Center for Advanced Transportation Technology Laboratory (CATT Lab)

National Performance Management Research Data Set (NPMRDS)

Data Quality Report

October 2018

Acknowledgments:

The research team would like to express its gratitude to Texas DOT, the city of Houston, TranStar and the Texas Transportation Institute for providing and helping facilitate acquisition of the re-identification data used to evaluate the NPMRDS probe data in this report.

Executive Summary

Wireless re-identification traffic monitoring (WRTM) data is collected to validate NPMRDS data. WRTM data includes Bluetooth, Wi-Fi and other wireless traffic monitoring devices that collect signals emitted by in-vehicle electronic equipment. Specifications used for comparison include the Average Absolute Speed Error (AASE) and the Speed Error Bias (SEB).

- Bluetooth and Wi-Fi re-identification sensors were deployed at the beginning and end of 20 different segments along the SH-6 corridor.
- SH-6 segments stretch from US-90A to Spencer Rd (FM-5269). (Figure 1).
- Travel time data was collected for both directions along the corridor, between April 1 and May 31, 2018.
- The dataset represents approximately 3285 hours of observations along the 20 arterial segments, whose total length is approximately 37 miles.
- The total number of effective five-minute travel time samples observed was 39,416.
- 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 summarizes the results of the comparison between the WRTM reference data and the NPMRDS data for all segments. Data quality measures meet the requirements in all speed categories for both SEB and AASE indicators.

ES Table 1- NPMRDS Arterial Evaluation Summary for Texas

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	2.24	4.22	1.78	3.08	2496
15-25 MPH	2.72	7.39	0.89	3.46	7753
25-35 MPH	2.84	7.01	-1.02	-0.16	14969
>35 MPH	3.53	7.42	-2.68	-3.52	14198
All Speeds	3.03	7.06	-1.07	-0.45	39416
Based upon data collected from April 1 to May 31 across 37 miles of roadway.					

Methodology

Corridor Description and Data Collection

Travel time samples were collected along 20 arterial segments with the assistance of Texas DOT, the city of Houston, TranStar, and the Texas Transportation Institute. The selected arterial segments are located on the SH-6 corridor from US-90A to the Spencer Rd (FM-5269). Travel time data was collected for both directions along the arterial segments between April 1 and May 31, 2018.

Figure 1 presents an overview snapshot of the sensor placements along SH-6 in Texas. Markers shows the start and end points of arterial segments selected for analysis.

