Modification M009 defines a method to link payment of invoices for data supplied by INRIX Inc. to the objective measure of quality resulting from the validation efforts supported by the I-95 Corridor Coalition as part of the Vehicle Probe Contract.

Description of Method

The evaluation process separates quality measures into four (4) "speed bins" as shown below: The quality specifications in the contract refer to the Average Absolute Speed Error and Speed Error Bias.

- 0-30 MPH
- 30-45 MPH
- 45-60 MPH
- 60 MPH

The formula to effect payments dependent on measured data quality is based on the four speed categories noted above. The payment formula is divided into four equal portions, each corresponding to one of the four speed categories. If quality specs are fully met in each of the four speed categories, the Contractor will receive the full invoiced amount. If the quality of the data falls short in a specific speed category, the corresponding payment for that respective speed category will be impacted. Any payment reduction will be affected based on a linear combination of two factors, Q_1 and Q_2, as described below. An illustration of the scheme is shown for a hypothetical invoice for March 2009 in Table 1.

Table 1. Hypothetical Invoice and payment calculation.

Hypothetical Invoice for March 2009

Total Amount Invoiced: $ 100,000.00

Application of Quality Metrics

Category	Payment Portion	Quality Factors		Overall Q Factor	Payment (P_x * Q * Invoice)
		AASE	SEB	$2/3*Q_1 + 1/3*Q_2$	
	P_x	Q_1	Q_2	**Q**	
0-30 MPH	25%	0.80	1.00	0.87	$ 21,666.67
30-45 MPH	25%	1.00	0.93	0.98	$ 24,416.67
45-60 MPH	25%	1.00	1.00	1.00	$ 25,000.00
> 60 MPH	25%	1.00	1.00	1.00	$ 25,000.00
Total Payment					$ 96,083.33

Each speed category is assigned an equal initial weight of 25% of the overall invoice payment. This approach is used in order to balance the volume of traffic in each category against value of the information represented by each speed bin. Traffic volume flowing at nominal speeds of 60+ mph (particularly daytime non-rush hour periods and overnight hour periods) represents approximately 75% of evaluated freeway traffic flow, while minor congestion of 45-60 mph represents roughly 20% of data, with maximum congestion (0-30MPH) being the remaining 5%. [Percentages were taken from the I95 Vehicle Probe Initial Validation Report.]

The value of the traffic information is greatest for congested conditions (0-30 mph and 30-45 mph). Accuracy of traffic data is most critical and valuable during congested time periods. By placing equal weights on each speed bin, relative traffic volumes and value of congestion information in each of the four speed categories are balanced.

Utilizing this model, a quarter of each invoice is dependent on the quality of traffic data in each of the four speed bins. Table 1 illustrates this with quality factors, Q_1 and Q_2. These factors are based on the validation results and are dependent on the two primary metrics of Average Absolute Speed Error (AASE) and Speed Error Bias (SEB) as follows. [Note the contractual definition for AASE and SEB are found on page 3-12 of the INRIX Technical proposal matrix block numbers 5 & 6 respectively and provided herewith in Attachment 1.] The contractual limit on AASE is 10 MPH. If the calculated AASE is 10 MPH or less, there is no penalty and the quality factor for AASE (referred to Q_1) is equal 1.0. If the measured AASE exceeds 10 MPH, the quality factor is decreased from 1.0 to 0 as the AASE increases from 10 MPH to 15 MPH as illustrated in the top graph in Figure 1. If the AASE is 15 or greater, the quality factor, Q_1, would be zero, resulting in no payment for that speed category.

