



Driving Intelligence

I-95 Vehicle Probe Project



I-95 CORRIDOR
COALITION



I-95 Corridor Coalition

Vehicle Probe Project Data Validation Summary

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Document Overview

This document serves to summarize the traffic data quality validations of INRIX data performed by the University of Maryland on behalf of the I-95 Corridor Coalition during the initial Vehicle Probe Project (VPP). The first VPP spanned six years, from Summer 2008 to Summer 2014,¹ and established numerous industry firsts, several of which are highlighted in the next section.

Among these industry firsts is establishing and conducting a process to evaluate the quality of the traffic data provided. Following a consistent methodology, 42 site tests were conducted in 11 states over six years to determine and monitor the quality of data INRIX provided under the VPP. All documentation related to quality requirements, validation testing methodology, and site test results are publicly available on the Coalition's web site.²

This document is created and published by INRIX and serves to:

1. Aggregate dozens of different reports regarding the methodology and results of VPP data validation into a single summary document.
2. Demonstrate how INRIX data consistently met, and typically far exceeded, the specified data quality requirements established in the VPP contract.
3. Illustrate how INRIX data improved in quality over time.

Results

- ✓ INRIX was never penalized for data quality during the life of the VPP.
- ✓ Speed Error and Speed Bias results met quality specifications from the outset of the project.
- ✓ Speed Error results improved 57% in heavy congestion from 2008-09 to 2012-13.
- ✓ Speed Error results improved 46% in moderate congestion from 2008-09 to 2012-13.
- ✓ Speed Bias results improved 87% overall from 2008-09 to 2012-13.
- ✓ Many of the site test locations later in the VPP were designed to be more challenging to report accurately than many of the initial site test locations, demonstrating high quality data was provided by INRIX in the toughest of scenarios.

¹ There is a follow-on project, VPPII, which started in July 2014

² Coalition's VPP Page: <http://www.i95coalition.org/i95/VehicleProbe/tabid/219/Default.aspx> (see Data Validation tab).

VPP Data Quality Summary

Throughout the VPP, INRIX data was subjected to the world’s largest ongoing validation of freeway data accuracy. Over more than five years, 42 validation tests have been conducted in 11 states in a full range of scenarios—urban/rural, overnight work zones, beach and holiday weekends, snowstorms, tunnels, parkways without commercial vehicle traffic, etc.

Table 1 summarizes all 42 site tests in a single table (see page 3, with links to each published report included in the table). In total during the VPP, INRIX data was tested over five years, on over 900 miles of freeways in over 430 discrete segments from as far south as Ft. Lauderdale, FL to as far north as Providence, RI (Figure 1 shows the site test locations across the corridor). Over 600,000 data comparisons were made across all site tests.

Figure 2 groups validations into the calendar ranges of 2008-09, 2010-11, and 2012-13 and shows the Average Absolute Speed Error (AASE). In the same time ranges, the summary Speed Error Bias (SEB) was -1.5 MPH in 2008-09, -0.7 MPH in 2010-11, and 0.2 MPH in 2012-2013.