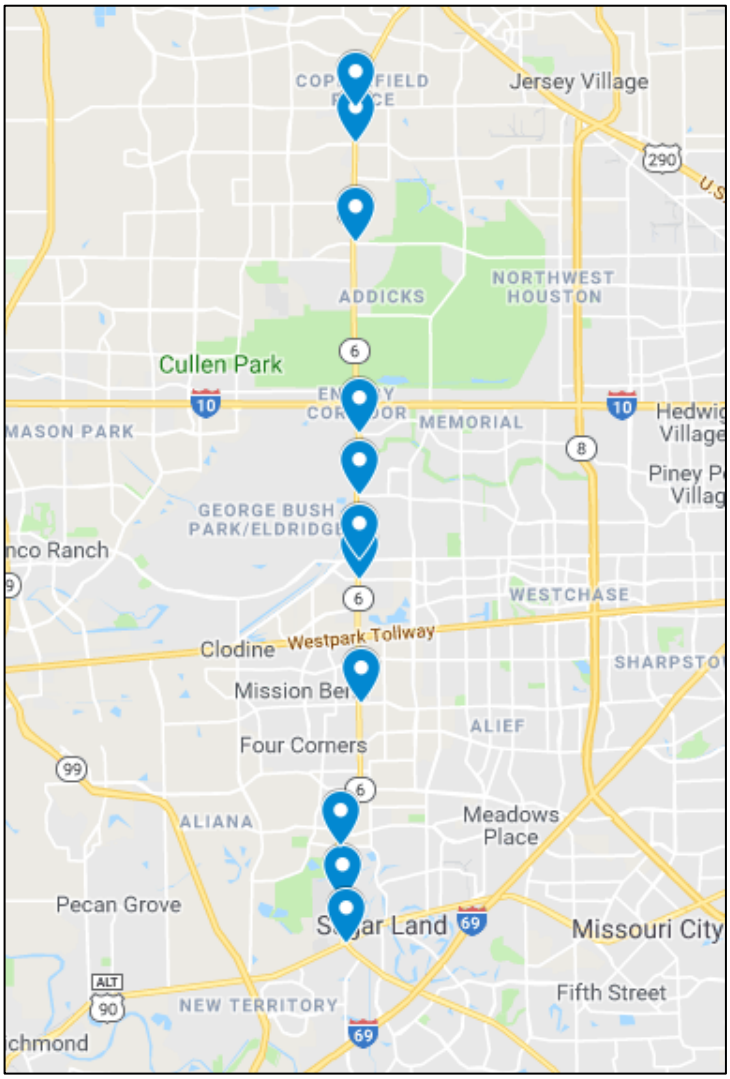

Figure 1- Locations of all segments selected on the SH-6 corridor for analysis in Texas

TMC segments selected for validation in Texas

Table 1 presents the data collection segments from Texas, whose endpoints are defined by permanent WRTM sensors that are deployed in the City of Houston and located along SH-6. The validation segments cover a total length of 37 arterial miles, are typically at least one mile in length, and are comprised of one or more Traffic Message Channel (TMC) base segments. The results of the validation performed on 20 directional arterial segments are included in this report.

Table 1 contains the summary information for each data collection segment, including the latitude/longitude coordinates of the locations at which the WRTM sensors were deployed along the SH-6 in Texas, as well as an active map link to view the data collection segment in detail. 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. The algorithm finds an equivalent probe travel time (and therefore travel speed) on the test segment of interest for each 5-minute interval.

Data Quality Measures

The following sections summarize the data quality measures based on comparison between WRTM and reported NPMRDS speeds for all vehicles. 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 NPMRDS and the ground truth mean speed for a specified time interval. The AASE is the primary accuracy metric. Based on the contract specifications, the speed data from the NPMRDS shall have a maximum average absolute error of 10 miles per hour (MPH) in each speed range: 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 NPMRDS consistently under or over estimates speed as compared to ground truth speed. The NPMRDS data shall have a maximum SEB of +/- 5 MPH in each of the previously-defined speed bins.

[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 Texas

Segment (Map Link)	DESCRIPTION						Deployment		
	Highway Direction	Starting at Ending at	Lane (Min) Lane (Max)	AADT	Signals Signal/mile	Access Points Speed Limit	Begin Lat/Lon End Lat/Lon		Length (mile)
A1	SH-6	US-90A	3	27,000	1	3	29.613312	-95.648997	0.96
TX-2018-01	Northbound	Imperial Blvd	4		1	45	29.62726	-95.650520	
A2	SH-6	Imperial Blvd	3	25,500	2	4	29.62726	-95.650520	1.2
TX-2018-02	Northbound	Voss Rd	3		1.7	55	29.644541	-95.651329	
A3	SH-6	Voss Rd	3	28,307	7	41	29.644541	-95.651329	3.1
TX-2018-03	Northbound	Beechnut St	3		2.2	50	29.689533	-95.643578	
A4	SH-6	Beechnut St	3	27,500	7	35	29.689533	-95.643578	2.7
TX-2018-04	Northbound	Richmond Ave	3		2.2	45	29.729282	-95.644234	
A5	SH-6	Richmond Ave	3	27,294	2	12	29.729282	-95.644234	0.4
TX-2018-05	Northbound	Westheimer Rd	3		5	45	29.735365	-95.644302	
A6	SH-6	Westheimer Rd	3	35,090	2	30	29.735365	-95.644302	1.4
TX-2018-06	Northbound	Briar Forest Dr	3		1.4	45	29.755726	-95.644340	
A7	SH-6	Briar Forest Dr	3	35,090	3	13	29.755726	-95.644340	1.4
TX-2018-07	Northbound	Memorial Dr	3		2.1	45	29.775480	-95.644325	
A8	SH-6	Memorial Dr	3	35,090	3	22	29.775480	-95.644325	4.2
TX-2018-08	Northbound	Clay Rd	4		0.7	55	29.836323	-95.645515	
A9	SH-6	Clay Rd	3	25,000	7	62	29.836323	-95.645515	2.2
TX-2018-09	Northbound	W Little York Rd	3		3.2	40	29.867769	-95.645401	
A10	SH-6	W Little York Rd	3	23,600	4	22	29.867769	-95.645401	0.8
TX-2018-10	Northbound	Spencer Rd (FM-5269)	3		5	40	29.879370	-95.645592	
A11	SH-6	Spencer Rd (FM-5269)	3	23,600	4	14	29.879370	-95.645592	0.8
TX-2018-11	Southbound	W Little York Rd	3		5	40	29.867769	-95.645401	

