The Eastern Transportation Coalition Vehicle Probe Project: HERE, INRIX and TomTom Data Validation

Report for Tennessee
Arterial Validation: Tennessee #01

Data Collection: March-April 2021
Report Date: July 2021

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Acknowledgements:
The research team would like to express its gratitude for the assistance it received from the state highway officials in Tennessee during the data collection phase of the validation effort.

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Executive Summary

This report provides the results of validation activities for the Eastern Transportation Coalition's (TETC's) Vehicle Probe Project in which multiple vendors provide travel time and speed data to our members for operations, planning and performance measures purposes. In this validation, wireless re-identification traffic monitoring (WRTM) technology (Bluetooth and/or Wi-Fi) is used to evaluate the quality of speeds reported by probe data vendors on selected validation road segments. WRTM equipment is deployed at strategic locations along these segments and identifies – and later re-identifies – unique signals emitted by in-vehicle electronic equipment via Bluetooth, Wi-Fi, and other technologies, thus allowing direct measurement of travel times from a sample of vehicles. Prior research indicates that this sampling approach is capable of accurately characterizing actual travel times (speeds)[1]; therefore, WRTM data serves as the ground-truth data source against which reported probe speeds are compared. This validation report is the latest in a long history of TETC validation activities dating back to 2009. The following bullets summarize key information about this data collection effort, while ES Table 1 provides a summary description of the study area:

Study area

- Arterial segments along SR-1 near Nashville, Tennessee, TN (see Figure 1)
- Number of validation segments: 34
- Directional miles: 57

WRTM sensors

- Re-identification technology: Bluetooth & Wi-Fi
- Number deployed: 22

Data collection:

- Dates: March 22-April 02, 2021
- Effective five-minute travel time samples observed: 43k

ES Table 1 - Arterial Corridor Description

Name	Lanes	Signal Density	AADT (bi-directional)	Speed Limit	Miles (directional)
SR-1	2-3 lanes	2.0 signals / mi	30.8k	45-55 mph	57

Two types of analyses are used to quantify probe data accuracy in this report: the first is our traditional analysis based on the relative agreement of travel times and speeds with WRTM

[1] Ali Haghani, Masoud Hamedi, Kaveh Farokhi Sadabadi, I-95 Corridor Coalition Vehicle Probe Project: Validation of INRIX Data July-September 2008, January 2010 (link)

reference data, and the second is a slowdown analysis. The traditional analysis involves comparing reported probe speeds to (a) the mean WRTM speed, and (b) a confidence band around the mean WRTM speed for each 5-minute time interval. These comparisons are quantified in terms of two error metrics: Average Absolute Speed Error (AASE) and Speed Error Bias (SEB), which are calculated separately for four different speed bins.

The slowdown analysis focuses specifically on time periods where major congestion events are observed, and scores each vendor using a simple "fully captured", "partially captured", or "failed to capture" classification system. The results of both reports are summarized below in ES Tables 2-7.

In the case of the traditional analysis, the columns relevant to contract specifications are outlined in red, and error metric values are colored green or red to indicate whether the value is within contract specifications (AASE <= 10 mph, SEB <= 5 mph).

ES Tables 2-3 summarize **HERE**'s traditional and slowdown analysis results, respectively. ES Table 2 indicates that **HERE data was within contract specifications in all speed bins for both AASE and SEB**. ES Table 3 shows that HERE data fully captured 15 of the 21 total slowdowns (71%), partially captured 5 (24%), and failed to capture 1 (5%).

HERE

ES Table 2 – HERE Traditional Analysis Summary

Speed Bin	Average Absolute Speed Error (<10mph)		Speed Error Bias (<5mph)		Number of 5 Minute Samples
	Comparison w/ 1.96 SEM Band	Comparison with Mean	Comparison w/ 1.96 SEM Band	Comparison with Mean	
0-15 MPH	3.46	5.02	3.3	4.67	384
15-25 MPH	2.58	5.25	2.43	4.49	5327
25-35 MPH	1.45	4.55	0.83	2.01	14892
>35 MPH	1.44	4.64	-0.61	-1.53	22466
All Speeds	1.6	4.69	0.3	0.49	43069

ES Table 3 -- HERE Slowdown Analysis Summary

Significant Slowdowns	Fully Captured	Partially Captured	Not Captured
21	15	5	1

INRIX

ES Tables 4-5 summarize **INRIX**'s traditional and slowdown analysis results, respectively. ES Table 4 indicates that **INRIX data was within contract specifications in all speed bins for both AASE and SEB**. ES Table 5 shows that INRIX fully captured 18 of the 21 significant slowdowns observed during the data collection period, with the remaining three falling during a period where speed data was unavailable.

ES Table 4 – INRIX Traditional Analysis Summary

Speed Bin	Average Absolute Speed Error (<10mph)		Speed Error Bias (<5mph)		Number of 5 Minute Samples
	Comparison w/ 1.96 SEM Band	Comparison with Mean	Comparison w/ 1.96 SEM Band	Comparison with Mean	
0-15 MPH	2.63	4.23	2.51	3.93	342
15-25 MPH	2.5	5.29	2.4	4.72	5260
25-35 MPH	1.26	4.27	0.9	2.47	14820
>35 MPH	1.35	4.59	-0.18	-0.56	22388
All Speeds	1.47	4.56	0.53	1.17	42810

ES Table 5 -- INRIX Slowdown Analysis Summary

Significant Slowdowns	Fully Captured	Partially Captured	Not Captured	Missing Data
21	18	0	0	3

TomTom

ES Tables 6-7 summarize **TomTom's** traditional and slowdown analysis results, respectively. ES Table 6 indicates that **TomTom data was within contract specifications in all speed bins for both AASE and SEB**. ES Table 7 shows that TomTom data fully captured all 21 slowdowns.

ES Table 6 – TomTom Traditional Analysis Summary					
Speed Bin	**Average Absolute Speed Error (<10mph)**		**Speed Error Bias (<5mph)**		Number of 5 Minute Samples
	Comparison w/ 1.96 SEM Band	Comparison with Mean	Comparison w/ 1.96 SEM Band	Comparison with Mean	
0-15 MPH	1.03	2.27	0.94	1.92	384
15-25 MPH	1.19	3.5	1.1	2.73	5327
25-35 MPH	0.86	3.54	0.54	1.62	14898
>35 MPH	1.29	4.4	0.28	0.64	22473
All Speeds	1.13	3.97	0.48	1.25	43082

ES Table 7-- TomTom Slowdown Analysis Summary			
Significant Slowdowns	Fully Captured	Partially Captured	Not Captured
21	21	0	0

The results for this arterial validation show continued improvement from the vendors with respect to the slowdown analysis. Traditional analysis, particularly on signalized arterials, have been consistently within contract specifications. However due to the large speed variance, combined with relatively slow speeds on such roadways (as compared to freeways from which the method originated) the traditional method does not provide a 'high hurdle' for vendors to attain. However, the slowdown analysis, though categorical in nature, has provided evidence of vendor's capability to capture unusual traffic patterns on signal-controlled roadways. The statistics as reported above for all vendors reflects a consistent trend of increased traffic data fidelity for such roadways which have historically proven challenging to monitor accurately.

Introduction

The University of Maryland (UMD), acting on behalf of the Eastern Transportation Coalition, was given the responsibility of evaluating the quality of Vehicle Probe Project (VPP) data at the inception of the project in 2009. To assess the quality of travel time and speed data, UMD developed a methodology using wireless re-identification traffic monitoring (WRTM) technology, which is documented in detail in the previously referenced full report: *The I-95 Corridor Coalition Vehicle Probe Project: Validation of INRIX Data.*

At a high level, WRTM equipment is deployed at strategic locations along selected road segments and identifies – and later re-identifies – unique signals emitted by in-vehicle electronic equipment via Bluetooth, Wi-Fi and other technologies, thus allowing direct measurement of travel times from a sample of vehicles. Initial research conducted by UMD shows that this sampling approach is capable of accurately characterizing travel times (speeds) when the distance between sensors is 60 seconds or more in travel time (equating to one mile apart at freeway speeds); therefore, WRTM data serves as the ground-truth data source against which reported probe speeds are compared.

In 2014, the project moved to a second phase (VPPII), during which a probe data marketplace was created with multiple vendors. Currently there are three data vendors that provide travel time and speed data through this marketplace: HERE, INRIX, and TomTom. The purpose of this report, which is produced on a regular basis, is to continue to rigorously assess the accuracy of speeds reported by each vendor on various road segments from The Eastern Transportation Coalition member states.

Probe Data Vendors

Three probe data vendors are evaluated in this report: HERE, INRIX, and TomTom. Each vendor provides travel time and speed data along the road segments and time periods of interest, which are subsequently compared to ground truth WRTM observations to assess data accuracy.

Specifically, each vendor reports travel time and speed data in one-minute intervals either along road segments defined by the WRTM sensor locations (i.e., validation segmentation) or Traffic Message Channel (TMC) segments. In the latter case the TMC-based speeds must first be transformed to equivalent speeds on validation segments before a direct comparison can be made.

Methodology

The primary means of evaluating the vendor data is through the traditional validation analysis, which is documented in the original report (*The I-95 Corridor Coalition Vehicle Probe Project: Validation of INRIX Data*) and summarized below. Additionally, supplemental analyses may be conducted depending on the road type being evaluated and observed data characteristics. The most common supplemental analysis for signalized arterials is the slowdown analysis[2], which evaluates probe data quality during major congestion events on arterials.