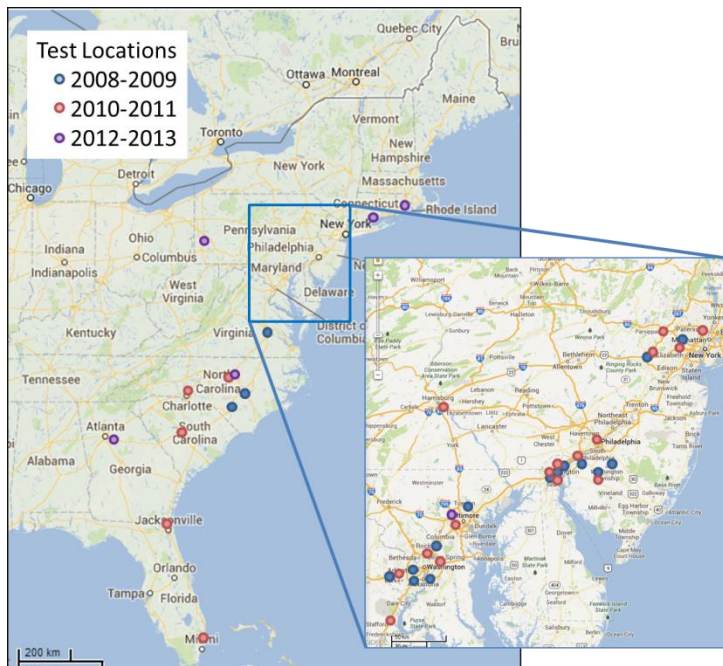


Figure 1: Site Test Locations Across the Corridor

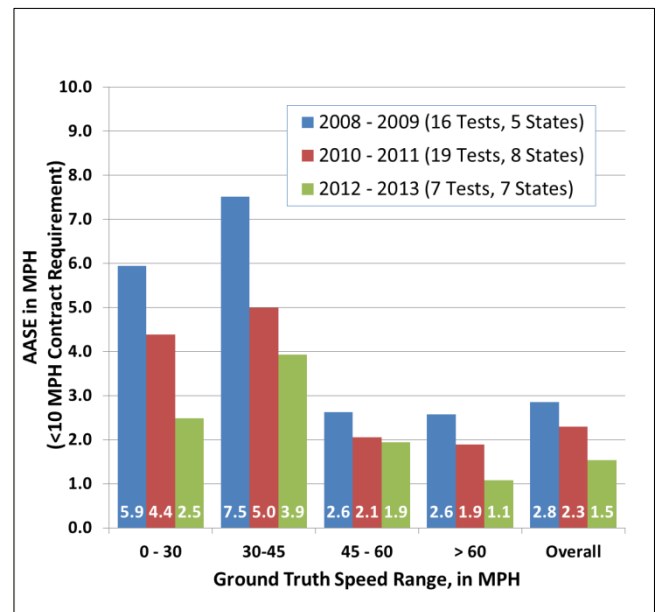


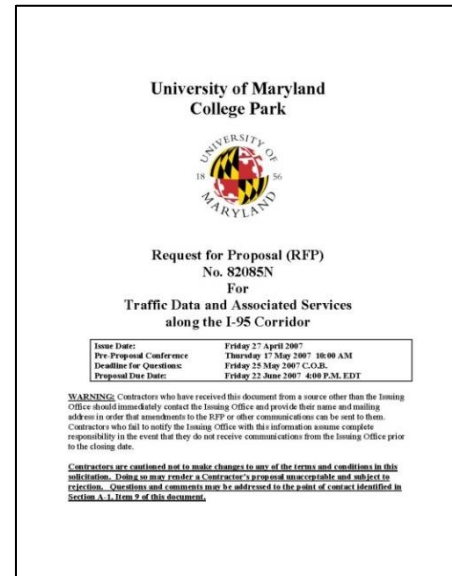
Figure 2: Group Validations

Table 1: VPP Data Quality Summary

State	Test Date	Test Scale						Notes	Link to Summary Report	Results			
		Road(s)	Miles	Segments	Total Hours Collected	Hours of Congested Data	% of Data Congested			Error in < 30 Range (MPH)	Error in 30-45 Range (MPH)	Total Error (MPH)	
RI	Apr 2012	I-95	25	10	1,076	12	1.1%	Various segments statewide	Link	4.2	7.8	1.4	
CT	Oct 2012	I-95	35	12	2,154	238	11%	Exit 13 to 32	Link	1.4	3.0	1.5	
NJ	10 Tests		216	89	13,640	462	3.4%			7.1	7.5	2.7	
1	Sep 2008	Various Statewide	28	12	1,008	21	2.1%	I-80, I-295, NJTP, GSP	Link	9.5	8.3	2.1	
2	Apr 2009	I-78, I-287	16	9	1,150	12	1.0%	North NJ	Link	6.4	8.1	2.8	
3	Jun 2009	NJ Turnpike	63	10	1,868	7	0.4%	South NJ, low congestion, long segments	Link	20.1	16.2	2.9	
4	Sep 2009	NJ 55	17	8	768	4	0.5%	South NJ commuter freeway, low congestion	Link	8.2	6.9	1.9	
5	Oct 2009	NJ 42/AC Expwy	14	10	1,983	113	5.7%	Night work zone; AASE within specs 5A - 8P	Link	12.5	14.4	4.2	
6	May 2010	I-287	12	7	1,350	121	9.0%	Includes Memorial Day Weekend	Link	3.2	4.0	2.3	
7	Jun 2010	NJ 42/AC Expwy	14	10	1,994	101	5.1%	Same location as Oct 2009 test	Link	5.9	5.4	3.3	
8	Apr 2011	I-95 (NJTP), I-80	16	8	1,286	20	1.6%	Turnpike, I-80, I-95 confluence study area	Link	2.6	3.3	1.6	
9	May 2011	I-287	8	6	819	53	6.5%	I-287 south of I-78	Link	6.0	7.3	1.8	
10	Sep 2012	GSP	28	9	1,413	10	0.7%	Reach the Beach Weekend, no trucks on GSP	Link	2.8	4.7	2.4	
PA	4 Tests		81	40	5,846	753	13%			4.3	4.2	2.3	
1	Jan 2010	I-95	16	7	1,656	60	3.6%	Chester Area	Link	6.5	7.0	3.2	
2	Aug 2010	I-76	8	5	964	278	29%	Philadelphia Area	Link	4.7	4.2	3.0	
3	Sep 2011	I-81, I-83	31	14	1,759	86	4.9%	Harrisburg Area	Link	3.5	5.2	1.2	
4	Dec 2012	I-376	26	14	1,467	329	22%	Includes tunnels and winter holidays	Link	3.8	3.4	2.0	
DE	6 Tests		70	46	5,982	354	5.9%			5.8	5.1	2.3	
1	Sep 2008	I-95	6	3	199	12	6.0%	Near I-295/I-495	Link	6.5	8.5	2.3	
2	Feb 2009	I-95, I-295, I-495	15	10	791	16	2.0%	Similar location to Sep 2008 Test	Link	12.0	7.6	2.6	
3	Aug 2009	I-95, I-295, I-495	11	7	1,149	108	9.4%	Complicated interchange with ramp queues	Link	5.5	5.9	2.7	
4	May 2010	I-95, I-295, DE 7	13	9	1,162	80	6.9%	Included DE 1, DE 7 freeways	Link	4.7	1.9	2.5	
5	Nov 2010	I-95, I-295, I-495	14	9	1,521	82	5.4%	Complicated interchange with ramp queues	Link	3.9	6.2	2.1	
6	Jun 2011	I-95/I-495	11	8	1,160	56	4.8%	Multiple non-contiguous locations	Link	7.1	6.7	1.7	
MD	6 Tests		127	73	6,362	686	11%			2.6	4.4	1.8	