Segment (Map Link)	DESCRIPTION						Deployment		
	Highway Direction	Starting at Ending at	Lane (Min) Lane (Max)	AADT	Signals Signal/mile	Access Points Speed Limit	Begin Lat/Lon End Lat/Lon		Length (mile)
A12	SH-6	W Little York Rd	3	25,000	7	33	29.867769	-95.645401	2.2
TX-2018-12	Southbound	Clay Rd	3		3.2	40	29.836323	-95.645515	
A13	SH-6	Clay Rd	3	35,090	3	16	29.836323	-95.645515	4.2
TX-2018-13	Southbound	Memorial Dr	4		0.7	55	29.775480	-95.644325	
A14	SH-6	Memorial Dr	3	35,090	3	13	29.775480	-95.644325	1.4
TX-2018-14	Southbound	Briar Forest Dr	3		2.1	45	29.755726	-95.644340	
A15	SH-6	Briar Forest Dr	3	35,090	2	21	29.755726	-95.644340	1. 4
TX-2018-15	Southbound	Westheimer Rd	3		1.4	45	29.735365	-95.644302	
A16	SH-6	Westheimer Rd	3	27,294	2	6	29.735365	-95.644302	0.4
TX-2018-16	Southbound	Richmond Ave	3		5	45	29.729282	-95.644234	
A17	SH-6	Richmond Ave	3	27,500	7	37	29.729282	-95.644234	2.7
TX-2018-17	Southbound	Beechnut St	3		2.2	45	29.689533	-95.643578	
A18	SH-6	Beechnut St	3	28,946	7	42	29.689533	-95.643578	3.1
TX-2018-18	Southbound	Voss Rd	3		2.2	50	29.644541	-95.651329	
A19	SH-6	Voss Rd	3	25,500	2	11	29.644541	-95.651329	1.2
TX-2018-19	Southbound	Imperial Blvd	3		1.7	55	29.627260	-95.650520	
A20	SH-6	Imperial Blvd	3	27,000	1	5	29.627260	-95.650520	0.96
TX-2018-20	Southbound	US-90A	4		1	45	29.613312	-95.648997	

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. The AASE in the lower two speed bins have proven to be the critical specification (and most difficult) to attain[2].

Overall Quality Measures

Table 2 shows the results of the comparison between the WRTM reference data and the NPMRDS data for all segments. Both the average absolute speed error (AASE) and speed error bias (SEB) were within the specifications in all speed bins.

Table 2 - NPMRDS Data quality measures for arterial segments in Texas

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	2.24	4.22	1.78	3.08	2496
15-25 MPH	2.72	7.39	0.89	3.46	7753
25-35 MPH	2.84	7.01	-1.02	-0.16	14969
>35 MPH	3.53	7.42	-2.68	-3.52	14198
All Speeds	3.03	7.06	-1.07	-0.45	39416
Based upon data collected from April 1 to May 31, 2018 across 37 miles of roadway.					

Quality Measures by Segment

Table 3 presents detailed data for individual test segments. Note that for some segments and in some speed bins the comparison results may not be statistically reliable due to the small number of observations (marked by asterisks).

[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 zvanderl@umd.edu for such inquiries.

Table 3- NPMRDS data quality measures for individual arterial validation segments in Texas