Traditional validation analysis

Overview

The traditional validation analysis consists of comparing ground truth (i.e., WRTM) speeds against vendor speeds over five-minute intervals and quantifying the discrepancy in terms of two error metrics defined in the contract specifications.

Obtain vendor speed data along validation road segments

Road segments used for validation are defined based on WRTM sensor locations – often resulting in different segment definitions than those typically reported by the probe vendors. Accordingly, vendors may either report speeds directly on the validation road segmentation used for evaluation, or report speeds based on standard Traffic Message Channel (TMC) segments. In the latter case, equivalent vendor speeds must be obtained for the geometry specified by the WRTM sensors, which is accomplished via a trajectory reconstruction algorithm. This algorithm is described in another report[3] and works by (a) identifying the portions of vendor road segments that correspond to the validation segment, and (b) using the speeds reported on the vendor's segments during multiple time intervals to calculate the equivalent speed.

Filter and aggregate ground truth data

Raw travel time (speed) observations are first filtered to remove outliers. The filtering step is necessary because WRTM sensors sometimes re-identify vehicles that stop between sensors or record travel times from pedestrians or non-motorized vehicles that are not representative of actual traffic conditions. After the outlier observations are removed, the remaining representative observations are aggregated for each segment over five-minute intervals, and intervals with too few observations or excessive variation are discarded.

[2] Sharifi, et. al., Outsourced probe data effectiveness on signalized arterials (link)
[3] Ali Haghani, Masoud Hamedi, Kaveh Farokhi Sadabadi, Estimation of Travel Times for Multiple TMC Segments, prepared for I-95 Corridor Coalition, February 2010 (link)

The remaining intervals are deemed suitable for evaluation of vendor probe data and are summarized in terms of (a) space-mean speed (SMS) and (b) confidence band around the mean. The space-mean speed captures average ground truth traffic behavior, while the confidence band accounts for sample size and variation in the observed speeds.

Several statistical measures were initially evaluated to define the width of this uncertainty band, all of which are described and reported in the original report. Ultimately, the standard error of the mean (SEM) measure was selected due to its simplicity and sensitivity to both variability and number of observations used for calculations. The SEM is calculated as the standard deviation (SD) of the WRTM speeds divided by the square root of the number WRTM data points (n) taken for a given time. In other words, $\text{SEM} = \frac{SD_{WRTM}}{\sqrt{n}}$. The confidence band based on this statistic, $[\text{SMS} - 1.96 \cdot \text{SEM},\ \text{SMS} + 1.96 \cdot \text{SEM}]$, narrows when there is a higher degree of confidence in the ground truth data (i.e., more observations or less variation) and widens when there is less confidence, serving as a proxy for a 95% confidence interval of ground truth speeds.

Compute Error Metrics

A statistical analysis of the data is conducted for four defined speed bins, where each five-minute interval is associated with a speed bin based on its corresponding ground truth space-mean speed (0-15 mph, 15-30 mph, 30-45 mph, 45+ mph for arterials; 0-30 mph, 30-45 mph, 45-60 mph, 60+ mph for freeways). Reported probe speeds are compared to both the space-mean and 1.96 SEM band speed for each five-minute time interval, and the discrepancies are quantified in terms of two error metrics: Average Absolute Speed Error (AASE) and Speed Error Bias (SEB), which are reported separately for each speed bin. According to contract specifications, AASE and SEB values must be within 10 mph and 5 mph, respectively, when compared with the SEM band.

AASE is calculated by summing up the absolute difference between probe vendor speeds (S_P) and ground truth speeds (S_{GT}) for each time interval and taking the average over n observations. That is, $\text{AASE} = \frac{1}{n}\sum_{i=1}^{n}|S_P - S_{GT}|$. Because the absolute value is used, positive and negative errors cannot cancel, and the result is always positive. Speed Error Bias is calculated similarly, with the difference that the absolute value of the errors is not taken. In other words, $\text{SEB} = \frac{1}{n}\sum_{i=1}^{n} S_P - S_{GT}$. Thus, positive and negative errors can cancel each other out, and the resulting value can provide insight into whether there is a consistent positive or negative error.

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 definition of a slowdown in this context is when traffic speeds (as identified by ground truth WRTM sensors) decrease by at least 15 mph for a period of one hour or more**.

An analyst visually compares ground truth and vendor speeds for each slowdown event, focusing on how well the vendor data captures the magnitude and duration of the speed reduction. Each slowdown is ultimately classified as 'Fully Captured', 'Partially Captured', or 'Failed to Capture' according to the following rules:

- 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.

Data Collection

Travel time samples were collected along 34 directional validation road segments outside Nashville, TN between March 22 and April 02, 2021. These validation segments are located along SR-1, and are defined based on WRTM sensor locations, which are shown in Figure 1. Table 1 contains the summary information for each data collection segment, including WRTM sensor latitude/longitudes and an active map link, which can be followed to view each data collection segment in detail. Please note 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.

