I-95 Corridor Coalition

Summary Report for
I-95 Corridor Coalition
Vehicle Probe Project:
Validation of INRIX Data
July-September 2008

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This report was produced by the I-95 Corridor Coalition. The I-95 Corridor Coalition is a partnership of state departments of transportation, regional and local transportation agencies, toll authorities, and related organizations, including law enforcement, port, transit and rail organizations, from Maine to Florida, with affiliate members in Canada. Additional information on the Coalition, including other project reports, can be found on the Coalition's web site at http://www.i95coalition.org.

Preface

This summary report was prepared by the I-95 Corridor Coalition based upon analyses and results presented in the complete and full detailed report titled, "I-95 Corridor Coalition Vehicle Probe Project: Validation of INRIX Data July-September 2008" and prepared by Ali Haghani, Masoud Hamedi, Kaveh Farokhi Sadabadi of the University of Maryland, College Park.

Acknowledgements

The I-95 Corridor Coalition acknowledges the above referenced research team for its efforts and would like to express its gratitude for the assistance it received from the state highway officials in Delaware, Maryland, New Jersey, and Virginia during the course of this study. Their effort was instrumental during the data collection phase of the project. This report would not have been completed without their help.

Introduction

The I-95 Corridor Coalition is facilitating a groundbreaking Vehicle Probe Project (VPP) involving the public and private sectors as well as academia to collect and evaluate real-time travel time and speed data for approximately 1,500 miles of freeways and 1,000 miles of arterials in New Jersey, Pennsylvania, Delaware, Maryland, Virginia and North Carolina as shown in Figure 1.

The primary source of the INRIX data is GPS equipped fleet vehicles. These data are supplemented by sensor- and detector-based data in some states. These data will facilitate traffic management, traveler information and planning activities for both local and long distance travelers. The VPP began with the release of a Request for Proposals in May 2007 and contract award to INRIX, Inc. in January 2008. In July 2008, INRIX activated the data feed for the network illustrated in Figure 1. Data collection for the initial evaluation activities were conducted between July and October 2008.

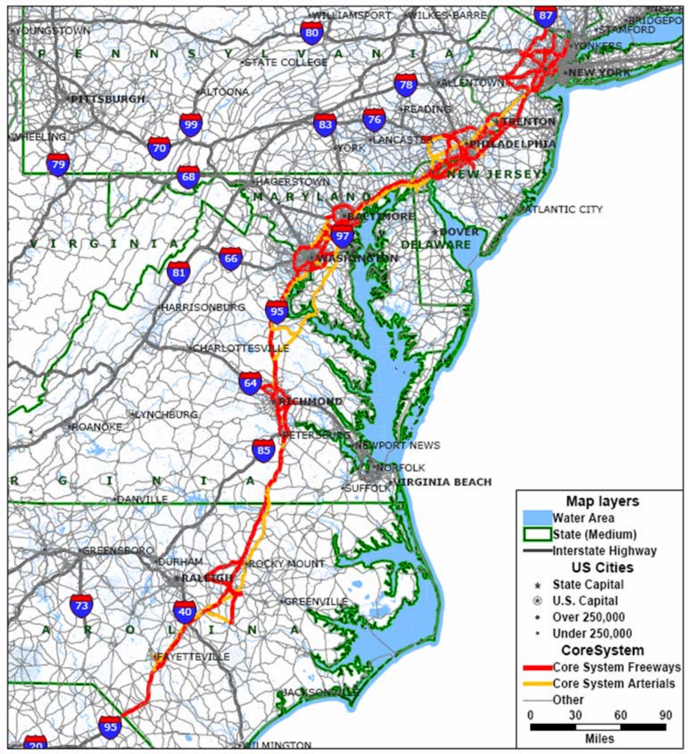

Figure 1 – Coverage Area

This report summarizes the methodology and results of the initial evaluation as well as discusses outstanding questions and issues on how to appropriately assess data quality and planned steps to move forward.

Evaluation Methodology

The University of Maryland is responsible for evaluating the quality of the VPP data at a level of detail that will determine its use for applications previously described. The evaluation was conducted by comparing INRIX GPS data to ground truth data collected on approximately 92 miles of representative roadway segments within the four states of Maryland, Virginia (northern), Delaware and New Jersey. This summary addresses the accuracy assessment of freeway segments and is based on the requirements established by the contract. The verification of data will be ongoing and will include an expanded data set over time. The evaluation had three basic stages: 1) collect ground truth data, 2) establish the statistical measures for comparison of INRIX GPS data to ground truth, and 3) compare the data to ground truth and draw conclusions.

