



**Addendum to:
Real-Time Traffic Flow Ground Truth Testing Methodology Validation
and Accuracy Measurement**

Prepared for: Inrix, Inc.

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Addendum to: Real-Time Traffic Flow Ground Truth Testing Methodology Validation and Accuracy Measurement

Introduction

Following the release of the Inrix-commissioned Frost & Sullivan study entitled “Real-Time Traffic Flow Ground Truth Testing Methodology Validation and Accuracy Measurement,” Inrix was approached by many of its current and prospective customers, and asked to provide additional comparative analysis of the accuracies between Inrix’s and Traffic.com’s real-time traffic, distinguishing between congested traffic conditions and free-flow traffic conditions. Inrix retained Frost & Sullivan to provide this additional analysis using the Ground Truth (GT) test data obtained from the testing carried out for the original study (released on September 25, 2006).

The original study compares the accuracy and coverage of Inrix’s and Traffic.com’s real-time traffic information from an end-user’s perspective. In Traffic.com’s case, the data is provided directly to consumers through their web site www.traffic.com at no charge. Inrix’s real-time traffic information is provided to their customers, who in turn provide the information to end-users. Frost & Sullivan would like to point out that Traffic.com adjusts the travel times that it provides directly to consumers (used by Frost & Sullivan for the analysis) for speed limits – that is, if traffic is moving faster than the speed limit, the travel time presented by Traffic.com reflects the speed limit rather than actual traffic flow. Inrix makes no such adjustment.

The results of this additional accuracy analysis; comparing accuracies across congested traffic and free-flow traffic conditions agree with the original analysis. There were sufficient trials in the original study across both congested and free-flow traffic conditions and the results upon further analysis in these scenarios were consistent with the overall original study results. Inrix had a clear and consistent advantage on miles of coverage and neither of the companies had a clear advantage on accuracy – either in free-flow or in congested conditions.

Scope

The scope of the original study, and of this addendum, is limited to the analysis of real-time traffic data available to consumers. The study addresses the question, “Which company provides the more-accurate travel times, and how extensive is the coverage?” The scope does not include analysis of data-aggregation and data-processing techniques and methodologies used on the back-end. The study, however, does mention the different approaches used by the two companies.

This Addendum is based on the same dataset that was used for the original study. No additional “Ground Truth” (GT) trials were run. Instead, the original dataset was filtered to include only GT trials that (1) were run during morning or afternoon rush hours and (2) that were run during the day, between rush hours. Or, to put it another way, the original dataset was split into two according to (1) times when traffic is likely to be congested and (2) times when traffic is unlikely to be congested. This resulted in an approximately 50:50 split – of the 141 original trials, 70 fell into the congested time group and 71 fell into the free-flow time group.

The purpose is to see if one company or the other provides better data in congested traffic conditions, when travel time information is most valuable.

Definitions

For the purposes of this analysis, Frost & Sullivan has adopted the following definitions:

Congested Traffic Conditions:

Traffic conditions during times of High Occupancy Vehicle (HOV) restriction in the markets studied. Although the HOV-restrictions vary across roads and road segments, 6:30 AM to 9:30 AM; and 3:30 PM to 6:30 PM, represent the HOV-restriction times across most roads and in this addendum are considered to represent congested traffic conditions.

Free-flow Traffic Conditions:

Traffic conditions during the times when there are no HOV-restrictions – 9:30 AM to 3:30 PM and 6:30 PM to 12:00 AM.

Conclusions

Figure 1 summarizes the results from the congested and free-flow travel times subsets of the complete dataset. This figure focuses on percent errors, since these measures express errors in relation to the length of each trial. Absolute errors, on the other hand, give the same weight to a two-minute error on a ten-minute run as to a two-minute error on a twenty-minute run. Mean Percent Error allows positive and negative errors to offset one-another. Mean Absolute Percent Errors give equal weight to positive and negative errors, and do not allow them to offset one-another. Hence, we regard Mean Absolute Percent Error as a better measure of accuracy than Mean Percent Error.

