significant slowdowns were observed. The results of each vendor will be explained below separately.

[3] S. E. Young, M. Hamedi, E. Sharifi, R. M. Juster, K. Kaushik, S. Eshragh, I-95 Corridor Coalition Vehicle Probe Project Evaluation, prepared for I-95 Corridor Coalition, July 2015 (link)

HERE

Of these 140 significant slowdowns observed in VA11, 128 were captured by HERE data. Of these 128 captured slowdowns, 101 were fully captured. Figure A.1 is a representative 24 hour plot of a fully captured slowdown observed in the corridor from October 3, 2016 on segment VA11-0038. During the peak period, the HERE data accurately captures the deduction in speed, in both magnitude and duration on this sample.

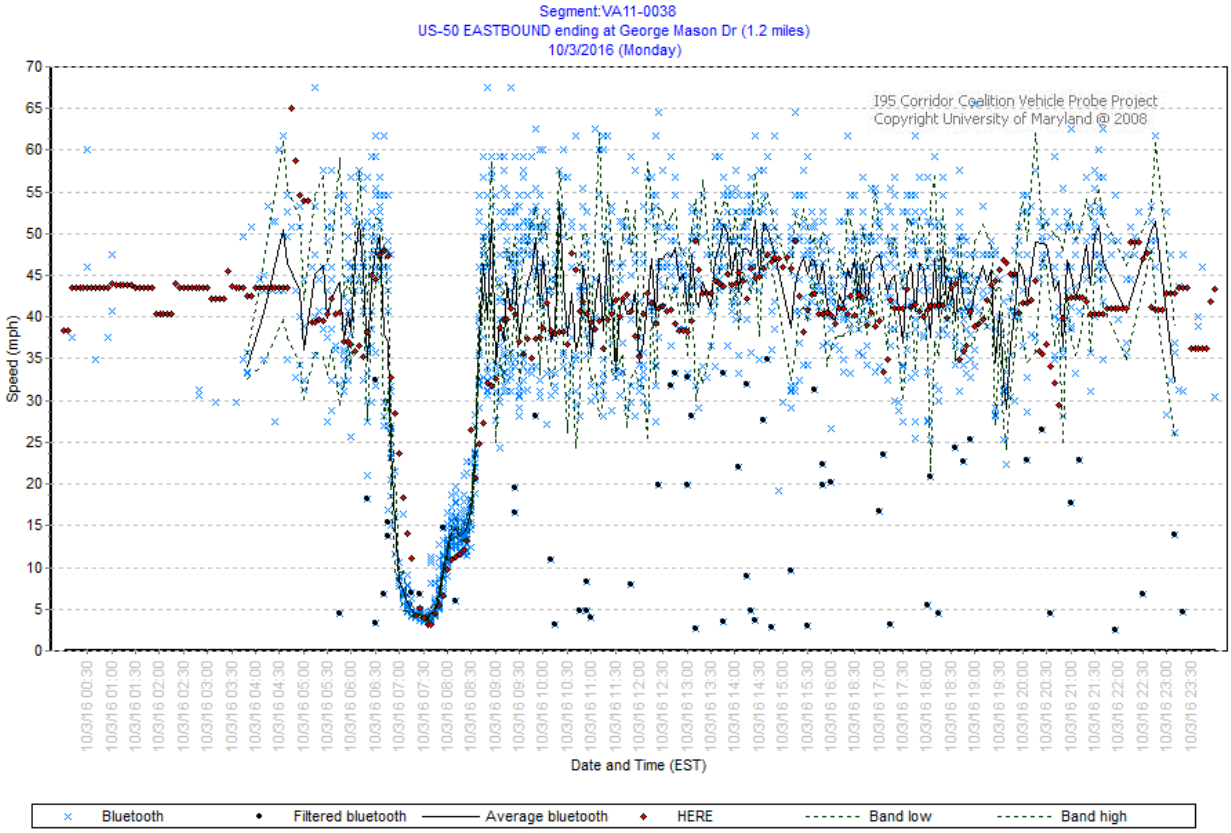

Figure A. 1— A representative sample of a fully captured slowdown on segment VA11-0038 from October 3, 2016

Also, of these 128 captured slowdowns, 27 were partially captured. Figures A.2 is a representative 24 hour plot of a partially captured slowdown observed in the corridor from October 4, 2016 on the VA11-0007 segment.