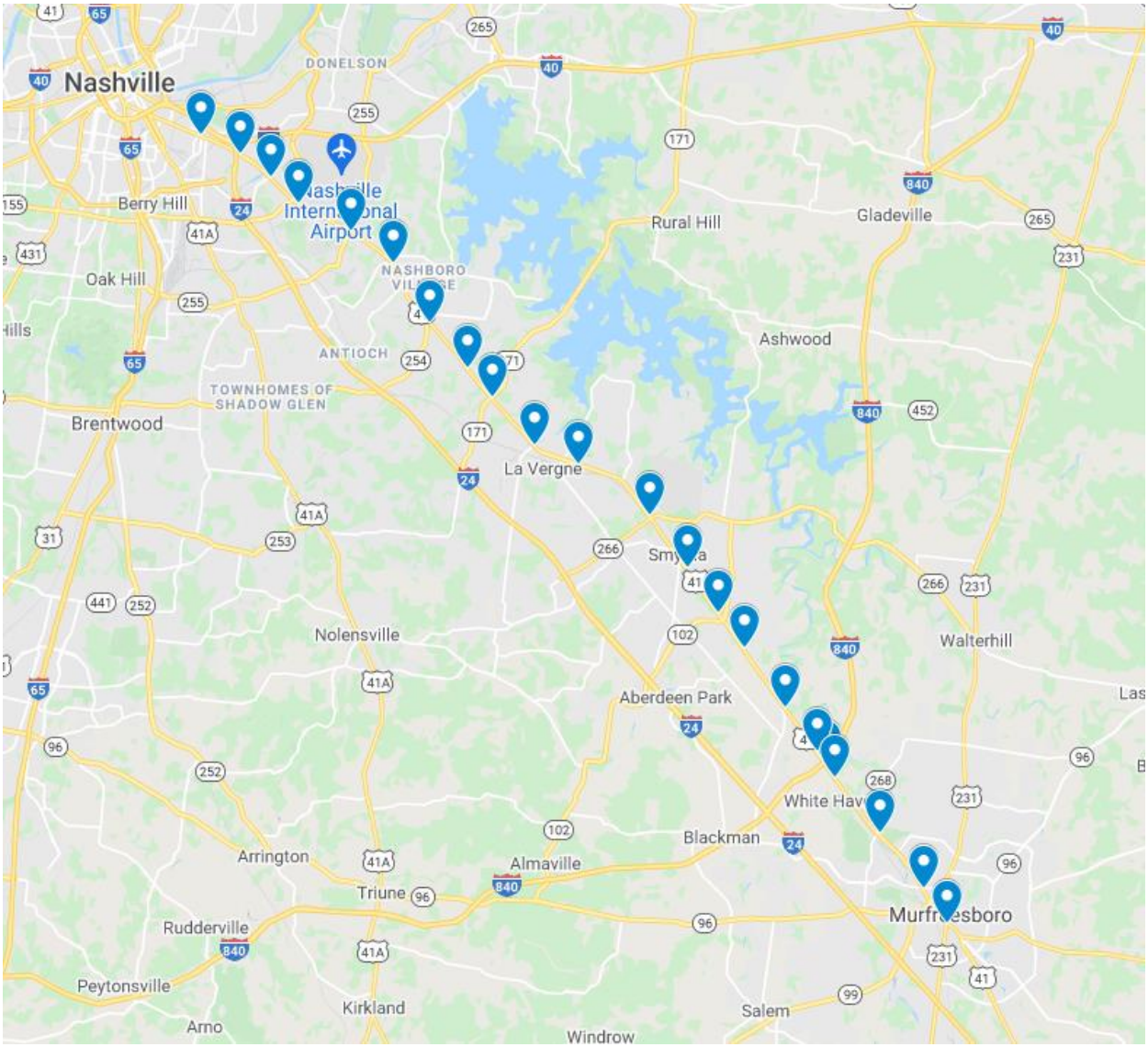

Figure 1 – WRTM Sensor locations

Table 1 - Validation Segment Attributes

Segment (Map Link)	DESCRIPTION						Deployment		
	Highway Direction	Starting at Ending at	Lane (Min) Lane (Max)	Signals Signal/mile	AADT	Access Points Speed Limit	Begin Lat/Lon End Lat/Lon		Length (mile)
Arterial									
A1 TN01-0001a	SR-1 Southbound	Fesslers Ln E Thompson Ln	2 2	9 4.10	25524	28 45	36.14282 36.12667	-86.74435 -86.71115	2.20
A2 TN01-0003	SR-1 Southbound	E Thompson Ln Donelson Pike	2 3	7 2.71	30085	20 45	36.12667 36.10623	-86.71115 -86.67304	2.58
A3 TN01-0004	SR-1 Southbound	Donelson Pike Franklin Limestone Rd	2 3	4 2.90	42349	11 45	36.10623 36.09442	-86.67304 -86.65334	1.38
A4 TN01-0005	SR-1 Southbound	Franklin Limestone Rd Bell Rd	2 3	9 4.79	36536	18 45	36.09442 36.07162	-86.65334 -86.63588	1.88
A5 TN01-0006	SR-1 Southbound	Bell Rd Mt View Rd	2 2	3 1.95	29816	9 45	36.07162 36.05433	-86.63588 -86.61869	1.54
A6 TN01-0007	SR-1 Southbound	Mt View Rd Hobson Pike	2 2	2 1.92	29844	10 45	36.05433 36.04286	-86.61869 -86.60653	1.04
A7 TN01-0008	SR-1 Southbound	Hobson Pike Waldron Rd	2 2	3 1.75	31642	10 45	36.04286 36.02436	-86.60653 -86.58615	1.71
A8 TN01-0009	SR-1 Southbound	Waldron Rd Floyd Mayfield Dr	2 2	3 2.44	28743	17 45	36.02436 36.01749	-86.58615 -86.56629	1.23
A9 TN01-0010	SR-1 Southbound	Floyd Mayfield Dr Sam Ridley Pkwy (ramps)	2 2	5 2.06	26613	14 45	36.01749 35.99792	-86.56629 -86.53248	2.43
A10 TN01-0011	SR-1 Southbound	Sam Ridley Pkwy (ramps) Mayfield Dr	2 2	3 1.76	24190	9 45	35.99792 35.97777	-86.53248 -86.51485	1.71
A11 TN01-0012	SR-1 Southbound	Mayfield Dr Lee Victory Pkwy (ramps)	2 2	6 4.23	20929	15 45	35.97777 35.96106	-86.51485 -86.50016	1.42
A12 TN01-0013	SR-1 Southbound	Lee Victory Pkwy (ramps) Sam Griffin Rd	2 2	0 0.00	29216	6 45	35.96106 35.94698	-86.50016 -86.48795	1.19

Segment (Map Link)	DESCRIPTION						Deployment		
	Highway Direction	Starting at Ending at	Lane (Min) Lane (Max)	Signals Signal/mile	AADT	Access Points Speed Limit	Begin Lat/Lon End Lat/Lon		Length (mile)
Arterial									
A13	SR-1	Sam Griffin Rd	2	1	31980	11	35.94698	-86.48795	1.90
TN01-0014	Southbound	Florence Rd	2	0.53		55	35.92461	-86.46827	
A14	SR-1	Florence Rd	2	1	32674	9	35.92461	-86.46827	1.42
TN01-0015	Southbound	#N/A	2	0.70		55	35.90791	-86.45334	
A15	SR-1	#N/A	2	0	44279	11	35.89816	-86.44508	1.88
TN01-0016	Southbound	N Thompson Ln	2	0.00		55	35.87651	-86.42468	
A16	SR-1	N Thompson Ln	2	2	27801	20	35.87651	-86.42468	1.88
TN01-0017	Southbound	Medical Center Pkwy	2	1.06		45	35.85566	-86.40341	
A17	SR-1	Medical Center Pkwy	2	3	33589	16	35.85566	-86.40341	1.13
TN01-0018	Southbound	Shelbyville Hwy	2	2.66		45	35.84229	-86.39202	
A18	SR-1	Shelbyville Hwy	2	3	33589	16	35.84229	-86.39202	1.13
TN01-0019	Northbound	Medical Center Pkwy	2	2.66		45	35.85566	-86.40341	
A19	SR-1	Medical Center Pkwy	2	2	27800	22	35.85566	-86.40341	1.89
TN01-0020	Northbound	N Thompson Ln	2	1.06		45	35.87664	-86.42452	
A20	SR-1	N Thompson Ln	2	1	44340	12	35.87664	-86.42452	1.88
TN01-0021	Northbound	#N/A	2	0.53		55	35.89829	-86.44497	
A21	SR-1	#N/A	2	0	31980	9	35.90801	-86.45321	1.42
TN01-0022	Northbound	Florence Rd	2	0.0		55	35.92469	-86.46812	
A22	SR-1	Florence Rd	2	1	31980	14	35.92469	-86.46812	1.90
TN01-0023	Northbound	Sam Griffin Rd	2	0.53		55	35.94707	-86.48779	
A23	SR-1	Sam Griffin Rd	2	1	29447	8	35.94707	-86.48779	1.19
TN01-0024	Northbound	Lee Victory Pkwy (ramps)	2	0.84		45	35.96117	-86.50003	
A24	SR-1	Lee Victory Pkwy (ramps)	2	6	20772	18	35.96117	-86.50003	1.42
TN01-0025	Northbound	Mayfield Dr	2	4.24		45	35.97777	-86.51485	

Segment (Map Link)	DESCRIPTION						Deployment		
	Highway Direction	Starting at Ending at	Lane (Min) Lane (Max)	Signals Signal/mile	AADT	Access Points Speed Limit	Begin Lat/Lon End Lat/Lon		Length (mile)
Arterial									
A25	SR-1	Mayfield Dr	2	3	24173	9	35.97777	-86.51485	1.71
TN01-0026	Northbound	Sam Ridley Pkwy (ramps)	2	1.76		45	35.99802	-86.53232	
A26	SR-1	Sam Ridley Pkwy (ramps)	2	5	26588	13	35.99802	-86.53232	2.44
TN01-0027	Northbound	Floyd Mayfield Dr	2	2.05		45	36.01765	-86.56625	
A27	SR-1	Floyd Mayfield Dr	2	3	28799	16	36.01765	-86.56625	1.22
TN01-0028	Northbound	Waldron Rd	2	2.46		45	36.02444	-86.58601	
A28	SR-1	Waldron Rd	2	3	31642	9	36.02472	-86.58632	1.69
TN01-0029	Northbound	Hobson Pike	2	1.78		45	36.04286	-86.60653	
A29	SR-1	Hobson Pike	2	2	29844	7	36.04286	-86.60653	1.04
TN01-0030	Northbound	Mt View Rd	2	1.92		45	36.05433	-86.61869	
A30	SR-1	Mt View Rd	2	3	29816	9	36.05433	-86.61869	1.54
TN01-0031	Northbound	Bell Rd	2	1.95		45	36.07162	-86.63588	
A31	SR-1	Bell Rd	2	9	36536	18	36.07162	-86.63588	1.88
TN01-0032	Northbound	Franklin Limestone Rd	3	4.79		45	36.09442	-86.65334	
A32	SR-1	Franklin Limestone Rd	2	4	42349	8	36.09442	-86.65334	1.38
TN01-0033	Northbound	Donelson Pike	3	2.90		45	36.10623	-86.67304	
A33	SR-1	Donelson Pike	2	7	30091	19	36.10623	-86.67304	2.58
TN01-0034	Northbound	E Thompson Ln	3	2.72		45	36.12673	-86.71101	
A34	SR-1	E Thompson Ln	2	10	25524	26	36.12673	-86.71101	2.20
TN01-0035a	Northbound	Spence Ln	2	4.54		45	36.14282	-86.74435	

Validation Results

Traditional Validation Results

HERE

Table 2 summarizes the error metrics computed between ground truth (i.e., WRTM) and HERE speeds. Average Absolute Speed Error (AASE) and Speed Error Bias (SEB) measures were each within specification for all speed bins – a result that held whether the 1.96 SEM Band or Mean reference speed was used as the basis for quantifying ground truth conditions.

Table 2 – HERE data quality measures

Speed Bin	Average Absolute Speed Error (<10mph)		Speed Error Bias (<5mph)		Number of 5 Minute Samples
	Comparison w/ 1.96 SEM Band	Comparison with Mean	Comparison w/ 1.96 SEM Band	Comparison with Mean	
0-15	3.46	5.02	3.3	4.67	384
15-25	2.58	5.25	2.43	4.49	5327
25-35	1.45	4.55	0.83	2.01	14892
35+	1.44	4.64	-0.61	-1.53	22466
All Speeds	1.6	4.69	0.3	0.49	43069

Table 3 shows the percentage of time the HERE data fell within 5mph of the mean and 1.96 SEM band for each speed bin.

Table 3 – Percent of HERE observations meeting data quality criteria

Speed Bin	Data Quality Measures for				Number of 5 Minute Samples
	1.96 SEM Band		Mean		
	Percent inside band	Percent within 5mph of band	Percent equal to mean	Percent within 5mph of mean	
0-15	20.3	75.6	-	60.4	384
15-25	42.0	79.2	-	56.1	5327
25-35	57.1	89.9	-	61.4	14892
35+	58.8	89.8	-	62.0	22466

Table 4 reports the error metrics on individual validation segments. Note that some segments and time bins only have a few observations, and thus may not be representative of the overall performance in each speed bin.