Collect Ground Truth Data
Traditionally, floating car methods (a method in which an instrumented vehicle travels with the traffic stream, in a manner that is intended to replicate the speeds and travel times of the majority of the vehicles in the stream) are used to collect ground truth data. However, this very costly method produces a sparse amount of data not well suited to the requirements of this project. As a result, a new data collection methodology was developed that receives anonymous emissions from Bluetooth equipped accessories (cell phones, car radios, PDAs, PCs, etc.) in passing vehicles that have been activated in the discovery mode. Bluetooth protocol uses an electronic identifier, or tag, in each device called a Media Access Control address (MAC address). In order to collect ground truth data, pairs of Bluetooth receivers were deployed temporarily along the roadside as presented in Figure 2. Bluetooth devices observed by consecutive receivers served as the basis to sample the travel time of the traffic stream between the two detectors. This technique captures the travel times for approximately 5 percent of the vehicles within the traffic stream. The Bluetooth technique proved to be an extremely cost-effective and accurate measurement tool.

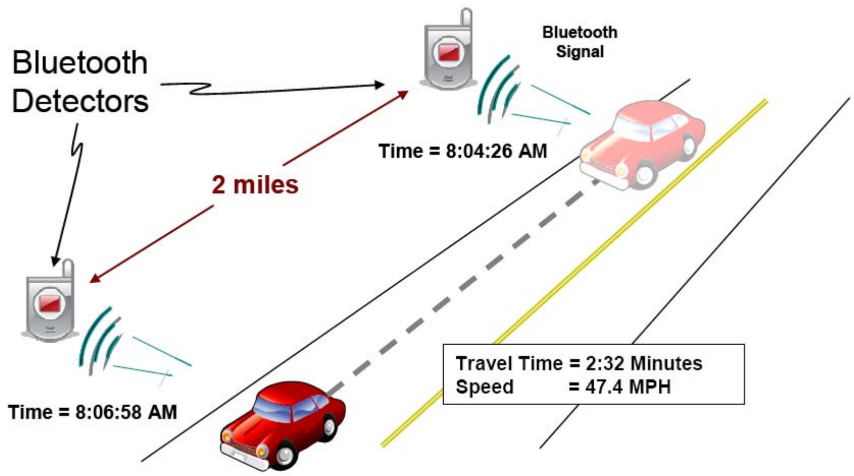

Figure 2 – Bluetooth Data Collection Method

Because the Bluetooth technology is a new technology, the verification of its accuracy was considered an important initial step of the evaluation. In Maryland and Virginia, a limited number of floating car data collection activities was performed by Motion Maps, LLC during morning and afternoon rush hours. Bluetooth sensors were deployed at the same time that the floating car runs were made with the objective of providing a comparison of the ability of the Bluetooth technology to provide ground truth travel times and speeds. A total of nine days of floating car testing was carried out in Maryland and Northern Virginia. The results of these comparisons confirmed the accuracy of the Bluetooth technology and its use as a method for field measurement of travel times.

Establish Statistical Measures for Comparison

While the Bluetooth technology provides a rich data source for evaluation of the INRIX GPS, there is still some uncertainty associated with the definition of the ground truth vehicle speeds and travel times that existed when the measurements were made. On any roadway section there are significant speed and travel time variations depending on driver, vehicle and roadway characteristics. For this reason, in addition to reporting the mean travel time and speed calculated from the Bluetooth data, a confidence band was defined that represents the uncertainty existing in the definition of the ground truth speeds and travel times. A number of statistical measures were evaluated to define the width of this uncertainty band, and all these measures are described and reported in the full report. The uncertainty measure presented in the summary is termed the standard error of the mean (SEM).[1] The SEM is commonly used to represent the uncertainty associated with a given measurement because it is a straightforward calculation that is sensitive to both the variability and volume of data being used as the basis for the calculations. An example of the SEM band is shown in Figure 3. As shown, the band narrows to represent a higher confidence of the Bluetooth data and widens when there is less confidence in the Bluetooth data. In essence, the SEM band is a surrogate for the 95 percent confidence interval of ground truth.