1	Aug 2008	I-495 and I-695	34	26	147	8	5.4%	Several locations near DC and Baltimore	Link	7.8	6.7	2.4	
2	Mar 2009	I-95, I-495	19	9	1,016	74	7.3%	Near DC	Link	4.2	4.2	1.8	
3	Feb 2010	I-495	14	10	772	174	23%	Test included "Snowmagedon"	Link	3.6	4.3	2.5	
4	Oct 2010	I-495/US 50	13	8	939	64	6.8%	Included large-scale ramp data analysis	Link	2.4	4.3	2.2	
5	Oct 2011	I-695	24	6	784	103	13%	Baltimore Area	Link	2.4	4.3	1.4	
6	Feb 2013	I-695, I-795	23	14	2,693	263	10%	Work Zones	Link	1.9	4.4	1.5	
VA	6 Tests		141	69	7,048	857	12%			5.0	6.2	2.6	
1	Jul 2008	I-95, I-395, I-495	33	24	230	41	18%	Northern VA Area	Link	4.1	5.7	3.0	
2	Nov 2008	I-95, I-64, I-295	17	10	729	18	2.5%	Richmond Area	Link	7.0	5.8	2.0	
3	May 2009	I-95, I-66, I-495	14	9	1,415	157	11%	On or near Capital Beltway	Link	4.2	7.0	2.5	
4	Nov 2009	I-66	14	8	1,659	352	21%	HOV inside and outside beltway included	Link	4.5	7.1	3.7	
5	Sep 2010	I-95	44	14	2,283	110	4.8%	Fredricksburg Area	Link	4.8	4.0	2.0	
6	July 2011	I-66	19	4	732	179	24%	Outside Beltway, Overnight Work Zones	Link	7.7	6.0	3.2	
NC	5 Tests		132	46	4,782	182	3.8%			3.7	6.9	1.9	
1	Oct 2008	I-95	42	11	327	3	0.9%	Low volumes, very low congestion	Link	16.1	12.2	2.0	
2	Jul 2009	I-95	42	9	885	42	4.7%	Daytime work zones in test area	Link	4.1	9.4	3.3	
3	Mar 2010	I-40, I-440	19	9	1,511	55	3.6%	Raleigh Area	Link	3.4	6.4	1.9	
4	Mar 2011	I-77/I-85	18	9	1,206	44	3.6%	Charlotte Area, included ramp analysis	Link	2.3	5.7	1.5	
5	Apr 2012	I-440	11	8	853	38	4.5%	Raleigh Area, include ramp analysis	Link	4.5	5.5	0.9	
SC	Feb 2011		I-20	23	10	1,188	10	0.8%	Columbia area	Link	6.2	7.0	1.3
GA	May 2013		I-20	31	16	2,251	9	0.4%	E. of Atlanta, Exits 74 to 90, low congestion	Link	4.7	10.1	1.0
FL	Nov 2011		I-95	53	25	3,021	179	5.9%	Broward and Duval Counties Combined	Link	3.4	5.5	1.9
Total	42 Tests, 11 States		934	436	53,350	3,742	7.0%			4.3	5.5	2.2	

VPP Overview

The I-95 Corridor Coalition’s Vehicle Probe Project (VPP), the world’s largest single acquisition of real-time private sector speed/travel time data by government organizations, began as a University of Maryland (UMD) Request for Proposal in April 2007 with the contract name “Traffic Data and Associated Services along the I-95 Corridor.” The objectives of the RFP³, published by UMD on behalf of the I-95 Corridor Coalition (the Coalition), included:



“...the Coalition is supporting a regional traffic monitoring system that acts as a continuous source of real-time transportation system status information within the Corridor. A regional traffic monitoring system will serve as a rich source of traveler information and will provide invaluable inputs to existing and future management tools...”