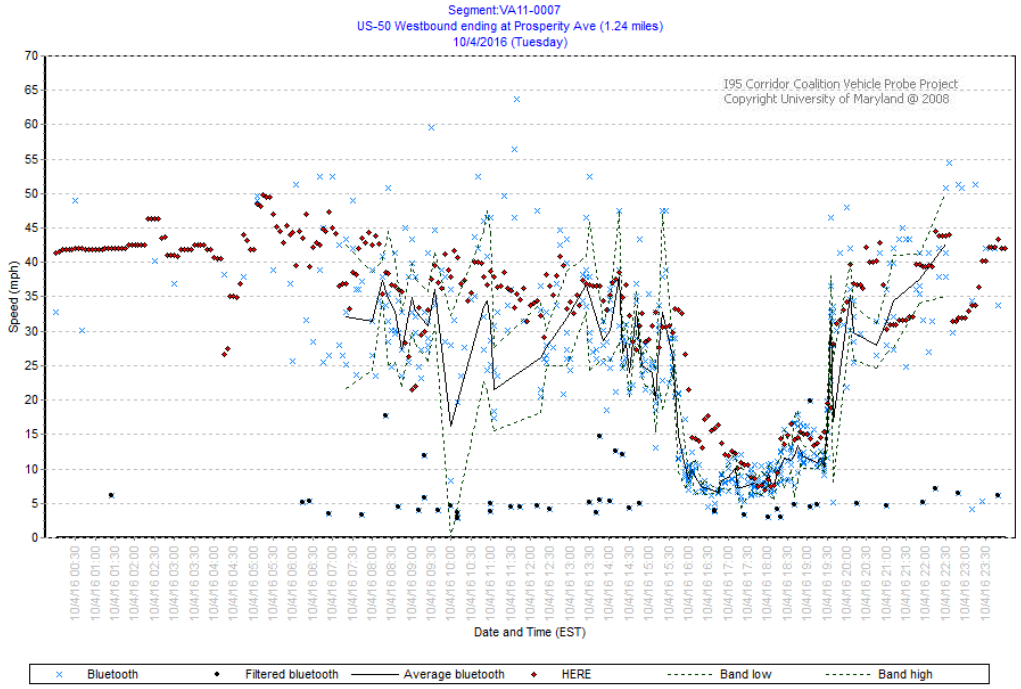

Figure A. 2— Representative sample of a partially captured slowdown on segment VA11-0007 from October 4, 2016

HERE failed to capture 12 slowdowns out of 140 slowdowns. Figure A.3 is from September 26, 2016 on VA11-0036 segment and shows that HERE data fails to capture a significant slowdown.