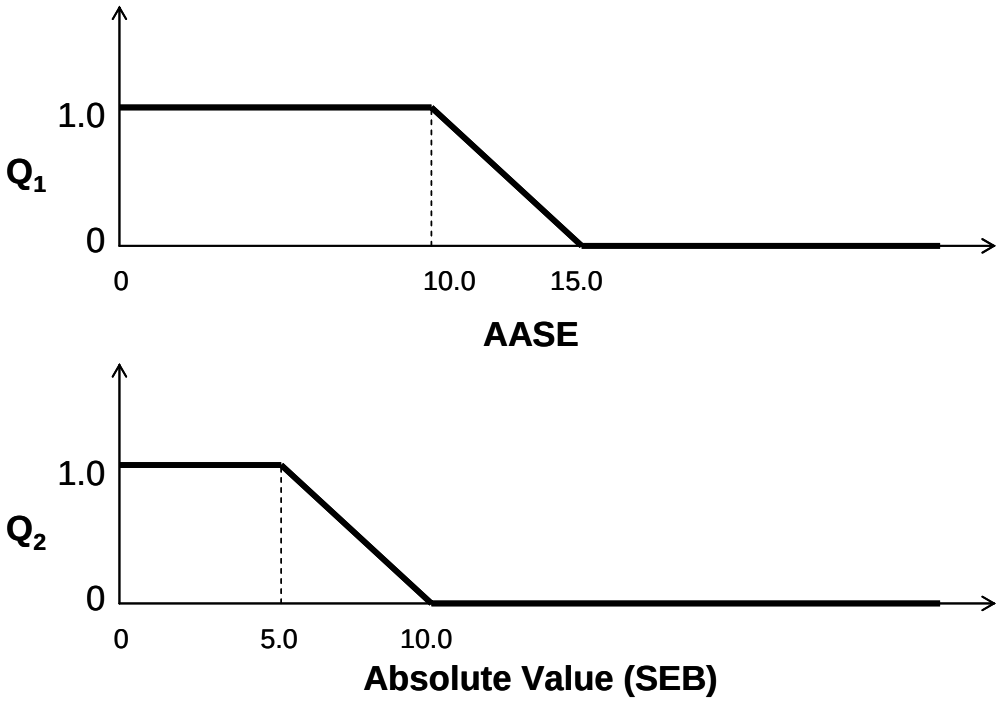

Figure 1 Illustration of the calculation of the AASE and SEB quality factors (Q_1 and Q_2)

A similar scheme is applied to the SEB to produce the Q_2 quality factor as illustrated in the bottom graph of Figure 1. The overall quality factor (Q) for the specified speed category is the linear combination of $2/3 * Q_1 + 1/3 * Q_2$. An illustration of the calculation of the quality factor for AASE and SEB are shown in Figure 1.

The data used in the calculation of the payments factors for AASE and SEB will be representative of the vehicle probe project as whole, inclusive of the "Core" system and additional state expansion programs, and include only Freeway segments as defined in the contract. Limits in terms of minimum amount of validation data and geographical and time extents of the data included in the calculations are provided below. This data set used to determine payment for a particular invoice is referred to as the 'Assessment Data Set' for a particular payment.

Guidelines for inclusion of validation data in the Assessment Data Set for the calculation of Quality Factors:

- The most recent three complete months of validation results predating the invoice. The time period will be extended if needed to meet other criteria.
- A minimum of data representing three states.
- A minimum of data representing 1500 hours in aggregate, but not less than 25, 50, 300, and 1000 hours in each of the speed bins (0-30, 30-45, 45-60, > 60) respectively.

- Data will be included sequentially by date proceeding backward from the date of the invoice until all of the above requirements are met.

Other guidelines for implementation require a consistent schedule and methodology for validation as put forth in the 'Ongoing Data Validation Plan' dated January 2009 by the I-95 Corridor Coalition. This process allows both the Coalition and INRIX to provide review and input into validation planning, processing and results prior to posting. In general, new validation data from one of the Coalition member jurisdiction will be added to the Assessment Data Set on a monthly basis. Likewise, it is anticipated that a data set will expire from the Assessment Data Set as well as new validation data is added to the Assessment Data Set, provided that the oldest data set is not needed to meet all the criteria as outlined above. The accuracy metrics for the calculation of quality factors will be applied against the SEM band (see Initial Validation Results for full explanation.)

Sample Payment Based on the Initial Validation Results

Based on the results of the initial evaluation reported in January 2009, the payment factor for data invoiced in February 2009 will be 100% as illustrated in Table 2. The aggregate Absolute Speed Error and Speed Error Bias were within specifications for all speed categories, resulting in no reduction of payment. Data from all four states (VA, MD, DE, and NJ) are needed to meet the minimum data requirements in terms of hours of data in each speed category.

Table 2 Sample Payment factor calculated from Initial Validation results

		Absolute Speed Error		Speed Error Bias					
		Comparison with SEM Band	Q1 Factor	Comparison with SEM Band	Q2 Factor	Hours of Data Collection	Payment Factor 2/3*Q1 + 1/3*Q2	Proportion	Total Payment
All States									
	0-30 MPH	5.90	1.00	3.80	1.00	28.7	1.00	25%	0.25
	30-45 MPH	6.90	1.00	2.20	1.00	53.0	1.00	25%	0.25
	45-60 MPH	2.30	1.00	0.20	1.00	325.3	1.00	25%	0.25
	> 60 MPH	2.30	1.00	-1.70	1.00	1176.5	1.00	25%	0.25
									100%

Offset Credit

In order to encourage improvements in data quality, THE University will implement an Offset Credit which will be calculated based on the results of the 0-30 MPH and 30-45 MPH speed bins. The quality of these bins best reflect the ability of the data feed to accurately capture congestion. If the data feed misses a congestion event or is significantly late in reporting, the AASE in these bins are impacted.