“...it is the intent of the Coalition to provide funding support and coordination with its members for the purpose of developing a common set of procedures for data acquisition and dissemination. Successful offerors will be responsible for providing real-time traffic data and supporting consulting services in support of the mission of developing a regional traffic monitoring system. A three year initial project is anticipated, with a contract life in excess of three years in-place to provide the flexibility to continue, if desired, by the Coalition members.”

“Real-time traffic data will support the development of seamless networks of corridor-wide traveler information systems and facilitate and support the coordination and implementation of interagency efforts in response to major incidents and special events of regional significance. Timeliness and accuracy of data are paramount to the success of these efforts.”

“Data quality will be validated by an independent contractor.”

³ <http://tinyurl.com/i95vpprfp>

INRIX was selected from multiple proposers by UMD and the Coalition as the sole contractor for the project in December 2007, was awarded the master contract in February 2008, and began supplying real-time data and associated services on July 1, 2008 for roughly 1,950 centerline freeway⁴ miles and 1,000 centerline arterial miles across six states, from New Jersey to North Carolina, including the District of Columbia. The baseline term for the VPP was three years (2008-2011), which was later extended an additional three years (2011-2014). The VPP enabled Coalition member states to add road coverage based on desire and funding availability. At its conclusion in Summer 2014, live data was being provided for over 40,000 centerline miles of roadways in ten states, including nearly 8,000 miles of freeways.

The VPP was groundbreaking in many ways, with many industry firsts:

- ✓ 1st comprehensive requirements for privately sourced real-time traffic data, with a world leading validation program to test and ensure data quality.
- ✓ 1st pay-for-performance contract, tying payments to validated data quality and availability.
- ✓ 1st consistent and publicly available data use agreement giving maximum flexibility to agencies to use, store and re-use data for their purposes.
- ✓ 1st use of private data to establish statewide travel times on dynamic messages signs.
- ✓ 1st statewide map of real-time traffic data on a state DOT's 511/travel information web site.
- ✓ 1st intelligent fusion of private data and available roadside sensor data on a statewide basis.
- ✓ 1st use of private data in a state DOT branded 511/mobile app.
- ✓ 1st high-definition displays of real-time traffic in shopping malls.
- ✓ 1st online performance monitoring and analysis tools, enabling large scale analysis with only a browser and credentials required for access.
- ✓ 1st corridor-wide multi-state traffic monitoring web site, including user reported incidents, with only a browser and credentials required for access.

⁴ The VPP Contract defines all limited access roads as "Freeways" – this document uses the term Freeways to refer to Interstates, Turnpikes, Expressways and all limited access highways

VPP Quality Requirements

The VPP Contract establishes two metrics for measuring the quality of speed data provided, Average Absolute Speed Error (AASE) and Speed Error Bias (SEB), to be in effect for vehicle flows exceeding 500 Vehicles per Hour in a direction of travel. Since road segments used in validation can vary in length, quality requirements based on speed rather than travel time were used to normalize the effect of varying segment lengths.

Average Absolute Speed Error (AASE)

- AASE measures the overall error in reported speeds compared to actual conditions
- The contractually required AASE was below 10 MPH in each of the following speed ranges: 0-30 MPH, 30-45 MPH, 45-60 MPH and > 60 MPH

Speed Error Bias (SEB)

- SEB measures the tendency for reported speeds to be systemically faster or slower than actual conditions
- The contractually required SEB was a maximum average error of +/- 5 MPH in each of the following speed ranges: 0-30 MPH, 30-45 MPH, 45-60 MPH and > 60 MPH.

In early 2009, once the initial validations were completed (using the process defined in the next section), the Coalition established a Payment Formula Method,⁵ which would reduce payments for data failing to meet the AASE and SEB requirements shown above.

Each month since Spring 2009, payments were calculated using the rolling average of the last three completed site validations. Each of the four speed ranges received equal weight, so how data performed in circumstances when ground truth traffic was below 45 MPH counted for 50% of each monthly payment – the formula was clearly calculated to reward or penalize data quality under congested conditions.

The VPP RFP and subsequent contract placed these data quality requirements only on Freeways. Thus the official site tests, results and payment calculations were based only on Freeways. During the VPP, data was collected on interchanges and arterials in a small number of site tests, used for research purposes, and included as appropriate in the individual site tests.