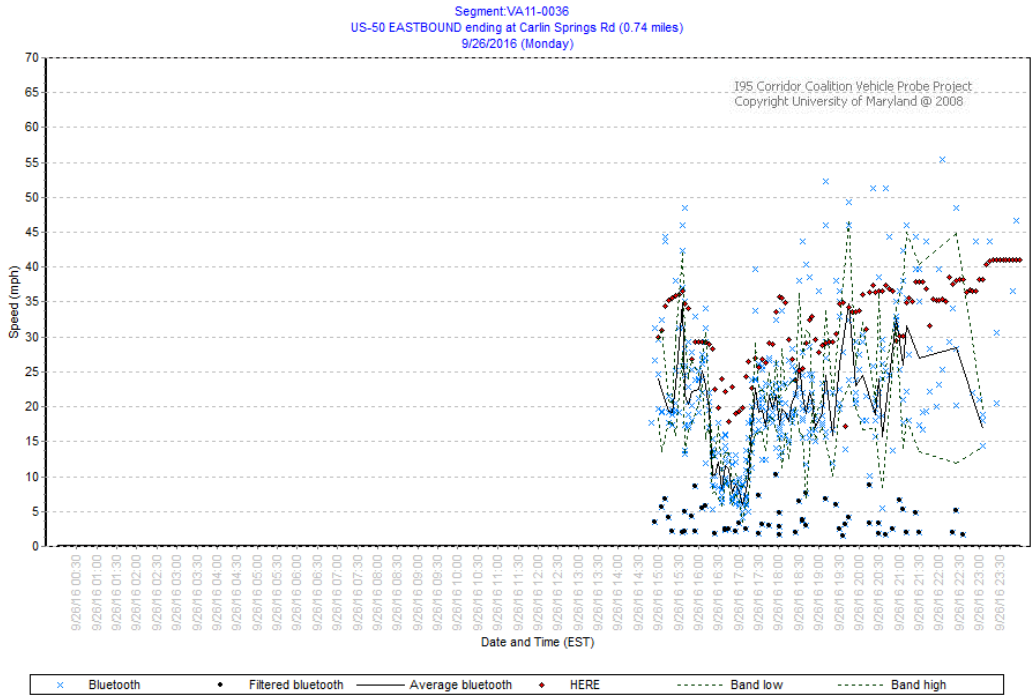

Figure A. 3— Representative sample of failure to capture a significant slowdown on segment VA11-0036 from September 26, 2016

INRIX

Of these 140 significant slowdowns observed in VA11, 124 were captured by INRIX data. Of these 124 captured slowdowns, 46 were fully captured. Figure A.4 is a representative 24 hour plot of a fully captured slowdown observed in the corridor from October 3, 2016 on segment VA11-0038. During the peak period, the INRIX data accurately captures the deduction in speed, in both magnitude and duration on this sample.