Table 4 – HERE data quality measures by validation segment

Path	Sensor distance	Speed Bin	Data Quality Measures for				No. of Obs.
			Avg Absolute Speed Error		Speed Error Bias		
			1.96 SEM Band	Mean	1.96 SEM Band	Mean	
TN01-0001a	2.20	0-15	2.62	5.25	2.62	5.05	28
		15-25	1.23	3.9	1.01	2.86	301
		25-35	0.88	3.72	-0.66	-2.44	234
		35+	2.89	6.88	-2.89	-6.59	28
TN01-0003	2.58	0-15	1.71	3.09	1.71	3.05	23
		15-25	3.39	6.15	3.39	6.09	29
		25-35	1.18	3.82	0.98	2.52	347
		35+	1.28	4.14	-1.14	-2.83	228
TN01-0004	1.38	0-15	1.62	2.19	1.11	1.33	77
		15-25	4.24	5.9	3.43	4.42	74
		25-35	2.25	5.31	1.57	3.34	383
		35+	1.35	4.28	-0.75	-1.54	979
TN01-0005	1.88	0-15	3.97	5.33	3.84	5.07	59
		15-25	1.68	3.67	1.48	2.88	641
		25-35	1.01	3.52	0.32	0.82	330
		35+	1.53	4.96	-1.53	-4.63	40
TN01-0006	1.54	0-15	10.27	11.88	10.14	11.57	24
		15-25	4.02	6.41	3.78	5.9	343
		25-35	1.25	3.98	0.81	1.91	1023
		35+	1.17	4.69	-0.97	-3.03	270
TN01-0007	1.04	0-15	4.67	9.32	4.67	9.32	1
		15-25	2.61	5.61	2.47	4.77	142
		25-35	1.42	5.06	0.68	1.92	619
		35+	2.05	5.96	-1.9	-4.35	1038
TN01-0008	1.71	0-15	2.59	3.68	2.59	3.68	19
		15-25	3.09	5.4	3.08	4.98	148
		25-35	1.45	4.53	1.09	2.79	747
		35+	1.03	3.88	-0.43	-1.11	723
TN01-0009	1.23	0-15	11.8	14.7	11.8	14.7	3
		15-25	4.61	8.05	4.61	8.04	233
		25-35	1.54	4.53	1.36	3.7	1040
		35+	0.57	2.91	-0.43	-1.47	162
TN01-0010	2.43	0-15	-	-	-	-	-
		15-25	-	-	-	-	-
		25-35	2.26	5.39	1.6	3.32	12
		35+	2.51	6.6	-2.49	-6.27	818
TN01-0011	1.71	0-15	-	-	-	-	-
		15-25	0.81	2.62	0.81	2.36	3
		25-35	0.64	3.1	-0.13	-0.63	380
		35+	1.77	4.96	-1.73	-4.48	318

Path	Sensor distance	Speed Bin	Data Quality Measures for				No. of Obs.
			Avg Absolute Speed Error		Speed Error Bias		
			1.96 SEM Band	Mean	1.96 SEM Band	Mean	
TN01-0012	1.42	0-15	-	-	-	-	-
		15-25	9.31	12.42	9.31	12.42	30
		25-35	2.83	7.21	2.83	7.17	520
		35+	0.54	3.05	-0.26	-0.46	278
TN01-0013	1.19	0-15	-	-	-	-	-
		15-25	-	-	-	-	-
		25-35	3.36	6.72	3.29	6.25	53
		35+	1.03	4.17	-0.72	-2.12	1293
TN01-0014	1.90	0-15	1.65	2.68	1.54	2.31	6
		15-25	5.73	6.93	5.66	6.68	40
		25-35	4.85	7.45	3.84	5.71	69
		35+	1.19	3.95	0.35	1.2	1685
TN01-0015	1.41	0-15	-	-	-	-	-
		15-25	-	-	-	-	-
		25-35	16.06	23.87	16.06	23.87	1
		35+	1.86	6.05	-1.73	-5.34	1793
TN01-0016	1.88	0-15	2.59	3.13	2.59	3.13	7
		15-25	3.64	5.13	3.53	4.94	89
		25-35	4.82	8.46	4.7	7.97	202
		35+	1.76	5.29	1.5	4.17	1637
TN01-0017	1.88	0-15	-	-	-	-	-
		15-25	1.23	3.42	1.18	2.95	73
		25-35	0.72	3.19	0.26	0.44	600
		35+	1.38	4.45	-1.31	-3.99	234
TN01-0018	1.13	0-15	1.03	3.05	0.32	0.58	14
		15-25	0.54	2.51	0.22	0.29	279
		25-35	1.35	4.92	-1.2	-3.89	714
		35+	4.76	9.89	-4.76	-9.89	149
TN01-0019	1.13	0-15	3.23	6.58	3.23	6.58	9
		15-25	0.84	3.33	0.61	1.26	431
		25-35	1.01	4.42	-0.64	-2.56	485
		35+	3.13	7.53	-3.13	-7.4	129
TN01-0020	1.89	0-15	0.98	2.51	0.98	2.51	11
		15-25	2.02	4.7	1.99	4.42	123
		25-35	1.01	3.6	0.54	1.5	614
		35+	1.41	4.23	-1.19	-3.21	224
TN01-0021	1.88	0-15	-	-	-	-	-
		15-25	-	-	-	-	-
		25-35	-	-	-	-	-
		35+	0.71	2.76	-0.02	-0.24	1954
TN01-0022	0.42	0-15	-	-	-	-	-
		15-25	9.07	12.89	9.07	12.89	5
		25-35	14.54	17.96	14.54	17.96	10
		35+	1.32	4.68	0.68	1.99	1863
TN01-0023	1.90	0-15	-	-	-	-	-
		15-25	11.96	13.79	11.96	13.79	6
		25-35	4.78	7.72	4.33	6.5	23
		35+	1.12	3.81	0.17	0.53	1848
TN01-0024	1.19	0-15					

Path	Sensor distance	Speed Bin	Data Quality Measures for				No. of Obs.
			Avg Absolute Speed Error		Speed Error Bias		
			1.96 SEM Band	Mean	1.96 SEM Band	Mean	
		15-25	-	-	-	-	-
		25-35	-	-	-	-	-
		35+	1.97	5.25	-1.73	-4.25	1135
TN01-0025	1.42	0-15	-	-	-	-	-
		15-25	7.22	11.09	7.22	11.09	89
		25-35	1.89	5.71	1.86	5.22	492
		35+	0.77	3.55	-0.52	-1.58	153
TN01-0026	1.71	0-15	-	-	-	-	-
		15-25	-	-	-	-	-
		25-35	0.76	2.67	-0.08	0.02	162
		35+	1.95	5.5	-1.92	-5.27	623
TN01-0027	2.44	0-15	-	-	-	-	-
		15-25	-	-	-	-	-
		25-35	0.87	2.72	0.08	-0.4	49
		35+	1.55	4.57	-1.49	-4.01	566
TN01-0028	1.22	0-15	4.5	6.52	4.5	6.48	93
		15-25	3.56	7.62	3.55	7.48	763
		25-35	1.22	4.95	1.04	4.01	742
		35+	1.64	4.27	-1.62	-3.51	42
TN01-0029	1.69	0-15	2.57	3.52	2.57	3.52	3
		15-25	2.62	4.96	2.54	4.62	48
		25-35	1.67	4.63	1.24	2.73	825
		35+	1.06	3.84	-0.5	-1.2	757
TN01-0030	1.04	0-15	-	-	-	-	-
		15-25	3.15	5.73	3.08	5.26	320
		25-35	1.62	4.31	1.07	2.33	1292
		35+	1.14	4.63	-0.48	-0.9	234
TN01-0031	1.54	0-15	-	-	-	-	-
		15-25	2.97	5.75	2.91	5.3	359
		25-35	1.24	4.09	0.59	1.27	1096
		35+	1.54	4.97	-1.22	-2.32	188
TN01-0032	1.88	0-15	0.56	3.08	0.56	3.08	3
		15-25	1.47	3.35	1.24	2.53	344
		25-35	0.92	3.59	-0.04	-0.56	438
		35+	2.56	5.53	-2.31	-4.49	190
TN01-0033	1.38	0-15	-	-	-	-	-
		15-25	4.63	9.36	4.63	9.34	77
		25-35	1.27	5.99	1.23	5.18	726
		35+	0.8	4.66	-0.59	-1.6	599
TN01-0034	2.58	0-15	-	-	-	-	-
		15-25	5.15	8.25	5.15	8.25	15
		25-35	0.96	3.69	0.63	1.42	425
		35+	1.44	4.85	-1.34	-4.19	270
TN01-0035a	2.20	0-15	2.36	6.15	2.36	6.15	4
		15-25	0.87	3.16	0.6	1.78	322
		25-35	1.37	4.14	-1.18	-2.95	239
		35+	4.3	7.68	-4.3	-7.68	18

INRIX

Table 5 summarizes the error metrics computed between ground truth (i.e., WRTM) and INRIX speeds. Average Absolute Speed Error (AASE) and Speed Error Bias (SEB) measures were each within specification for all speed bins – a result that held whether the 1.96 SEM Band or Mean reference speed was used as the basis for quantifying ground truth conditions.