⁵ http://www.i95coalition.org/i95/Portals/0/Public_Files/uploaded/Vehicle-Probe/Modification%20M009-payment%20formula.pdf

VPP Site Test Overview

The University of Maryland designed, implemented and conducted the VPP Validation Program. The Methodology was developed and proven July through September 2008 with initial validation tests in four states: Virginia, Maryland, Delaware and New Jersey.⁶ Key to the VPP Validation Program was the utilization of portable Bluetooth Data Collection. Now commonly used for both temporary and permanent data collection, Bluetooth monitoring was far from mainstream in 2008. UMD and the Coalition determined that Bluetooth provided the most cost-effective method for statistically significant ground truth data collection.⁷

The basic concept was for portable Bluetooth readers to be deployed to coincide as near as possible to the start and end of INRIX reporting segments (during the VPP, INRIX utilized TMC codes as reporting segments) to compare ground truth as determined via Bluetooth with INRIX real-time speed/travel time data. Figure 3 illustrates the conceptual approach for Bluetooth data collection. A typical site test would collect data on 10-20 segments for 10-14 days, with segments usually ranging from one to three miles.

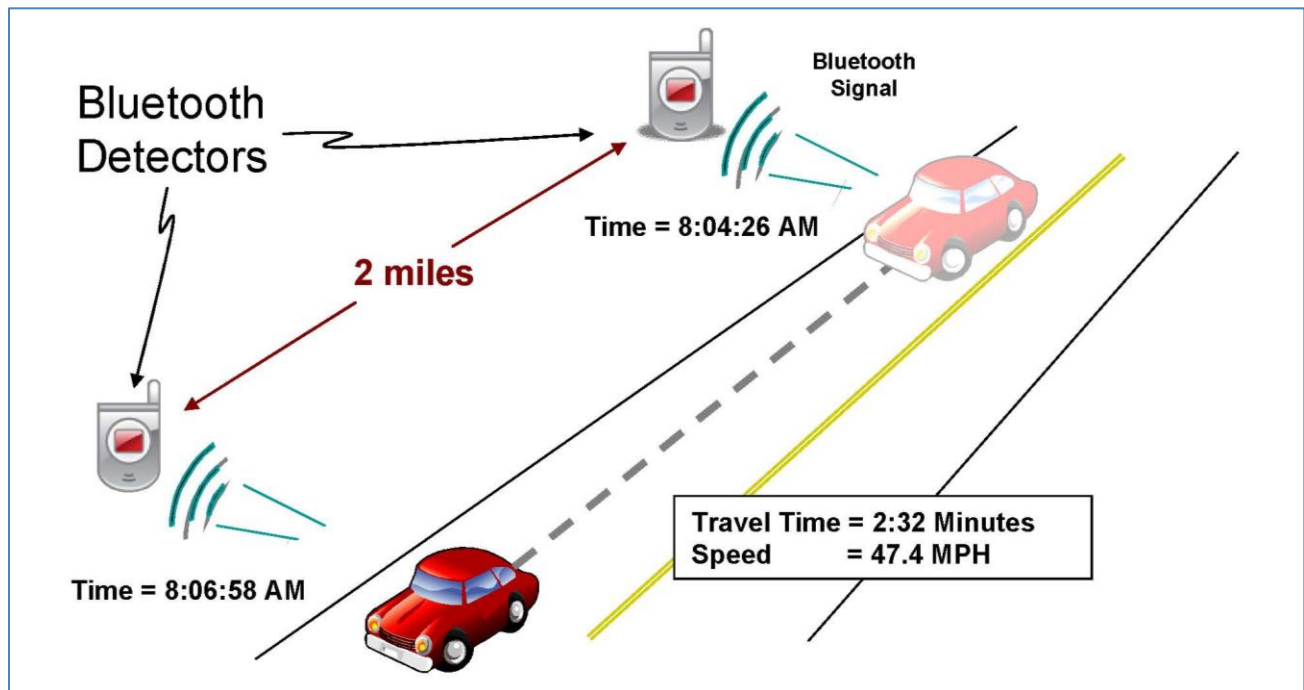


Figure 3: Bluetooth Operating Concept

Each site test was planned and executed in collaboration with the appropriate Coalition member agency using the process shown in Figure 4, with results published to the Coalition web site upon report completion. During the VPP, 42 site tests were completed in 11 Coalition states between July 2008 and February 2013.

⁶ [http://www.i95coalition.org/i95/Portals/0/Public_Files/uploaded/Vehicle-Probe/Validation%20Process%20May%2019%202009%20distr%20June%202009\(2\).pdf](http://www.i95coalition.org/i95/Portals/0/Public_Files/uploaded/Vehicle-Probe/Validation%20Process%20May%2019%202009%20distr%20June%202009(2).pdf)

⁷ http://www.i95coalition.org/i95/Portals/0/Public_Files/uploaded/Vehicle-Probe/Bluetooth%20Concept%20and%20Use%20Brochure%2029%20July%202008.pdf