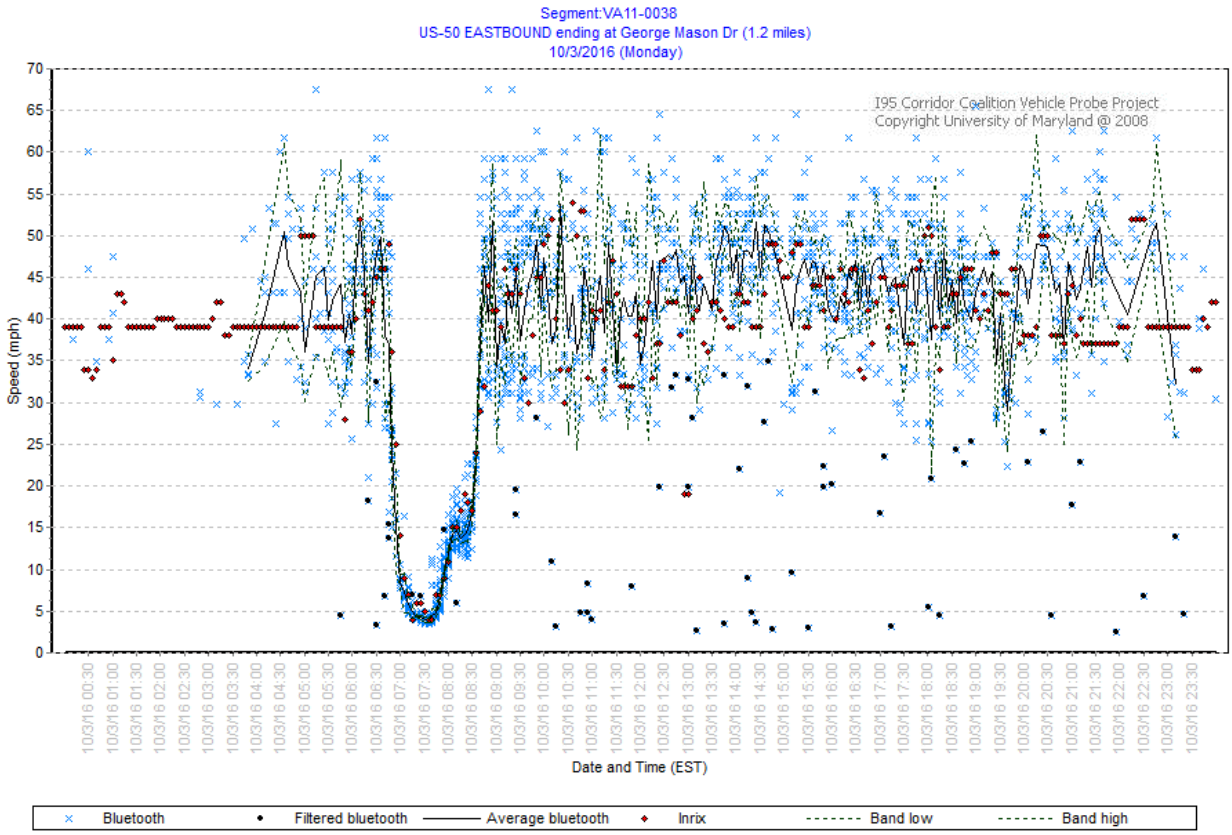

Figure A. 4— A representative sample of a fully captured slowdown on segment VA11-0038 from October 3, 2016

Also, of these 124 captured slowdowns, 78 were partially captured. Figures A.5 is a representative 24 hour plot of a partially captured slowdown observed in the corridor from October 4, 2016 on the VA11-0007 segment.

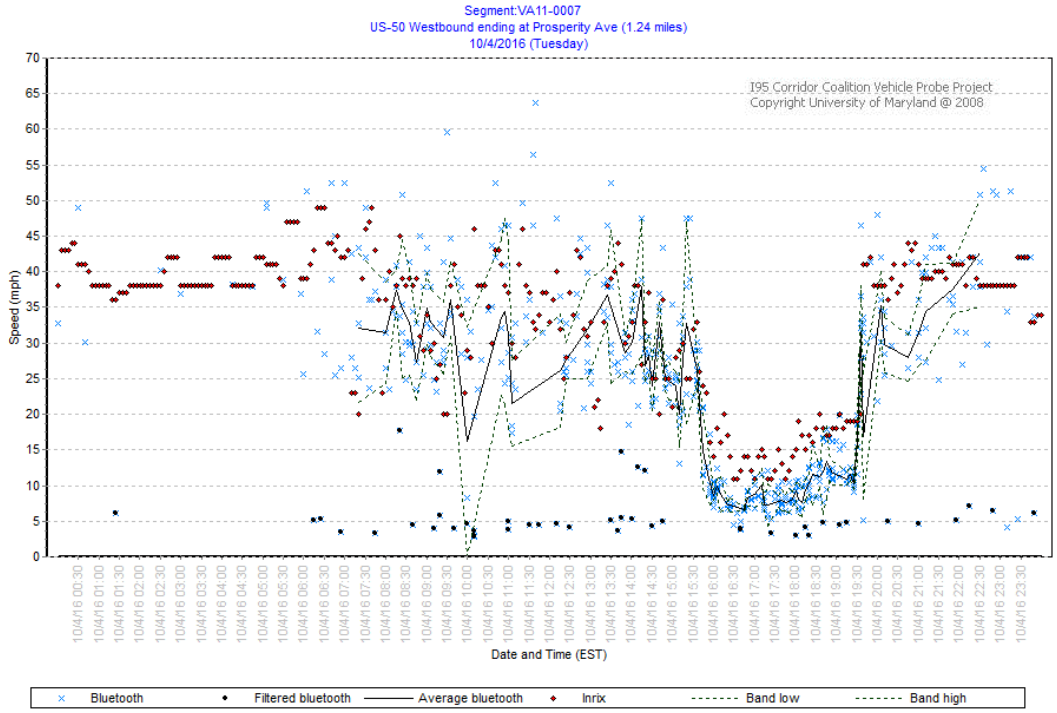

Figure A. 5— Representative sample of a partially captured slowdown on segment VA11-0007 from October 4, 2016

INRIX failed to capture 16 slowdowns out of 140 slowdowns. Figure A.6 is from September 30, 2016 on VA11-0012 segment and shows that INRIX data fails to capture a significant slowdown.