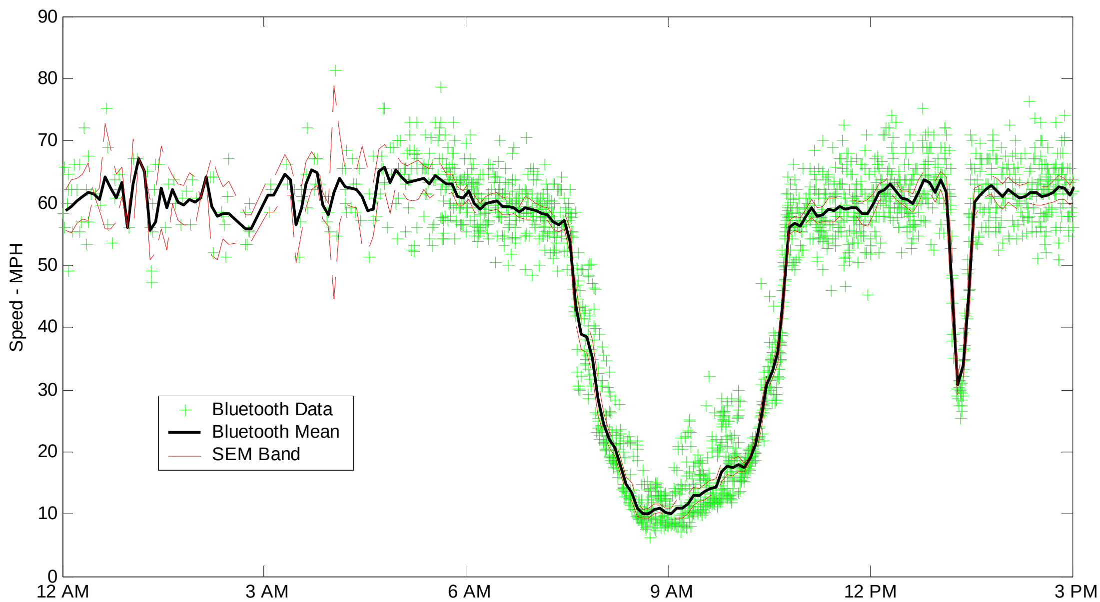

Figure 3 - Example of Standard Error of the Mean (SEM) Band

A statistical analysis of the data was conducted for four defined speed ranges: 0 to 30 mph, 30 to 45 mph, 45 to 60 mph and greater than 60 mph as defined in the contract.

[1] Standard Error of the Mean (SEM) is calculated as the standard deviation (S) of the calculated error (the difference between the Bluetooth data and the INRIX GPS) divided by the square root of the number of Bluetooth data points (N) taken for a given time. In other words, $SEM = S/(N)^{1/2}$

The ground truth SEM band and mean were calculated for these ranges as were the two basic measures of error used to evaluate the accuracy of the INRIX GPS data. The two measures are: 1) average absolute speed error (AASE)[2] – compares INRIX GPS data to ground truth – and 2) the speed error bias (SEB)[3] to identify bias (consistent differences) between INRIX GPS data and ground truth. The allowable maximum for the AASE and SEB is 10 mph and 5 mph, respectively.

Compare Data to Ground Truth and Draw Conclusions

This evaluation focused primarily on the accuracy of data collected along the freeways in the corridor. Data were objectively determined to fall within the SEM band and subjectively reviewed to determine the degree by which sudden slow downs in traffic flow due to either congestion or incidents were identified and correctly captured. It is concluded that the INRIX travel time and speed data across the system and by individual state generally satisfies the accuracy specifications of the contract (average absolute speed error less than 10 mph and speed error bias less than 5 mph). It was also observed that quality of the INRIX travel time and speed data improves with increase in speed. Further, a subjective review established that INRIX positively identified the majority of congestion events defined as traffic slowing to 40mph or less for more than 15 minutes. This result confirms that the INRIX GPS data provides an accurate overall picture of traffic conditions for limited access roadways within the Corridor.

Table 1 presents the evaluation results by individual state and a composite of all states. The average absolute speed error (AASE) and speed error bias (SEB) are presented for comparison to both the Bluetooth ground truth SEM band and the mean for each of the four speed ranges previously defined. The following conclusions are drawn:

- In Northern Virginia, all data quality specifications are satisfied for all speed ranges using both the SEM band and mean.
- The average absolute speed error specification, that compares the INRIX GPS to the Bluetooth ground truth, is satisfied in comparison with the SEM band for data collected in all states at all speed ranges.
- The speed error bias specification, used to identify bias and consistent differences in the data, is satisfied in comparison with the SEM band for data collected in all states at all speed ranges with two exceptions in the 0-30mph speed range and one exception in the 30-45mph speed range.