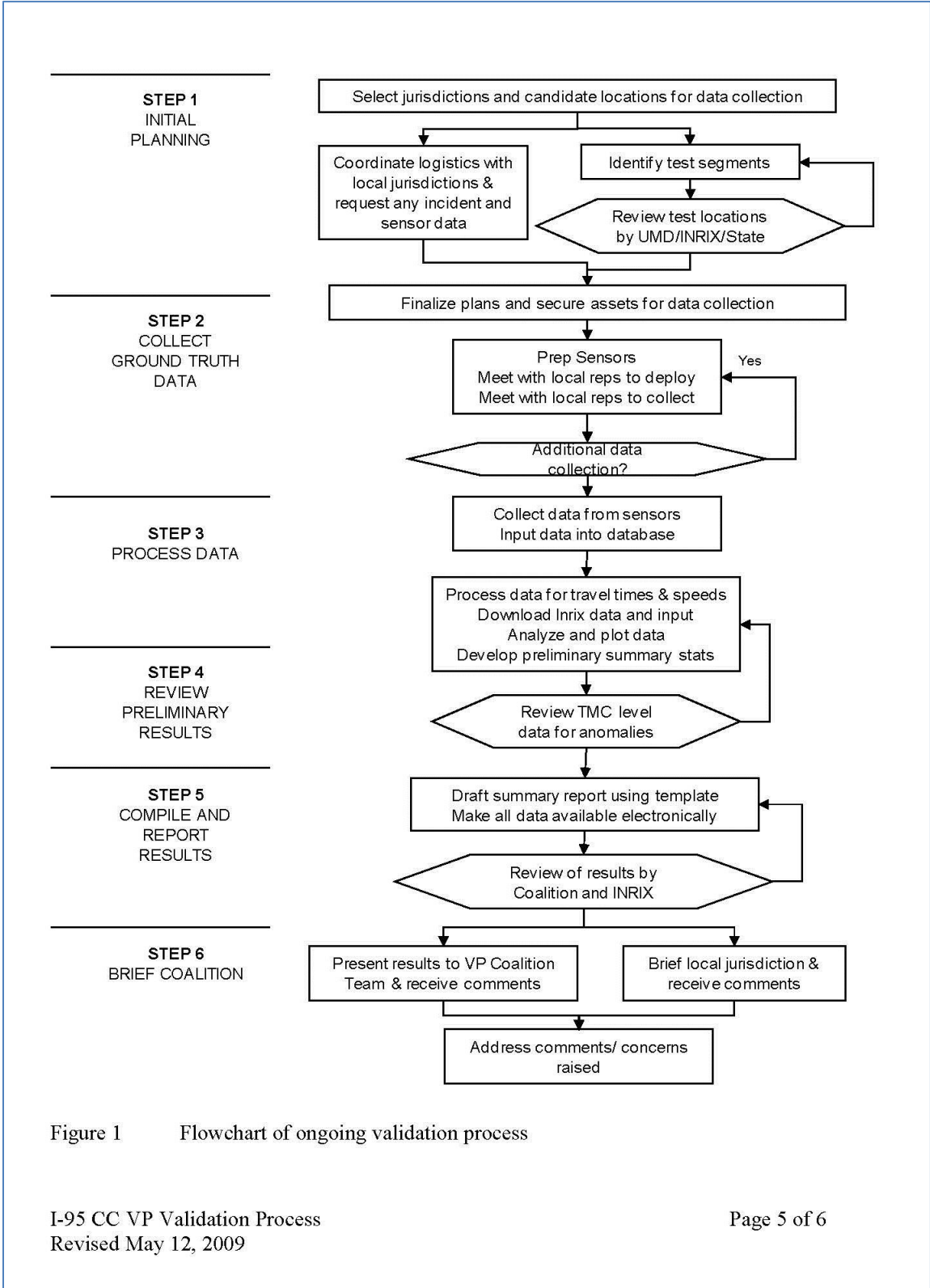


Figure 1 Flowchart of ongoing validation process

Figure 4: VPP Site Test Validation Process

Each Bluetooth sample segment could create up to 288 specific comparison data samples in a day. In each site test, for each five minute increment that a deployed Bluetooth segment had sufficient samples (UMD determined that three or more valid Bluetooth readings traversing a reporting segment in a five minute period provided sufficient ground truth representation), the average Bluetooth speed/travel time was compared to the average INRIX provided speed/travel time. In cases where multiple INRIX TMC reporting segments were examined by a single Bluetooth reporting segment, a methodology was defined and utilized by UMD for proper comparison.⁸ Samples were collected 24x7 during the duration of the site test (typically two weeks as stated before). As illustrated in the next section, this approach generated huge amounts of ground truth data on each segment and enabled far greater evaluation of data quality over all hours of the day and days of the week, as well as far better apples-to-apples comparison data, than the traditional testing alternative of drive testing.

In the process established by UMD, one output of each site test were numerous “dayplots” that compared individual and aggregated Bluetooth traversal to INRIX reported travel times, with each dayplot representing a specific segment for a specific calendar day. These dayplots were made available to each member agency for their review and are available from UMD upon request.