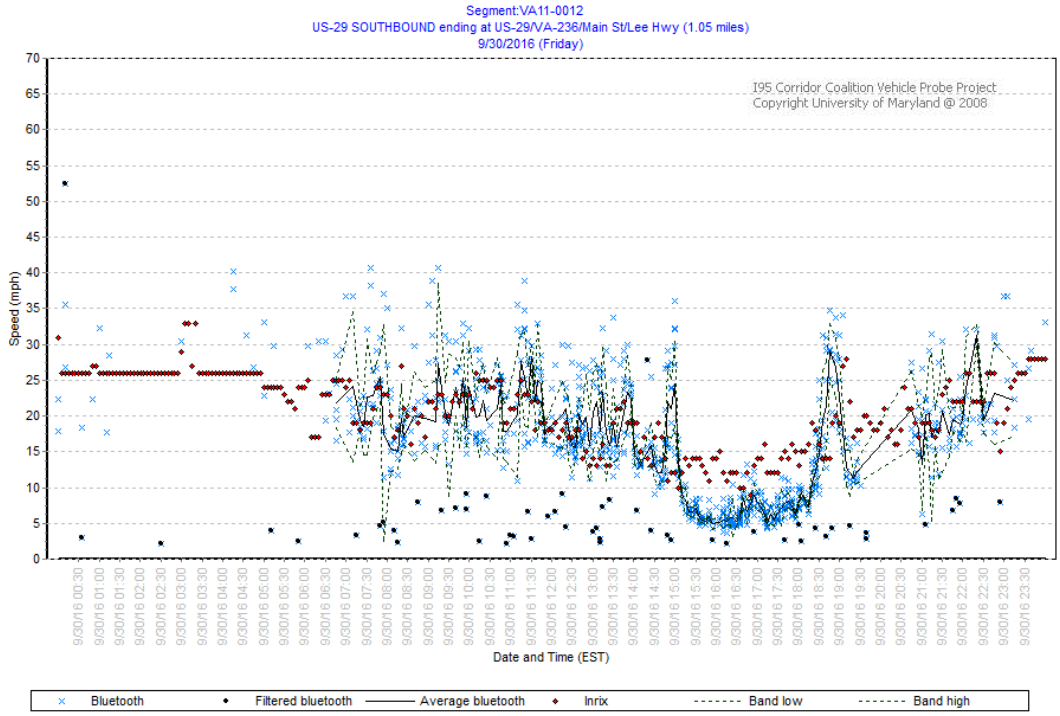

Figure A. 6— Representative sample of failure to capture a significant slowdown on segment VA11-0012 from September 30, 2016

TOMTOM

Of these 140 significant slowdowns observed in VA11, 125 were captured by TomTom data. Of these 125 captured slowdowns, 83 were fully captured. Figure A.7 is a representative 24 hour plot of a fully captured slowdown observed in the corridor from October 3, 2016 on segment VA11-0038. During the peak period, the TomTom data accurately captures the deduction in speed, in both magnitude and duration on this sample.