Figure 1

Data Comparison by Time of Travel (Three Metropolitan Areas), 2006

Company	Number of Measures on which Company X Scored Best							
	Philadelphia		Providence		Washington		Total	
	Traffic	Inrix	Traffic	Inrix	Traffic	Inrix	Traffic	Inrix
Mean Percent Error C	1.9*	-12.7	17.3	-1.1*	10.5	-5.9*	10.3	-6.3*
Mean Percent Error FF	7.8	-6.1*	9.0*	15.2	32.8	7.8*	18.3	5.9*
Percent Std Dev C	17.1*	27.0	21.4	15.1*	23.2*	31.1	21.4*	24.7
Percent Std Dev FF	19.2*	30.1	20.9*	21.9	30.4	28.0*	27.3*	27.9
Accuracy (100-RMSPE) C	83.2*	70.7	72.8	85.2*	75.0*	69.1	75.0*	69.1
Accuracy (100-RMSPE) FF	79.7*	70.0	77.7*	73.8	55.7	71.4*	67.3	71.7*
Mean Abs. Pct. Error C	14.3*	24.0	21.8	10.0*	20.7*	23.7	19.0	18.4*
Mean Abs. Pct. Error FF	17.9*	22.5	17.7*	18.5	39.7	20.1*	26.7	20.3*
* Advantage C:	Traffic.com		Inrix		Traffic.com		Mixed	
Advantage FF:	Traffic.com		Traffic.com		Inrix		Inrix	

Notes: In all rows except Accuracy, lower numbers are better.
 C = Congested = 6:30 to 9:30 AM and 3:30 to 6:30 PM
 FF = Free-flow = 9:30 AM to 3:30 PM
 RMSPE = Root mean square percent error
 Mean percent error – The mean error calculation based on percent errors. Positive and negative errors offset one another.
 Percent standard deviation – The standard deviation calculation based on percent errors rather than errors in minutes.
 Root mean square percent error – The root mean square error calculation based on percent errors rather than errors in minutes.
 Mean absolute percent error – The mean absolute error calculation based on percent errors rather than errors in minutes.

Source: Inrix and Frost & Sullivan

The conclusion from the original study holds – neither Traffic.com nor Inrix has a clear overall advantage in absolute accuracy either as a whole, or when the data is filtered to analyze just free flow or congested travel times. Traffic.com came out ahead in Philadelphia during both congested and free-flow travel times, but in Providence and Washington, the results are mixed, with each company scoring best in one subset but not the other. This is also true when trials are combined across the three metropolitan areas. Traffic.com shows superior accuracies in Philadelphia and Washington in congested traffic conditions, while Inrix comes out ahead in Providence and Washington in free-flow traffic conditions. Traffic.com showed significant deterioration in accuracies in free-flow traffic conditions in Washington, while maintaining accuracies in the other two cities in the two driving conditions.

Inrix’s traffic solution provides comparable accuracies between congested-traffic and free-flow-traffic conditions in all three cities while providing superior road coverage within specific markets and across markets. We maintain our initial finding that, based on coverage and accuracy, Inrix is currently the leading provider of real-time traffic information.

Appendix 1 – Measures of Accuracy

Figure A1-1 repeats Figure 1 from the original study. It presents a range of measures of accuracy for Traffic.com and Inrix travel time data for the three metropolitan areas that were studied, based on all GT trials – those run during congested travel times and those run during free-flow travel times.