Path	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	
TX-2018-01	0.96	0-15	9.15	9.15	10.54	10.54	1*
		15-25	16.22	16.22	25.10	25.10	7*
		25-35	3.65	3.88	11.31	12.21	137
		35+	-0.07	2.18	1.29	7.63	476
TX-2018-02	1.2	0-15	7.52	7.79	10.35	10.73	9*
		15-25	2.66	5.00	4.04	7.53	92
		25-35	0.39	2.92	2.23	7.41	239
		35+	-3.99	4.76	-5.72	9.24	1305
TX-2018-03	3.1	0-15	6.29	6.29	16.89	16.89	6*
		15-25	1.78	2.85	4.77	6.58	236
		25-35	0.21	2.19	0.89	4.96	1088
		35+	-2.29	2.85	-4.27	6.74	702
TX-2018-04	2.7	0-15	5.88	5.88	9.55	9.58	33
		15-25	3.33	3.40	5.66	5.92	293
		25-35	0.63	1.34	1.95	4.50	457
		35+	-1.83	2.25	-2.95	5.19	210
TX-2018-05	0.4	0-15	1.25	1.65	2.45	3.60	1239
		15-25	-0.38	2.06	1.15	6.96	2634
		25-35	-3.42	4.24	-4.73	8.90	2288
		35+	-7.20	7.64	-11.26	12.72	342
TX-2018-06	1.4	0-15	1.04	1.49	1.68	2.63	80
		15-25	0.61	2.17	1.43	4.36	312
		25-35	-0.52	2.16	0.24	5.41	2723
		35+	-2.49	3.28	-3.63	6.53	1837
TX-2018-07	1.4	0-15	0.73	1.48	0.93	2.51	215
		15-25	-0.07	2.25	-0.11	4.35	294
		25-35	-0.70	2.19	-0.38	5.59	452
		35+	-2.86	3.37	-4.26	7.13	2375
TX-2018-08	4.2	0-15	4.99	4.99	7.19	7.19	2*
		15-25	12.08	12.08	14.20	14.20	8*
		25-35	5.76	6.59	8.42	9.56	39
		35+	1.31	1.88	3.01	5.68	88
TX-2018-09	2.2	0-15	2.57	2.75	8.31	8.84	42
		15-25	1.06	2.03	3.51	5.41	307
		25-35	-0.58	1.43	-0.67	5.05	369
		35+	-3.26	3.96	-4.70	6.34	78
TX-2018-10	0.8	0-15	2.27	2.27	6.61	6.80	14
		15-25	-0.13	1.77	1.25	6.48	54
		25-35	-0.89	2.42	-0.08	6.63	31
		35+	0.85	0.85	1.07	1.79	3*
TX-2018-11	0.8	0-15	2.39	6.06	5.57	10.14	6*
		15-25	1.90	3.01	4.12	7.81	86
		25-35	-1.72	2.84	-2.42	7.46	91
		35+	-1.41	1.76	-2.25	4.96	15*

Path	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	
TX-2018-12	2.2	0-15	3.31	3.97	5.29	6.21	126
		15-25	2.10	2.53	5.95	6.87	390
		25-35	-0.18	1.62	0.78	4.95	430
		35+	-2.20	2.51	-3.21	4.61	122
TX-2018-13	4.2	0-15	31.17	31.17	32.76	32.76	1*
		15-25	9.59	9.59	12.62	12.62	8*
		25-35	2.83	3.08	6.10	6.84	13*
		35+	-2.10	3.01	-2.61	6.06	212
TX-2018-14	1.4	0-15	0.52	1.46	0.71	2.24	74
		15-25	0.54	3.13	1.60	5.65	141
		25-35	0.47	1.99	2.43	6.18	558
		35+	-0.78	1.81	-0.69	5.33	2325
TX-2018-15	1.4	0-15	1.15	1.49	1.77	2.68	420
		15-25	1.60	2.80	4.28	6.55	602
		25-35	-0.35	2.16	1.06	6.33	1956
		35+	-2.96	3.45	-4.56	7.51	761
TX-2018-16	0.4	0-15	2.42	3.06	4.70	6.36	198
		15-25	-0.06	2.16	3.20	7.62	1946
		25-35	-2.82	3.63	-2.46	8.18	3164
		35+	-7.67	7.92	-10.20	11.61	1369
TX-2018-17	2.7	0-15	4.94	4.94	12.77	12.77	2*
		15-25	3.08	3.21	6.45	6.74	86
		25-35	1.59	2.00	3.20	4.56	276
		35+	-0.79	0.98	-1.31	3.86	137
TX-2018-18	3.1	0-15	28.84	28.84	31.60	31.60	3*
		15-25	3.19	3.19	12.84	13.19	28
		25-35	1.54	2.44	4.12	6.32	236
		35+	-2.28	2.75	-3.39	5.99	499
TX-2018-19	1.2	0-15	14.31	16.13	16.54	19.01	5*
		15-25	4.52	4.71	8.44	8.99	8*
		25-35	3.51	3.90	9.77	10.90	199
		35+	-0.32	2.37	2.07	7.45	1283
TX-2018-20	0.96	0-15	27.93	27.93	34.38	34.38	20*
		15-25	14.57	14.57	26.98	26.98	221
		25-35	5.38	5.38	19.46	19.48	223
		35+	1.53	1.82	8.53	10.38	59

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

Daily Comparison Charts

To visually inspect the quality of data, a set of 24-hour comparison graphs have been produced for each test segment. Sample graphs for the test segment TX-2018-14 are presented in Figures 2 and 3. Figure 2 shows individual Bluetooth observations, filtered Bluetooth observations, NPMRDS data points and the 95% confidence f band around the mean of Bluetooth speed for one day. Figure 3 shows the Bluetooth speed, NPMRDS speed as well as number of Bluetooth speed observations for each five-minute interval.