A Guide to the Elements of the Day Plot

- The title of each dayplot provides the location as well as meta-data about the site test and the specific segment.
- The horizontal axis shows speeds by time of day, from midnight to midnight.
- The vertical axis displays speed in MPH (Bluetooth traversal times are converted to speed across the segment).
- Each individual Bluetooth traversal is noted by a blue “x”, and a blue “x” with a dot indicates a reading UMD has determined in post-processing to be an outlier, which is discounted from further analysis.
- For each five minute period with three or more valid Bluetooth traversals, the mean is calculated and represented on the solid line as the ground truth mean for that time period.
- To account for the statistical probability that the Bluetooth mean is the actual mean for the full stream of traffic it represents, UMD applied the standard error of means methodology, which is represented in the dayplot “Band low” and “Band high” dashed lines.
- INRIX data for the five minute period is noted by a red diamond (note that while INRIX reports continuously, an INRIX data point is only present on the dayplot if there is a valid Bluetooth sample).
- To determine error, INRIX data is compared to the closest of the bands if outside the area between the high and low bands, if inside the error band, zero error is reported.
- The average Bluetooth speed for a given sample determines which of the four defined speed ranges the INRIX error result populates for that time period.

⁸ http://www.i95coalition.org/i95/Portals/0/Public_Files/uploaded/Vehicle-Probe/I-95%20CC-Estimation%20of%20Travel%20Times%20for%20Multiple%20TMC%20Segments%20-%20FINAL2.pdf

Figure 5 illustrates a typical dayplot, in this case from a late 2011 site test in Broward County Florida. Many dayplots are uninteresting and show primarily free flow conditions. However, in congestion these charts provide an insightful window into the freeway segment and how well INRIX data is reflecting reality.