Figure A1-1

Data Comparison: All Travel Times (Three Metropolitan Areas), 2006

	<u>Philadelphia</u>		<u>Providence</u>		<u>Washington</u>		<u>Overall</u>	
	<u>Traffic</u>	<u>Inrix</u>	<u>Traffic</u>	<u>Inrix</u>	<u>Traffic</u>	<u>Inrix</u>	<u>Traffic</u>	<u>Inrix</u>
Mean Error (minutes)	-0.2*	-1.9	0.9	0.5*	1.2	-0.5*	0.7	-0.6*
Standard Deviation (minutes)	3.6*	5.7	2.5	2.0*	3.3*	4.0	3.2*	4.2
Root Mean Square Error (minutes)	3.6*	6.0	2.6	2.0*	3.5*	4.0	3.2*	4.2
Mean Absolute Error (minutes)	2.6*	4.1	1.8	1.2*	2.7	2.3*	2.3*	2.5
Mean Percent Error (%)	4.7*	-9.5	13.6	6.0*	23.7	2.2*	14.4	-0.2*
Percent Standard Deviation (%)	18.2*	28.4	21.4	19.9*	29.6*	29.8	24.8*	27.0
Root Mean Square Percent Error (%)	18.6*	29.7	25.2	20.6*	37.7	29.5*	28.6	26.9*
Accuracy (%) (100-RMSPE)	81.4*	70.3	74.8	79.4*	62.3	70.5*	71.4	73.1*
Mean Absolute Percent Error (%)	<u>16.0*</u>	<u>23.3</u>	<u>20.0</u>	<u>13.7*</u>	<u>31.9</u>	<u>21.4*</u>	<u>22.9</u>	<u>19.4*</u>
* Advantage:	Traffic.com		Inrix		Mixed		Mixed	
Memo: Number of trials	44		48		49		141	
Number of routes	5		4		6		15	

Note: In all rows except Accuracy, lower numbers are better.

Key: Mean error – Average of errors in minutes. Positive and negative errors offset one another.

Standard deviation – A statistical measure of how spread-out a dataset is. Positive and negative errors do not offset one another.

Root mean square error – Square root of the average of squared errors. Positive and negative errors do not offset one another.

Mean absolute error – The average of the absolute values of the errors. Positive and negative errors do not offset one another.

Mean percent error – The mean error calculation based on percent errors rather than errors in minutes.

Percent standard deviation – The standard deviation calculation based on percent errors rather than errors in minutes.

Root mean square percent error – The root mean square error calculation based on percent errors rather than errors in minutes.

Mean absolute percent error – The mean absolute error calculation based on percent errors rather than errors in minutes.

Source: Inrix and Frost & Sullivan

Figure A1-2 presents the same measures across the three metropolitan areas, based on GT runs that began between 6:30 and 9:30 AM, and 3:30 and 6:30 PM. These are regarded as travel times during which traffic is likely to be congested.

Figure A1-2

Data Comparison: Congested Travel Times (Three Metropolitan Areas), 2006

	<u>Philadelphia</u>		<u>Providence</u>		<u>Washington</u>		<u>Overall</u>	
	<u>Traffic</u>	<u>Inrix</u>	<u>Traffic</u>	<u>Inrix</u>	<u>Traffic</u>	<u>Inrix</u>	<u>Traffic</u>	<u>Inrix</u>
Mean Error (minutes)	-0.5*	-2.1	1.3	-0.2*	0.1*	-1.6	0.4*	-1.2
Standard Deviation (minutes)	3.5*	6.0	2.0	1.6*	3.0*	4.7	2.9*	4.4
Root Mean Square Error (minutes)	3.5*	6.2	2.4	1.5*	2.9*	4.8	2.9*	4.5
Mean Absolute Error (minutes)	2.5*	4.4	1.8	0.9*	2.0*	2.8	2.1*	2.6
Mean Percent Error (%)	1.9*	-12.7	17.3	-1.1*	10.5	-5.9*	10.3	-6.3*
Percent Standard Deviation (%)	17.1*	27.0	21.4	15.1*	23.2*	31.1	21.4*	24.7
Root Mean Square Percent Error (%)	16.8*	29.3	27.2	14.8*	25.0*	30.9	23.6*	25.3
Accuracy (%) (100-RMSPE)	83.2*	70.7	72.8	85.2*	75.0*	69.1	75.0*	69.1
Mean Absolute Percent Error (%)	<u>14.3*</u>	<u>24.0</u>	<u>21.8</u>	<u>10.0*</u>	<u>20.7*</u>	<u>23.2</u>	<u>19.0</u>	<u>18.4*</u>
* Advantage:	Traffic.com		Inrix		Traffic.com		Traffic.com	
Memo: Number of trials	23		27		20		70	
Number of routes	4		4		6		14	

Note: In all rows except Accuracy, lower numbers are better.