Table 5– INRIX data quality measures

Speed Bin	Average Absolute Speed Error (<10mph)		Speed Error Bias (<5mph)		Number of 5 Minute Samples
	Comparison w/ 1.96 SEM Band	Comparison with Mean	Comparison w/ 1.96 SEM Band	Comparison with Mean	
0-15	2.63	4.23	2.51	3.93	342
15-25	2.5	5.29	2.4	4.72	5260
25-35	1.26	4.27	0.9	2.47	14820
>35	1.35	4.59	-0.18	-0.56	22388
All Speeds	1.47	4.56	0.53	1.17	42810

Table 6 shows the percentage of time the INRIX data fell within 5mph of the mean and 1.96 SEM band for each speed bin.

Table 6– Percent of INRIX observations meeting data quality criteria

Speed Bin	Data Quality Measures for				Number of 5 Minute Samples.
	1.96 SEM Band		Mean		
	Percent inside band	Percent within 5mph of band	Percent equal to mean	Percent within 5mph of mean	
0-15	25.4	83.0	-	70.5	342
15-25	40.5	79.6	-	55.4	5260
25-35	59.5	91.7	-	65.2	14820
35+	58.7	90.7	-	61.6	22388

Table 7 reports the standard error metrics on individual validation segments. Note that some segments and time bins only have a few observations, and thus may not be representative of the overall performance in each speed bin.

Table 7 – INRIX data quality measures by validation segment

Path	Sensor distance	Speed Bin	Data Quality Measures for				No. of Obs.
			Avg Absolute Speed Error		Speed Error Bias		
			1.96 SEM Band	Mean	1.96 SEM Band	Mean	
TN01-0001a	2.20	0-15	3.16	5.78	3.16	5.6	26
		15-25	1.17	3.92	0.99	3.03	291
		25-35	0.84	3.34	-0.74	-2.4	233
		35+	3.76	8.3	-3.76	-8.3	28
TN01-0003	2.58	0-15	2.68	4.34	2.68	4.34	12
		15-25	3.6	6.46	3.6	6.46	28
		25-35	1.15	3.96	1.07	3.34	349
		35+	0.74	3.35	-0.57	-2.1	229
TN01-0004	1.38	0-15	0.99	1.54	0.37	0.35	63
		15-25	1.75	3.3	1.26	1.83	74
		25-35	1.21	3.81	0.64	2.09	385
		35+	0.82	3.41	-0.53	-1.55	979
TN01-0005	1.88	0-15	2.63	4.05	2.59	3.95	50
		15-25	0.88	2.66	0.62	1.37	637
		25-35	0.75	3.14	-0.3	-0.94	330
		35+	2.63	6.27	-2.59	-5.73	40
TN01-0006	1.54	0-15	1.87	3.1	1.87	2.89	19
		15-25	3.09	5.42	3.06	5.31	338
		25-35	1.17	3.84	1	2.72	1020
		35+	0.84	4.05	-0.66	-2.48	269
TN01-0007	1.04	0-15	-	-	-	-	-
		15-25	2.17	4.92	2.16	4.44	135
		25-35	0.84	3.96	0.27	1.15	618
		35+	1.81	5.91	-1.75	-5.2	1036
TN01-0008	1.71	0-15	3.58	4.74	3.58	4.74	19
		15-25	1.46	3.45	1.19	2.19	144
		25-35	1.2	4.19	0.99	3.07	741
		35+	0.78	3.37	-0.25	-0.88	721
TN01-0009	1.23	0-15	12.72	15.61	12.72	15.61	3
		15-25	4.77	8.36	4.77	8.36	230
		25-35	1.43	4.46	1.37	4.07	1033
		35+	0.68	3.3	-0.31	-1.45	163
TN01-0010	2.43	0-15	-	-	-	-	-
		15-25	-	-	-	-	-
		25-35	1.62	4.04	0.78	1.57	12
		35+	2.45	6.6	-2.39	-6.3	818
TN01-0011	1.71	0-15	-	-	-	-	-
		15-25	1.88	4.3	1.88	4.3	3
		25-35	0.41	2.74	0.13	-0.07	380
		35+	1.28	4.43	-1.2	-3.72	318
TN01-0012	1.42	0-15	-	-	-	-	-
		15-25	7.32	10.36	7.32	10.36	30

Path	Sensor distance	Speed Bin	Data Quality Measures for				No. of Obs.
			Avg Absolute Speed Error		Speed Error Bias		
			1.96 SEM Band	Mean	1.96 SEM Band	Mean	
		25-35	1.79	5.27	1.76	4.97	511
		35+	0.69	3.44	-0.55	-1.45	278
TN01-0013	1.19	0-15	-	-	-	-	-
		15-25	-	-	-	-	-
		25-35	4.7	8.25	4.7	8.25	53
		35+	0.92	4.15	0.64	2.25	1286
TN01-0014	1.90	0-15	0.35	1.21	0.35	0.86	6
		15-25	1.9	2.86	1.03	1.25	40
		25-35	3.78	6.47	3.12	4.7	69
		35+	1.32	4.25	1.06	3.09	1674
TN01-0015	1.41	0-15	-	-	-	-	-
		15-25	-	-	-	-	-
		25-35	18.78	26.59	18.78	26.59	1
		35+	1.89	6.21	-1.83	-5.72	1784
TN01-0016	1.88	0-15	0.41	0.87	0.16	0.15	7
		15-25	1.69	3.07	1.52	2.41	85
		25-35	5.49	9.18	5.44	8.93	196
		35+	2.37	6.38	2.32	6.06	1632
TN01-0017	1.88	0-15	-	-	-	-	-
		15-25	2.47	5.27	2.47	5.27	71
		25-35	0.7	3.04	0.63	2.16	596
		35+	0.94	3.76	-0.8	-2.8	233
TN01-0018	1.13	0-15	0.78	2.48	0.78	1.99	14
		15-25	0.38	2.36	0.21	0.23	279
		25-35	1.12	4.57	-0.99	-3.74	713
		35+	4.63	9.82	-4.63	-9.81	148
TN01-0019	1.13	0-15	1.67	4.67	1.67	4.67	9
		15-25	1	3.67	0.96	3.08	431
		25-35	0.48	3.39	-0.14	-1.49	484
		35+	2.67	6.84	-2.63	-6.66	129
TN01-0020	1.89	0-15	0.26	1.47	0.26	1.47	11
		15-25	2.23	5.08	2.17	4.67	120
		25-35	0.86	3.43	0.68	2.4	610
		35+	1.02	3.88	-0.72	-2.38	224
TN01-0021	1.88	0-15	-	-	-	-	-
		15-25	-	-	-	-	-
		25-35	-	-	-	-	-
		35+	0.57	2.65	-0.2	-0.86	1942
TN01-0022	0.42	0-15	-	-	-	-	-
		15-25	0.66	3.75	0.66	3.75	5
		25-35	12.44	16.03	12.44	16.03	10
		35+	1.76	5.52	1.58	4.61	1853
TN01-0023	1.90	0-15	-	-	-	-	-
		15-25	5.04	6.61	5.04	6.61	6
		25-35	3.92	6.65	3.92	6.63	23
		35+	1.01	3.69	0.73	2.09	1837
TN01-0024	1.19	0-15	-	-	-	-	-
		15-25	-	-	-	-	-
		25-35	-	-	-	-	-
		35+	1.1	3.96	-0.85	-2.44	1128

Path	Sensor distance	Speed Bin	Data Quality Measures for				No. of Obs.
			Avg Absolute Speed Error		Speed Error Bias		
			1.96 SEM Band	Mean	1.96 SEM Band	Mean	
TN01-0025	1.42	0-15	-	-	-	-	-
		15-25	6.93	10.72	6.93	10.72	88
		25-35	1.84	5.73	1.84	5.54	487
		35+	0.83	3.7	-0.09	-0.72	153
TN01-0026	1.71	0-15	-	-	-	-	-
		15-25	-	-	-	-	-
		25-35	0.53	2.52	-0.09	-1.07	162
		35+	2.11	5.95	-2.06	-5.77	623
TN01-0027	2.44	0-15	-	-	-	-	-
		15-25	-	-	-	-	-
		25-35	0.69	2.92	0.41	0.72	49
		35+	0.98	3.61	-0.87	-2.73	566
TN01-0028	1.22	0-15	4.2	6.34	4.2	6.34	93
		15-25	5.38	9.98	5.38	9.95	754
		25-35	1.65	6.1	1.61	5.91	742
		35+	0.69	2.93	-0.26	-1.58	43
TN01-0029	1.69	0-15	2.64	3.59	2.64	3.59	3
		15-25	2.65	5.51	2.65	5.43	46
		25-35	1.44	4.27	1.31	3.44	819
		35+	0.57	3.1	-0.15	-0.51	756
TN01-0030	1.04	0-15	-	-	-	-	-
		15-25	2.18	4.67	2.08	3.97	317
		25-35	1.32	3.76	1	2.33	1284
		35+	1.33	5.26	-0.92	-2.58	234
TN01-0031	1.54	0-15	-	-	-	-	-
		15-25	2.45	5.16	2.45	5.08	356
		25-35	0.97	3.44	0.73	1.75	1091
		35+	1.2	4.8	-0.64	-2.11	189
TN01-0032	1.88	0-15	1.97	4.77	1.97	4.77	3
		15-25	1.33	3.14	1.2	2.47	340
		25-35	0.68	3.09	0.05	-0.31	436
		35+	2.13	5.31	-2.02	-4.42	189
TN01-0033	1.38	0-15	-	-	-	-	-
		15-25	6.66	12.56	6.66	12.56	77
		25-35	1.93	7.56	1.92	7.39	723
		35+	0.55	3.95	-0.26	-0.35	597
TN01-0034	2.58	0-15	-	-	-	-	-
		15-25	6.43	9.65	6.43	9.65	15
		25-35	0.94	3.63	0.83	2.69	422
		35+	1	4.09	-0.83	-3.02	271
TN01-0035a	2.20	0-15	2.99	6.99	2.99	6.99	4
		15-25	1.51	4.58	1.5	4.47	320
		25-35	0.64	2.82	-0.24	-0.79	238
		35+	3.01	6.28	-3.01	-6.13	18

TomTom

Table 8 summarizes the error metrics computed between ground truth (i.e., WRTM) and TomTom speeds. Average Absolute Speed Error (AASE) and Speed Error Bias (SEB) measures were each within specification for all speed bins – a result that held whether the 1.96 SEM Band or Mean reference speed was used as the basis for quantifying ground truth conditions.