[2] The average absolute speed error (AASE) is calculated in the following manner. For each INRIX data point, find the difference between the data point and the Bluetooth data at the same time. Take the absolute value of the difference. Take the average of these absolute differences. In this way, positive errors and negative errors do not cancel each other.

[3] The speed error bias is calculated using the same procedure as the absolute speed error, except that the absolute value is not taken. Thus if there is a consistent positive or negative error, it would appear in the result of the calculation.

Table 1 - Evaluation Results					
State	**Average Absolute Speed Error (less than 10mph)**		**Speed Error Bias (less than 5mph)**		**Hours of data collection**
	Comparison with SEM Band	Comparison with Mean	Comparison with SEM Band	Comparison with Mean	
Virginia					
0-30 MPH	4.10	5.30	2.20	2.60	16.7
30-45 MPH	5.70	7.40	1.40	1.70	24.3
45-60 MPH	2.90	5.20	0.20	0.90	87.2
> 60 MPH	2.20	4.30	-1.60	-2.80	101.7
All Speeds	2.97	5.04	-0.32	-0.53	229.8
Maryland					
0-30 MPH	7.80	11.70	7.20	10.60	2.4
30-45 MPH	6.70	10.70	4.00	6.10	5.8
45-60 MPH	3.30	6.20	-0.70	-0.20	30.8
> 60 MPH	1.80	4.00	-1.30	-2.20	108.2
All Speeds	2.40	4.85	-0.83	-1.25	147.2
Delaware					
0-30 MPH	6.50	10.90	-0.20	2.50	3.0
30-45 MPH	8.50	11.80	-1.90	-0.10	9.0
45-60 MPH	1.20	3.60	-0.10	0.00	74.4
> 60 MPH	2.50	5.50	-2.40	-4.90	112.4
All Speeds	2.35	5.16	-1.48	-2.74	198.8
New Jersey					
0-30 MPH	9.50	12.50	8.30	10.90	6.6
30-45 MPH	8.30	11.60	5.30	7.60	14.0
45-60 MPH	2.40	4.80	0.70	1.90	132.9
> 60 MPH	1.90	4.20	-1.60	-3.10	854.3
All Speeds	2.10	4.44	-1.14	-2.20	1007.8
All States					
0-30 MPH	5.90	8.10	3.80	5.20	28.7
30-45 MPH	6.90	9.60	2.20	3.40	53.0
45-60 MPH	2.30	4.70	0.20	1.00	325.3
> 60 MPH	2.30	4.30	-1.70	-3.20	1176.5
All Speeds	2.52	4.63	-1.08	-1.96	1583.5

Outstanding Questions and Issues

The evaluation discussed in this document represents the results of analyses of data collected from a snapshot in time and at the early stages of this major data collection effort. There are a number of issues for consideration as the evaluation process continues, including but not limited to:

- Specific issues related to false alarms and other short-duration, deviations of INRIX GPS data from the Bluetooth data.
- Mapping and geospatial accuracy issues.
- Temporal distribution and penetration rate of both Bluetooth and GPS data.
- Measurement of data lag[4] remains an issue to be resolved.
- Travel time variability and its impact on both the Bluetooth and GPS data.
- Outlier filtering and its impact on the ground truth data.

The project team will continue to research and identify countermeasures to either eliminate or reduce the severity of the effects of these issues.

Moving Forward

These data were collected within the first five months of the project and revealed a great deal about the vehicle probe data characteristics, the nature of GPS data, and mapping and geo-coding issues facing the industry in general. To date, the project team has gleaned much insight, but the work has just begun. Observations and lessons learned include:

- The density of GPS-based data used as the basis of the INRIX GPS feed continues to grow and thus improving the accuracy of the VP data over time.
- GPS data may not be a single-source replacement for traditional data collection methods. A blend or fusion of traditional traffic data and GPS-based VP data can and should be used when available. Further, historical data may be used under certain circumstances and during times when GPS-based data is not available.
- The fundamental accuracy and technical limitations of VP data presented here must be understood to properly design data applications for travel times on message signs, 511 and web sites in addition to operational uses such as incident detection.
- The evaluation process and efforts related to developing applications must continue in parallel in order to utilize the VPP data to its fullest extent. Methods to better quantify the quality of the VPP data will continue to be developed.

[4] The difference between the time the traffic flow is perturbed as a result of an incident and the time that the change in speed is reported in the traffic data.