Figure 2- Sample Bluetooth and NPMRDS graph for a test segment in Houston

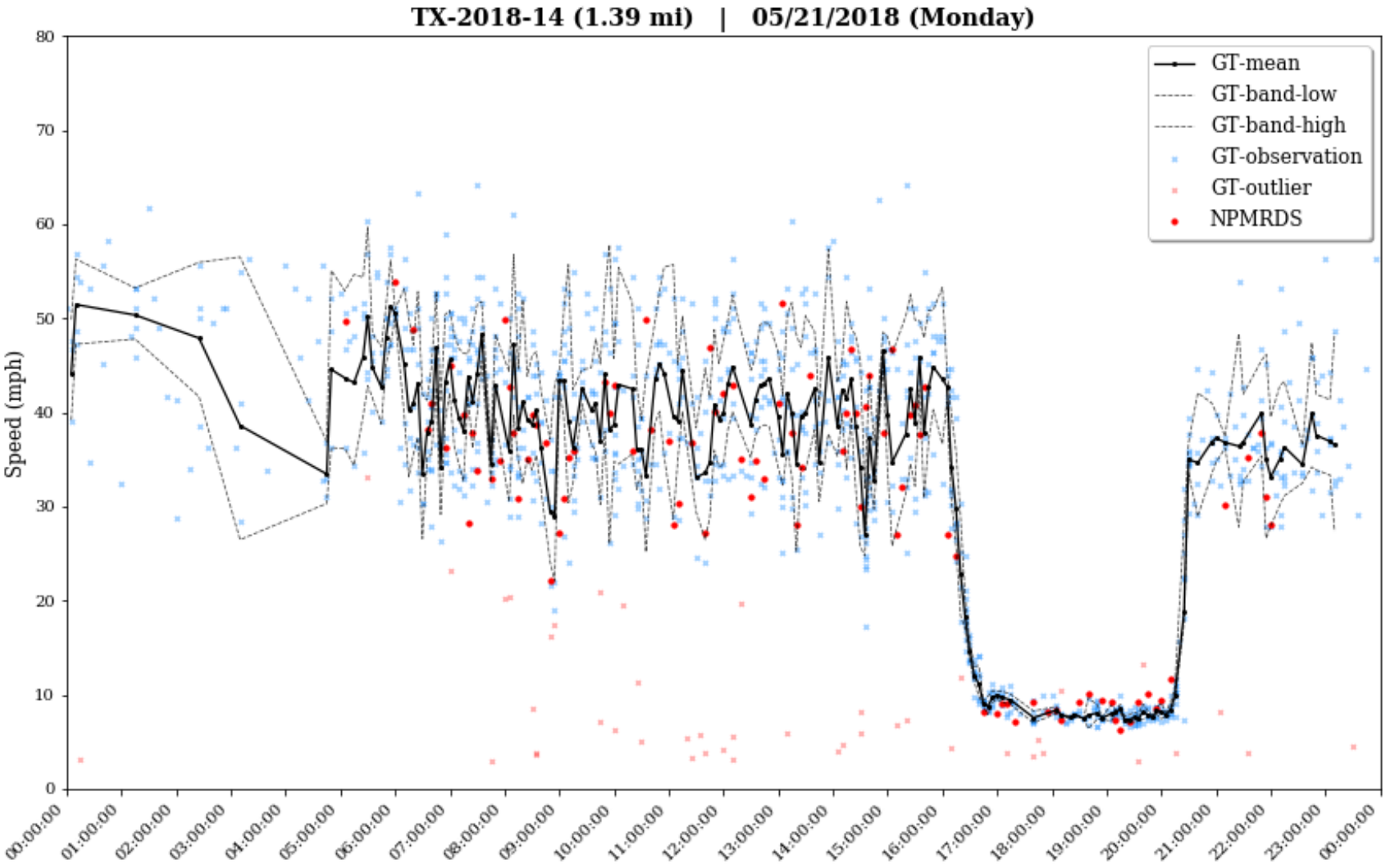

Figure 3 - Sample Bluetooth count and Bluetooth / NPMRDS speeds for a test segment in Houston