Table 8 – TomTom data quality measures

Speed Bin	Average Absolute Speed Error (<10mph)		Speed Error Bias (<5mph)		Number of 5 Minute Samples
	Comparison w/ 1.96 SEM Band	Comparison with Mean	Comparison w/ 1.96 SEM Band	Comparison with Mean	
0-15	1.03	2.27	0.94	1.92	384
15-25	1.19	3.5	1.1	2.73	5327
25-35	0.86	3.54	0.54	1.62	14898
>35	1.29	4.4	0.28	0.64	22473
All Speeds	1.13	3.97	0.48	1.25	43082

Table 9 shows the percentage of time the TomTom data fell within 5 mph of the mean and SEM band for each speed bin.

Table 9 – Percent of TomTom observations meeting data quality criteria

Speed Bin	Data Quality Measures for				Number of 5 Minute Samples.
	1.96 SEM Band		Mean		
	Percent inside band	Percent within 5mph of band	Percent equal to mean	Percent within 5mph of mean	
0-15	47.9	94.3	-	89.1	384
15-25	59.1	92.6	-	74.7	5327
25-35	67.0	95.4	-	74.8	14898
35+	60.3	91.5	-	64.2	22473

Table 10 reports the standard error metrics on individual validation segments. Note that some segments and time bins only have a few observations, and thus may not be representative of the overall performance in each speed bin.

Table 10 – TomTom data quality measures by validation segment

Path	Sensor distance	Speed Bin	Data Quality Measures for				No. of Obs.
			Avg Absolute Speed Error		Speed Error Bias		
			1.96 SEM Band	Mean	1.96 SEM Band	Mean	
TN01-0001a	2.20	0-15	4.4	7.24	4.4	7.24	28
		15-25	1.54	4.75	1.45	4.38	301
		25-35	0.47	2.71	-0.18	-0.45	234
		35+	1.96	5.7	-1.96	-5.7	28
TN01-0003	2.58	0-15	1.21	2.5	1.21	2.47	23
		15-25	2.08	4.68	2.08	4.52	29
		25-35	0.84	3.34	0.82	2.85	349
		35+	0.7	3.32	-0.66	-2.58	229
TN01-0004	1.38	0-15	0.42	0.91	0.22	0.39	77
		15-25	0.85	2.37	0.78	1.87	74
		25-35	1.64	4.75	1.58	4.16	385
		35+	0.42	2.72	-0.13	-0.13	979
TN01-0005	1.88	0-15	0.9	1.9	0.81	1.64	59
		15-25	0.52	2.08	0.38	1.19	641
		25-35	0.49	2.41	-0.03	-0.18	330
		35+	2.35	6.55	-2.35	-6.55	40
TN01-0006	1.54	0-15	0.9	1.99	0.9	1.64	24
		15-25	1.31	3.3	1.31	3.06	343
		25-35	0.77	3.33	0.7	2.34	1023
		35+	0.79	3.87	-0.77	-3.35	270
TN01-0007	1.04	0-15	0	3.05	0	3.05	1
		15-25	1.01	3.33	0.97	2.61	142
		25-35	0.62	3.54	0.21	1.46	620
		35+	1.42	5.05	-1.41	-4.8	1038
TN01-0008	1.71	0-15	0.81	1.67	0.42	0.79	19
		15-25	0.48	1.87	0.4	0.57	148
		25-35	0.75	3.45	0.57	2.03	747
		35+	0.56	3.04	-0.29	-1.29	724
TN01-0009	1.23	0-15	2.16	5.06	2.16	5.06	3
		15-25	2.23	5.12	2.22	4.91	233
		25-35	0.84	3.48	0.64	2.46	1040
		35+	1.09	3.98	-1.09	-3.76	163
TN01-0010	2.43	0-15	-	-	-	-	-
		15-25	-	-	-	-	-
		25-35	3.28	7.2	3.28	7.2	12
		35+	0.65	3.26	-0.32	-1.07	818
TN01-0011	1.71	0-15	-	-	-	-	-
		15-25	1.71	4.69	1.71	4.69	3
		25-35	0.35	2.44	0.23	0.8	380
		35+	0.85	3.44	-0.82	-3.01	318
TN01-0012	1.42	0-15	-	-	-	-	-
		15-25	5.57	8.51	5.57	8.51	30

Path	Sensor distance	Speed Bin	Data Quality Measures for				No. of Obs.
			Avg Absolute Speed Error		Speed Error Bias		
			1.96 SEM Band	Mean	1.96 SEM Band	Mean	
		25-35	1.69	5.41	1.68	5.26	520
		35+	0.39	2.83	-0.25	-0.59	278
TN01-0013	1.19	0-15	-	-	-	-	-
		15-25	-	-	-	-	-
		25-35	4.66	8.37	4.66	8.37	53
		35+	0.97	4.21	0.74	2.83	1293
TN01-0014	1.90	0-15	3.15	4.08	3.15	4.08	6
		15-25	6.1	7.33	6.1	7.33	40
		25-35	6.76	9.7	6.76	9.7	69
		35+	2.8	6.37	2.75	6.13	1685
TN01-0015	1.41	0-15	-	-	-	-	-
		15-25	-	-	-	-	-
		25-35	17.97	25.78	17.97	25.78	1
		35+	1.34	4.71	-1.05	-3.07	1793
TN01-0016	1.88	0-15	1.16	1.66	1.16	1.66	7
		15-25	1.36	2.77	1.32	2.53	89
		25-35	3.13	6.67	3.13	6.63	202
		35+	0.96	4.16	0.89	3.43	1637
TN01-0017	1.88	0-15	-	-	-	-	-
		15-25	0.97	2.98	0.95	2.63	73
		25-35	0.34	2.4	0.14	0.37	600
		35+	1.28	4.25	-1.26	-3.96	234
TN01-0018	1.13	0-15	0.25	1.01	0.16	0.28	14
		15-25	0.23	2.01	0.11	-0.18	279
		25-35	0.9	3.96	-0.83	-3.36	714
		35+	4.18	9.36	-4.18	-9.36	149
TN01-0019	1.13	0-15	0.3	2.5	0.3	2.16	9
		15-25	0.46	2.49	0.23	0.32	431
		25-35	0.52	3.6	-0.43	-2.81	485
		35+	3.17	7.96	-3.17	-7.96	129
TN01-0020	1.89	0-15	0.73	2.25	0.73	2.25	11
		15-25	1.24	3.89	1.24	3.51	123
		25-35	0.7	3.2	0.61	2.3	614
		35+	0.85	3.43	-0.72	-2.63	224
TN01-0021	1.88	0-15	-	-	-	-	-
		15-25	-	-	-	-	-
		25-35	-	-	-	-	-
		35+	0.88	3.12	0.83	2.49	1954
TN01-0022	0.42	0-15	-	-	-	-	-
		15-25	0.15	1.91	0.15	0.97	5
		25-35	14.94	18.55	14.94	18.55	10
		35+	2.45	6.69	2.42	6.37	1863
TN01-0023	1.90	0-15	-	-	-	-	-
		15-25	2.22	3.67	2.22	3.67	6
		25-35	4.01	6.86	4.01	6.86	23
		35+	1.47	4.44	1.38	3.77	1848
TN01-0024	1.19	0-15	-	-	-	-	-
		15-25	-	-	-	-	-
		25-35	-	-	-	-	-
		35+	0.62	3.17	0.01	0.21	1135