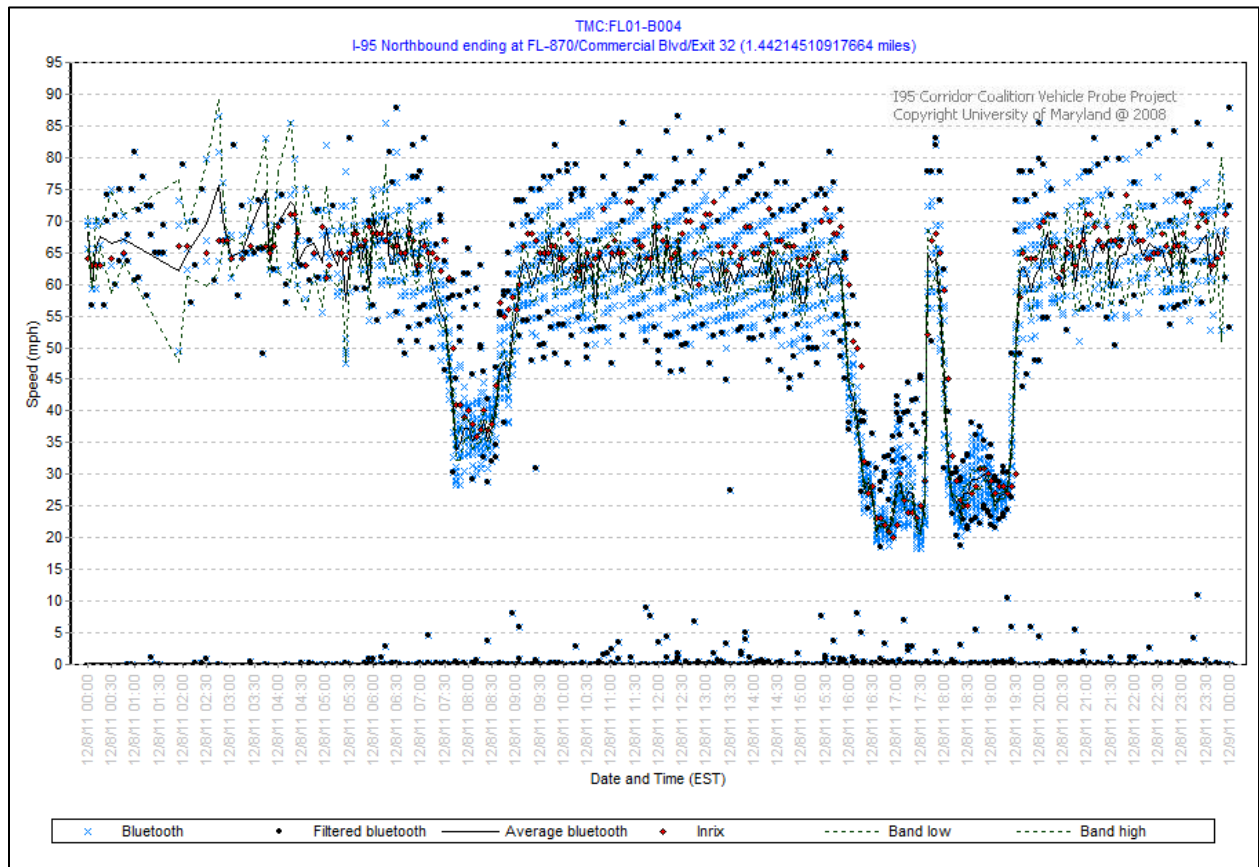


Figure 5: Dayplot from December 8, 2011 Florida Site Test

Each sample from each site test is rolled up first into overall segment summaries, and finally into an overall result. Exhibit 1 was extracted from the September 2011 Pennsylvania site test to illustrate segment summaries and Exhibit 2 shows the overall summary result for this site test (performed near Harrisburg, PA), the format of this table is used across all VPP site tests to summarize results. The SEM Band (shown as 1.96 SE Band in Exhibit 1) results are the contractual defined data quality results and are used throughout this report. In this site test, 514 observations occurred when ground truth speeds were below 30 MPH, and in those instances, INRIX data's Average Absolute Speed Error (AASE) was 3.5 MPH.

Exhibit 1

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

TMC	Standard TMC length	Bluetooth distance	SPEED BIN	Data Quality Measures for				No. of Obs.	
				1.96 SE Band		Mean			
				Speed Error Bias	Average Absolute Speed Error	Speed Error Bias	Average Absolute Speed Error		
103+04522	3.1	3.1	0-30					136	
			30-45				2051		
			45-60	1.5	1.5	3.7			3.7
			60+	-0.8	1.0	-2.1			2.8
103-04521	3.3	3.0	0-30						252
			30-45				835		
			45-60	1.6	1.6	4.2		4.2	
			60+	0.1	0.5	-0.2		2.2	
PA03-0001	1.3	1.2	0-30	2.0	3.7	2.0		4.8	24*
			30-45	3.7	6.1	4.1	7.8	48	
			45-60	0.6	1.2	1.6	3.0	892	
			60+	-1.1	1.3	-3.2	3.7	603	
PA03-0002	1.2	1.2	0-30	1.3	3.1	2.2	5.1	52	
			30-45	7.0	8.1	9.8	11.2	50	
			45-60	1.1	1.5	2.7	3.6	1401	
			60+	-0.9	1.1	-2.6	3.3	519	
PA03-0003	1.4	1.3	0-30	3.9	4.0	4.7	5.3	10*	
			30-45	-0.1	3.1	0.6	4.9	15*	
			45-60	-0.9	1.4	-2.1	3.6	336	
			60+	-2.6	2.6	-6.6	6.6	3*	
PA03-0004	1.3	1.3	0-30	3.5	3.8	5.1	5.6	53	
			30-45	4.9	6.0	7.3	9.0	93	
			45-60	0.9	1.5	2.1	3.7	854	
			60+	-1.2	1.2	-3.9	4.1	16*	
PA03-0005	1.3	1.2	0-30	2.2	3.1	2.7	5.6	56	
			30-45	0.3	3.9	0.6	6.7	91	
			45-60	0.5	1.8	2.1	4.1	854	
			60+	-0.9	1.0	-2.6	3.2	345	
PA03-0006	1.3	1.3	0-30	3.8	4.2	4.9	5.8	136	
			30-45	4.1	5.1	5.2	7.4	106	
			45-60	0.8	1.2	2.2	3.4	898	
			60+	-0.9	1.0	-2.8	3.4	316	
PA03-0007	2.8	2.6	0-30	1.3	1.5	2.1	2.6	87	
			30-45	3.6	4.9	7.0	9.8	35	
			45-60	0.6	1.1	2.0	2.9	412	
			60+	-0.5	0.7	-1.6	2.4	1021	

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

Exhibit 2

Data quality measures for INRIX speed data with a score higher than 25 on freeway segments greater than one mile in Pennsylvania.

SPEED BIN	Data Quality Measures for				No. of Obs.
	1.96 SE Band		Mean		
	Speed Error Bias	Average Absolute Speed Error	Speed Error Bias	Average Absolute Speed Error	
0-30	2.9	3.5	3.8	5.2	514
30-45	3.6	5.2	5.2	8.1	521
45-60	0.8	1.3	2.2	3.4	8410
60+	-0.6	0.9	-1.9	2.8	11659

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



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About INRIX

INRIX is one of the fastest growing big data technology companies in the world. The company leverages big data analytics to reduce the individual, economic and environmental toll of traffic congestion. Through cutting-edge data intelligence and predictive traffic technologies, INRIX helps leading automakers, fleets, governments and news organizations make it easier for drivers to navigate their world. Our vision is simple – to solve traffic, empower drivers, inform planning and enhance commerce.