For the lower two speed bins, Q_1 will be calculated as illustrated in Figure 2. If the AASE falls below 5 MPH, a Q_1 value greater than 1.0 is possible. As the AASE decreases from 5.0 to 0, the Q_1 proportionally increase from 1.0 to 1.5. These Q_1 values are used in the calculation of the payment for the lower speed bins. If the resulting payment is greater than the invoice, the overage may only be applied to future invoice payments in the event that quality falls below minimum standards for full payment.

- Payment for any invoice can never exceed the amount of the invoice.
- Any offset credit is applied to future invoices in the event data quality dictates a reduction in payment.
- Earned Offset Credits shall remain active for a not-to-exceed period of eighteen (18) months.

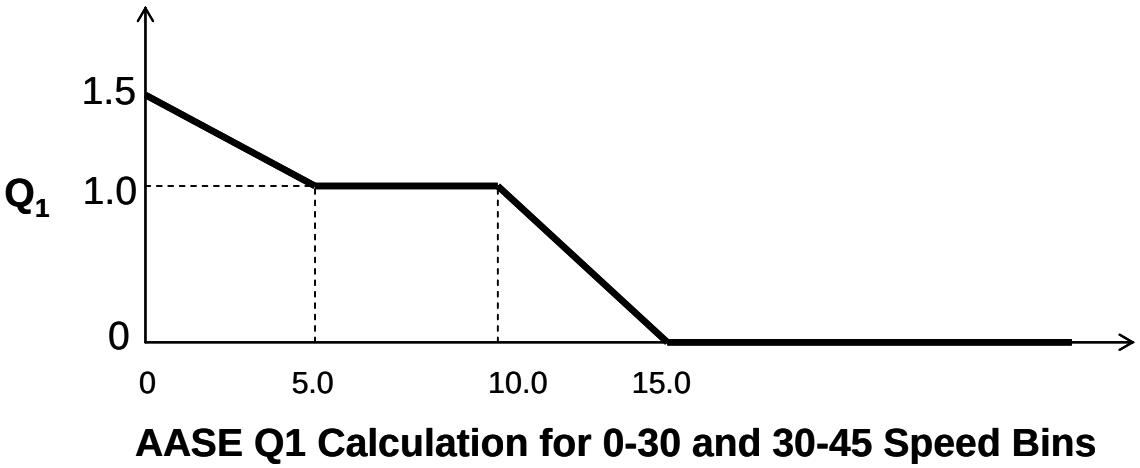

Figure 2 Illustration of the Q1 factor for Offset Credit

Payment Calculations for Network Expansions

Payment calculations for Network Expansions (such as New Jersey and North Carolina) will be adjusted using the same quality factors (designated the base calculation) as that used to determine payment for the core network, subject to the following exception:

In the event that the state in which the expansion has occurred is not one of the states represented in the Assessment Data Set for which the base calculation has been made, a revised calculation will be developed. In the revised calculation, the Assessment Data Set will be augmented to include the most recent data available from the state in question. The revised calculation will only be applicable to payment for the expanded network of the state in question. The base calculation will be used for payment of all other data.

Attachment 1

Average Absolute Speed Error

The absolute speed error is defined as the absolute value of the difference between the mean speed reported from the data service and the mean speed provided by validation procedures for a specified time period or polling interval. Given that monitored links will be of different lengths, quality requirements based on speed rather than travel time will normalize the effect of varying link lengths.

Speed data shall have a maximum average absolute error of 10 MPH in each of the following speed ranges: 0-30 MPH, 30-45 MPH, 45-60 MPH and > 60 MPH.

Calculation Method

Let: A_{ij} = Speed data for link *i* at time *j* from the data service.
B_{ij} = Corresponding speed from the validation data

Average absolute error = mean(abs($A_{ij} – B_{ij}$)).

Speed range is dependent on the validation data (B_{ij}).

Example: A source of validation data exists for various routes and for various times interval within the I-95 corridor. Speed data from the validation data source will be grouped according to the speed ranges given above. All validation speed data points within the 0-30 MPH range will be compared with the respective speed data reported by the data service and a single average absolute error will be calculated for the 0-30 MPH speed range. Similarly, for each of the remaining speed ranges, a single average absolute error metric will be calculated based on the difference between the validation data in that range and the corresponding speed from the data service.

Speed Error Bias

Error bias is defined as the average speed error (not the absolute value) in each speed range. Speed data shall have 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.

Calculation Method

Let: A_{ij} = Speed data for link *i* at time *j* from the data service.
B_{ij} = Corresponding speed from the validation data

Average error = mean($A_{ij} – B_{ij}$)

Speed range is dependent on the value B_{ij}. The calculation is similar to that of Average Absolute Speed Error, but without the absolute value operator.