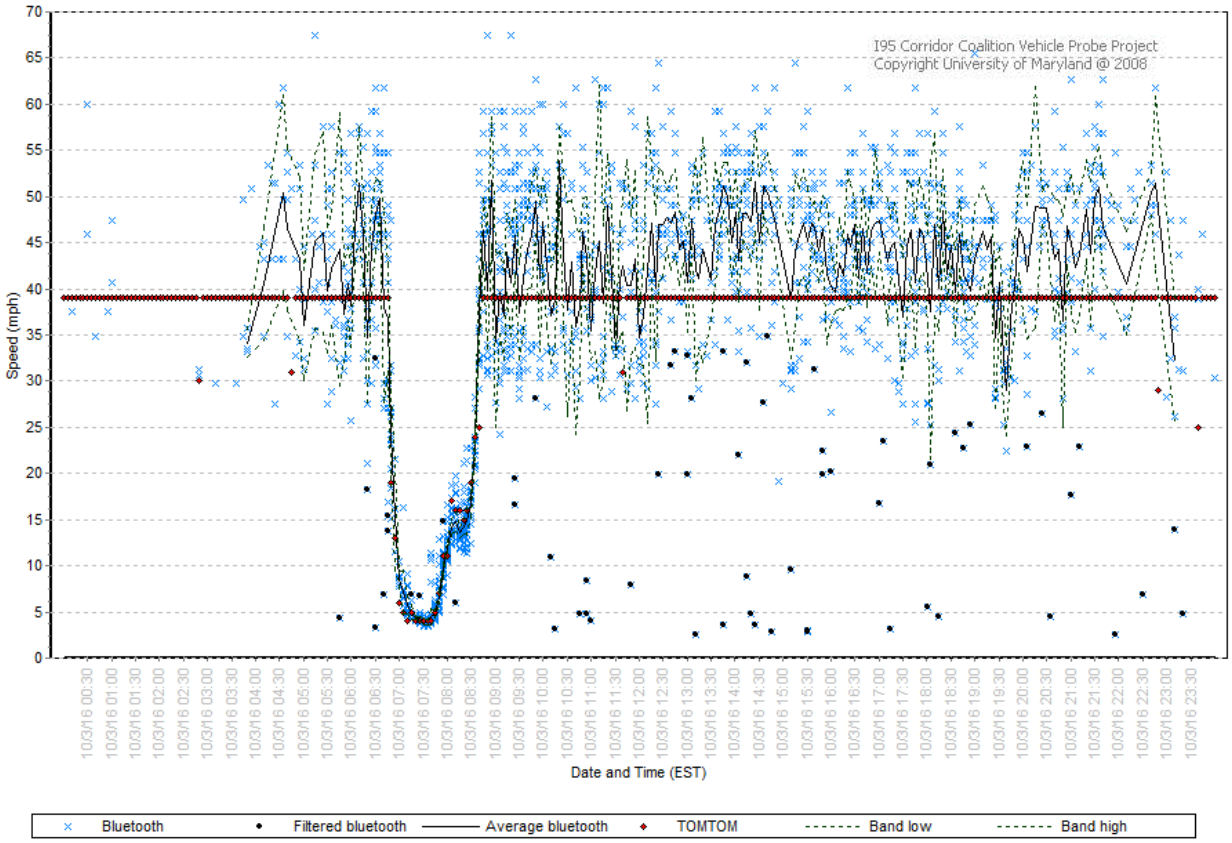

Figure A. 7— A representative sample of a fully captured slowdown on segment VA11-0038 from October 3, 2016

Also, of these 125 captured slowdowns, 42 were partially captured. Figures A.8 is a representative 24 hour plot of a partially captured slowdown observed in the corridor from September 30, 2016 on the VA11-0012 segment.