Key: Mean error – Average of errors in minutes. Positive and negative errors offset one another.

Standard deviation – A statistical measure of how spread-out a dataset is. Positive and negative errors do not offset one another.

Root mean square error – Square root of the average of squared errors. Positive and negative errors do not offset one another.

Mean absolute error – The average of the absolute values of the errors. Positive and negative errors do not offset one another.

Mean percent error – The mean error calculation based on percent errors rather than errors in minutes.

Percent standard deviation – The standard deviation calculation based on percent errors rather than errors in minutes.

Root mean square percent error – The root mean square error calculation based on percent errors rather than errors in minutes.

Mean absolute percent error – The mean absolute error calculation based on percent errors rather than errors in minutes.

Source: Inrix and Frost & Sullivan

Figure A1-3 presents the same measures across the three metropolitan areas, based on GT runs that began between 9:30 AM and 3:30 PM. These are travel times during which free-flow conditions are likely to be encountered.

Figure A1-3

Data Comparison: Free-Flow Travel Times (Three Metropolitan Areas), 2006

	<u>Philadelphia</u>		<u>Providence</u>		<u>Washington</u>		<u>Overall</u>	
	Traffic	Inrix	Traffic	Inrix	Traffic	Inrix	Traffic	Inrix
Mean Error (minutes)	0.2*	-1.6	0.3*	1.4	2.0	0.2*	1.0	0.0*
Standard Deviation (minutes)	3.8*	5.6	2.9	2.1*	3.4	3.4	3.4*	4.0
Root Mean Square Error (minutes)	3.7*	5.6	2.9	2.5*	3.9	3.3*	3.5*	4.0
Mean Absolute Error (minutes)	2.6*	3.8	1.7	1.7	3.2	1.9*	2.6	2.4*
Mean Percent Error (%)	7.8	-6.1*	9.0*	15.2	32.8	7.8*	18.3	5.9*
Percent Standard Deviation (%)	19.2*	30.1	20.9*	21.9	30.4	28.0*	27.3*	27.9
Root Mean Square Percent Error (%)	20.3*	30.0	22.3*	26.2	44.3	28.6*	32.7	28.3*
Accuracy (%) (100-RMSPE)	79.7*	70.0	77.7*	73.8	55.7	71.4*	67.3	71.7*
Mean Absolute Percent Error (%)	<u>17.9*</u>	<u>22.5</u>	<u>17.7*</u>	<u>18.5</u>	<u>39.7</u>	<u>20.1*</u>	<u>26.7</u>	<u>20.3*</u>
* Advantage:	Traffic.com		Traffic.com		Inrix		Mixed	
Memo: Number of trials	21		21		29		71	
Number of routes	5		4		6		15	

Note: In all rows except Accuracy, lower numbers are better.

Key: Mean error – Average of errors in minutes. Positive and negative errors offset one another.
 Standard deviation – A statistical measure of how spread-out a dataset is. Positive and negative errors do not offset one another.
 Root mean square error – Square root of the average of squared errors. Positive and negative errors do not offset one another.
 Mean absolute error – The average of the absolute values of the errors. Positive and negative errors do not offset one another.
 Mean percent error – The mean error calculation based on percent errors rather than errors in minutes.
 Percent standard deviation – The standard deviation calculation based on percent errors rather than errors in minutes.
 Root mean square percent error – The root mean square error calculation based on percent errors rather than errors in minutes.
 Mean absolute percent error – The mean absolute error calculation based on percent errors rather than errors in minutes.

Source: Inrix and Frost & Sullivan