Path	Sensor distance	Speed Bin	Data Quality Measures for				No. of Obs.
			Avg Absolute Speed Error		Speed Error Bias		
			1.96 SEM Band	Mean	1.96 SEM Band	Mean	
TN01-0025	1.42	0-15	-	-	-	-	-
		15-25	7.08	10.77	7.08	10.77	89
		25-35	2.39	6.84	2.39	6.74	492
		35+	0.5	3.22	0.04	0.81	153
TN01-0026	1.71	0-15	-	-	-	-	-
		15-25	-	-	-	-	-
		25-35	0.33	2.05	-0.01	-0.73	162
		35+	2.04	5.94	-2.03	-5.88	623
TN01-0027	2.44	0-15	-	-	-	-	-
		15-25	-	-	-	-	-
		25-35	2.3	5.88	2.3	5.88	49
		35+	0.65	3.2	0.48	2.05	566
TN01-0028	1.22	0-15	0.56	1.94	0.52	1.53	93
		15-25	1.2	4.18	1.17	3.73	763
		25-35	0.33	2.81	-0.01	0.61	742
		35+	2.9	6.94	-2.9	-6.94	43
TN01-0029	1.69	0-15	0.64	1.59	0.64	1.59	3
		15-25	1.91	4.78	1.87	4.59	48
		25-35	1.15	3.92	1.04	3.24	825
		35+	0.43	2.72	-0.15	-0.23	757
TN01-0030	1.04	0-15	-	-	-	-	-
		15-25	0.86	2.79	0.6	1.64	320
		25-35	0.68	2.88	0.02	0.19	1292
		35+	1.33	4.81	-1.33	-4.57	235
TN01-0031	1.54	0-15	-	-	-	-	-
		15-25	1.14	3.32	1.12	2.94	359
		25-35	0.59	2.93	0.4	1.24	1096
		35+	0.9	4.17	-0.9	-3.93	189
TN01-0032	1.88	0-15	1.74	4.25	1.74	4.25	3
		15-25	0.55	2.11	0.35	1.1	344
		25-35	0.4	2.78	0.04	0.15	438
		35+	1.63	4.56	-1.63	-4.54	190
TN01-0033	1.38	0-15	-	-	-	-	-
		15-25	2.15	6.55	2.15	6.47	77
		25-35	0.4	3.73	0.34	2.48	727
		35+	1.03	4.95	-1.02	-4.11	599
TN01-0034	2.58	0-15	-	-	-	-	-
		15-25	4.14	7.28	4.14	7.28	15
		25-35	0.54	2.85	0.26	0.9	425
		35+	1.11	4.45	-1.11	-4.12	271
TN01-0035a	2.20	0-15	3.85	8.59	3.85	8.59	4
		15-25	1.46	4.65	1.45	4.46	322
		25-35	0.43	2.38	-0.17	0	239
		35+	2.25	5.64	-2.25	-5.64	18

Slowdown Analysis Results

HERE

As summarized in Table 11, HERE data captured 20 of the 21 significant slowdowns observed during the data collection period. 15 of the 20 captured slowdowns were fully captured, while the remaining five were partially captured.

Table 11 – HERE Slowdown Analysis Summary

Significant Slowdowns	Fully Captured	Partially Captured	Not Captured
21	15	5	1

Figures 2-4 provide representative examples of significant slowdowns that were fully captured, partially captured, or not captured by HERE speed data. Each figure shows 24-hour speed data for both ground truth and HERE on a selected validation segment.