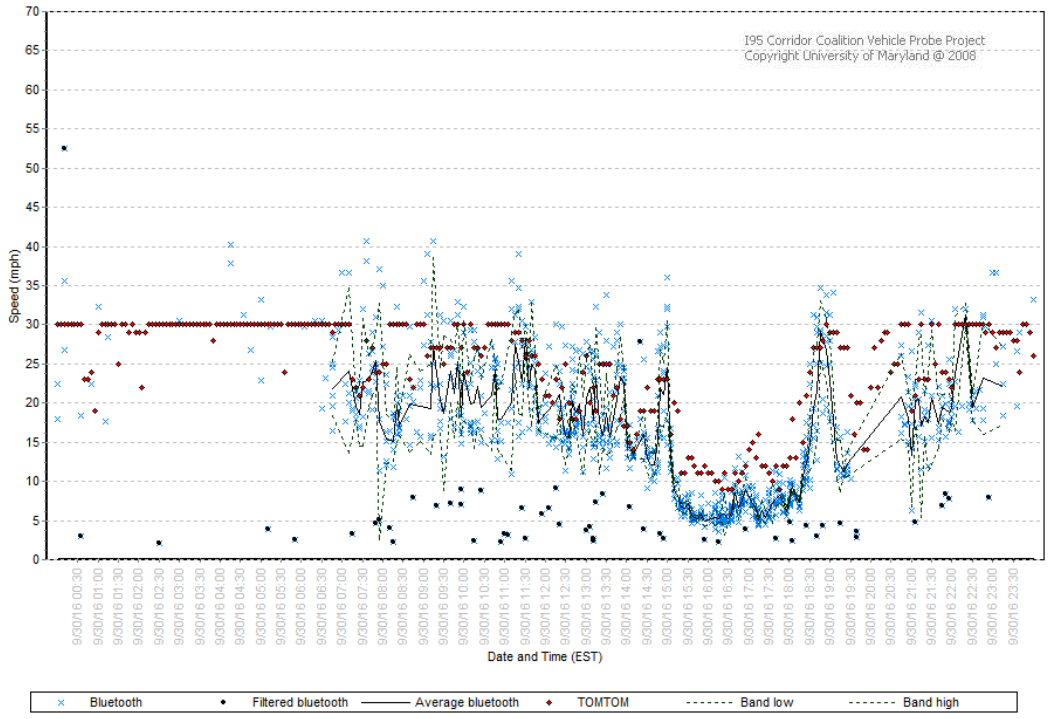

Figure A. 8— Representative sample of a partially captured slowdown on segment VA11-0012 from September 30, 2016

TomTom failed to capture 15 slowdowns out of 140 slowdowns. Figure A.9 is from September 26, 2016 on VA11-0036 segment and shows that TomTom data fails to capture a significant slowdown.

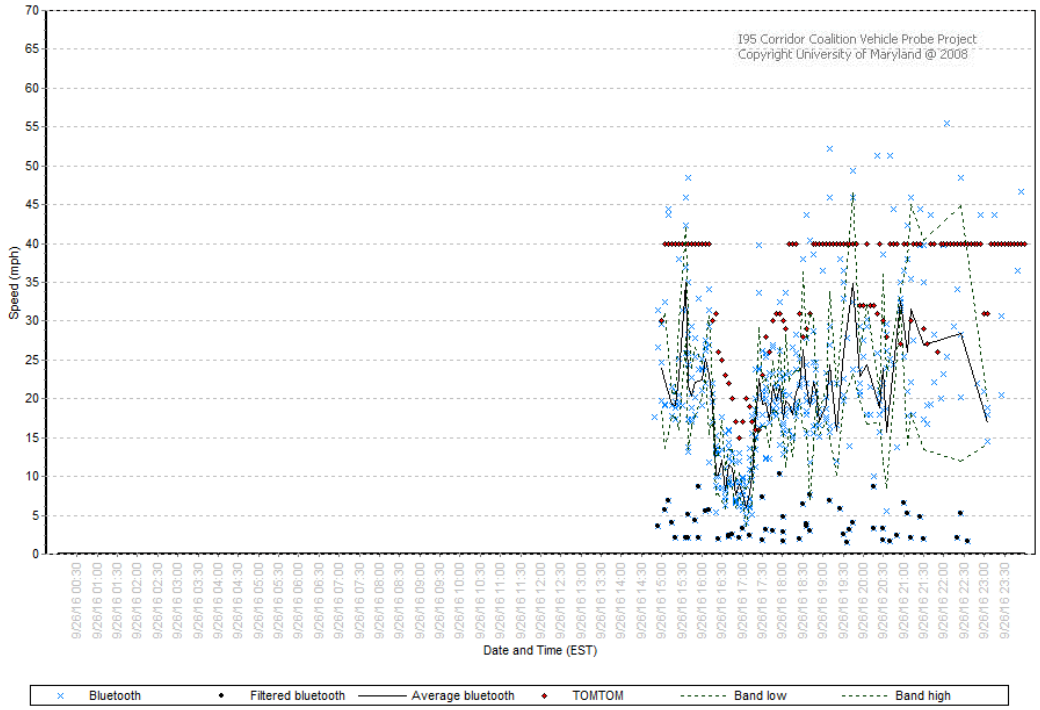

Figure A. 9— Representative sample of failure to capture a significant slowdown on segment VA11-0036 from September 26, 2016