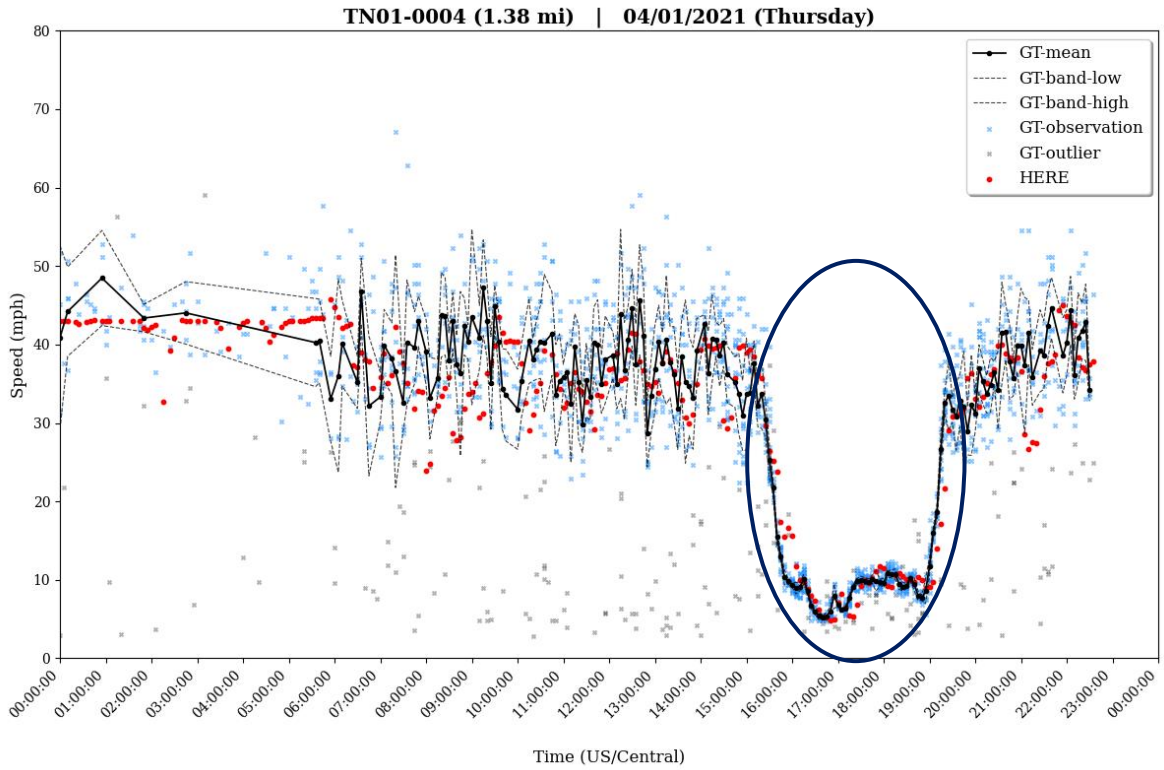

Figure 2 - Representative example of a fully captured slowdown: HERE

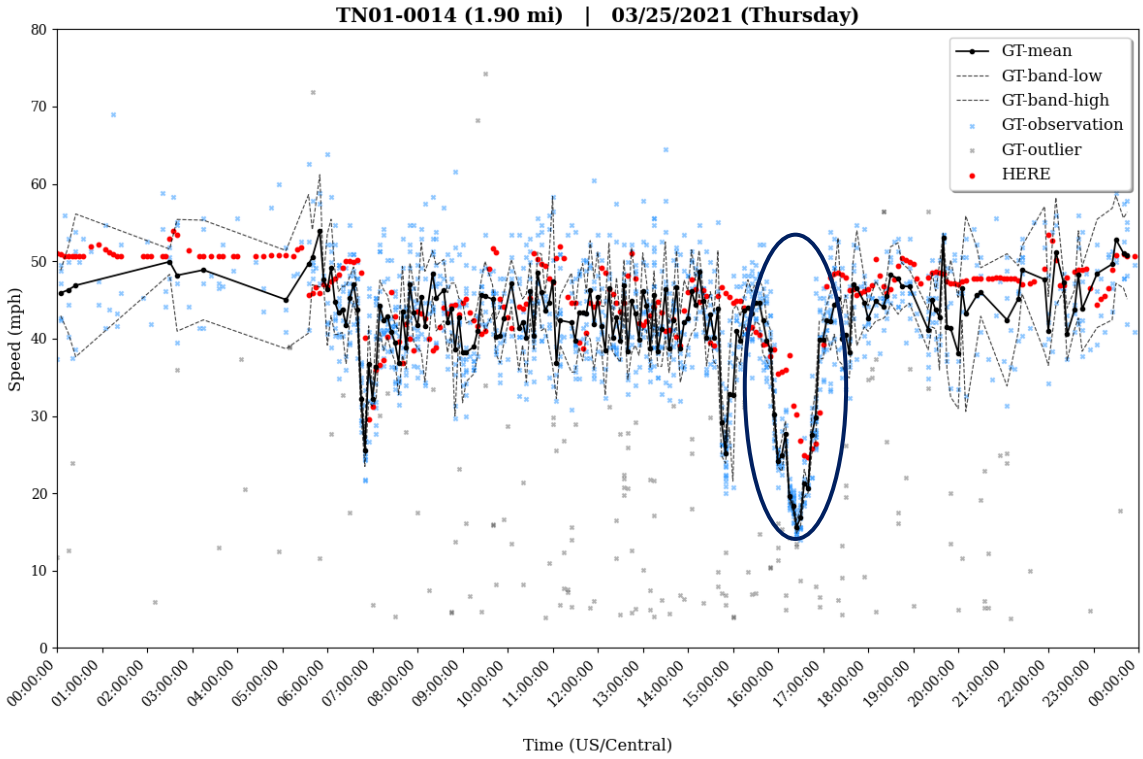

Figure 3 - Representative example of a partially captured slowdown: HERE

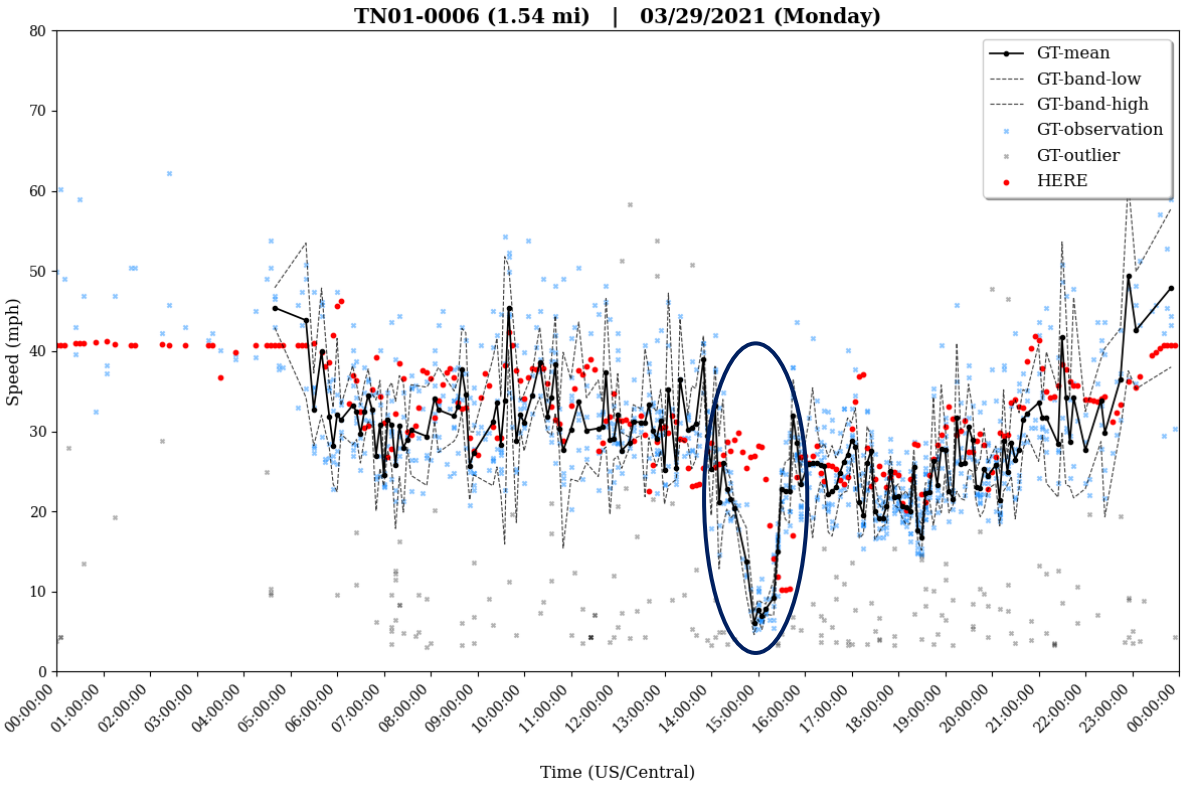

Figure 4 - Representative example of failure to capture a slowdown: HERE

INRIX

As summarized in Table 12, INRIX data captured 18 of the 21 significant slowdowns observed during the data collection period, with the remaining three falling during a period where speed data was unavailable. All 18 of the captured slowdowns were fully captured.

Table 12– INRIX Slowdown Analysis Summary

Significant Slowdowns	Fully Captured	Partially Captured	Not Captured	Missing Data
21	18	0	0	3

Figure 5 provides a representative example of a significant slowdown that was fully captured by INRIX speed data. The figure shows 24-hour speed data for both ground truth and INRIX on a selected validation segment.

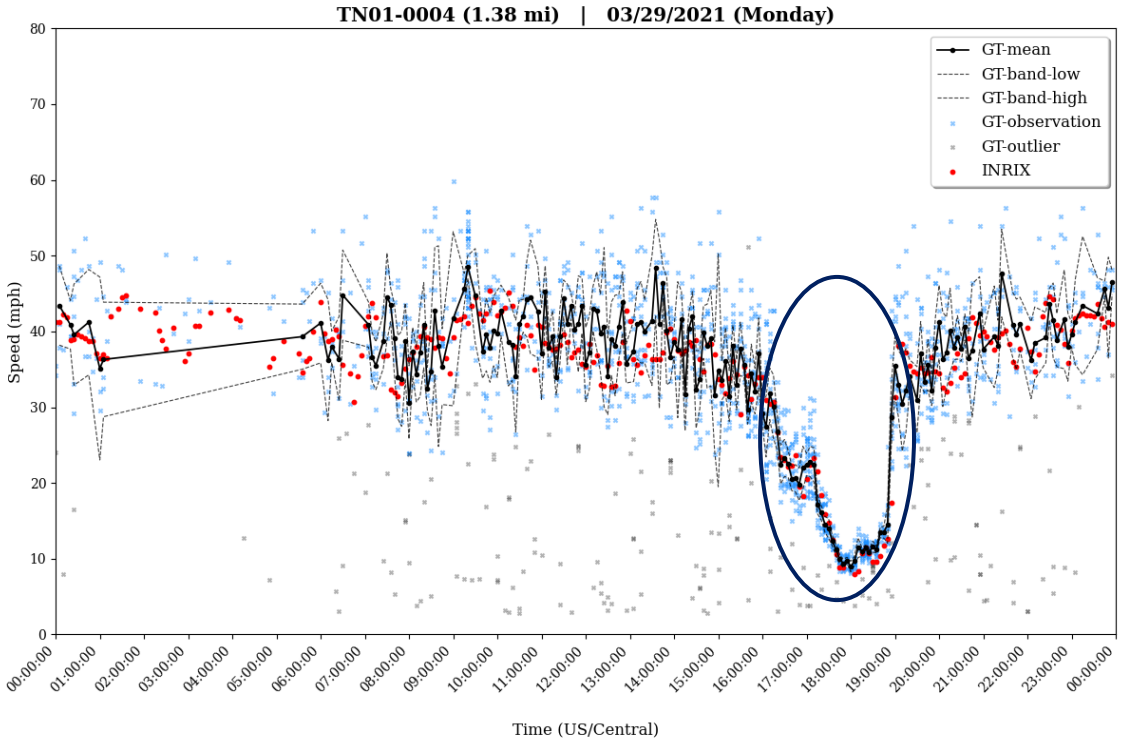

Figure 5 - Representative example of a fully captured slowdown: INRIX

TomTom

As summarized in Table 13, TomTom data captured 21 of the 21 significant slowdowns observed during the data collection period. Each of the 21 captured slowdowns was fully captured.

Table 13 – TomTom Slowdown Analysis Summary

Significant Slowdowns	Fully Captured	Partially Captured	Not Captured
21	21	0	0

Figure 6 provides a representative example of a significant slowdown that was fully captured by TomTom speed data. The figure shows 24-hour speed data for both ground truth and TomTom on a selected validation segment.

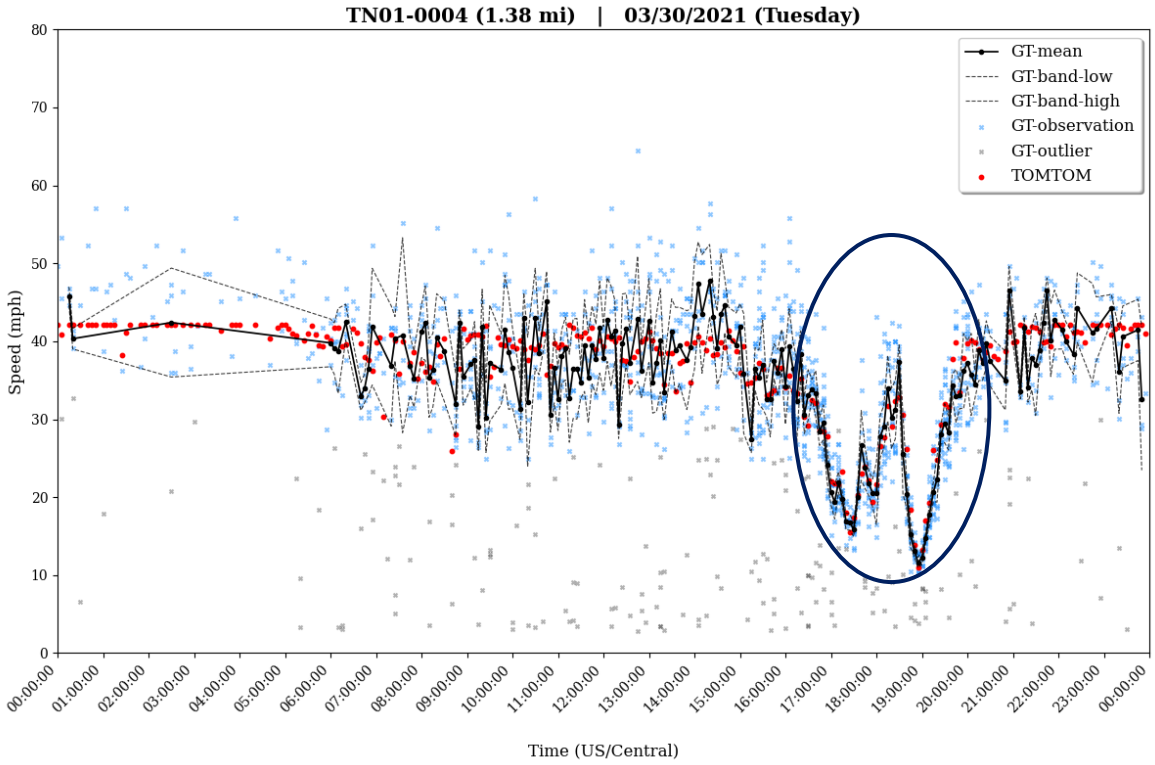

Figure 6 - Representative example of a fully captured slowdown: TomTom