WIM System Field Calibration and Validation Summary Report - Amended

Arizona SPS-2
SHRP ID – 040200

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1 Executive Summary

A WIM validation was performed on September 13 and 14, 2010 at the Arizona SPS-2 site located on route I-10 at milepost 108.6, 1.1 miles west of S. Palo Verde Road interchange.

This site was installed on November 28, 2006. The in-road sensors are installed in the eastbound lane. The site is equipped with bending plate WIM sensors and IRD iSINC WIM controller. The LTPP lane is identified as lane 1 in the WIM controller. From a comparison between the report of the most recent validation of this equipment on February 12, 2008 and this validation visit, it appears that no changes have occurred during this time to the basic operating condition of the equipment.

The equipment is in working order. Electronic and electrical checks of all WIM components determined that the equipment was operating within tolerances. Further equipment discussion is provided in Section 3.

During the on-site pavement evaluation, it was noted that an old WIM installation is located approximately 330 feet prior to current location. Observations of trucks passing over the site *noted that* there is truck movement at the old WIM site location, but it appears to diminish prior to crossing current installation. Further pavement condition discussion is provided in Section 4.

Based on the criteria contained in the LTPP Field Operations Guide for SPS WIM Sites, Version 1.0 (05/09), this site is providing research quality loading data. The summary results of the validation are provided in Table 1.1 below.

Table 1-1 – Post-Validation Results – 14-Sep-10

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-0.5 ± 7.5%	Pass
Tandem Axles	±15 percent	-0.6 ± 8.1%	Pass
GVW	±10 percent	-0.6 ± 6.5%	Pass
Vehicle Length	±3 percent (1.9 ft)	3.0 ± 1.3 ft	FAIL
Axle Spacing Length	± 0.5 ft [150mm]	0.0 ± 0.3 ft	Pass

Truck speeds were manually collected for each test run by a radar gun and compared with the speed reported by the WIM equipment. For this site, the error in speed measurement was 0.1 ± 1.3 mph, which is greater than the ±1.0 mph tolerance established by the LTPP Field Operations Guide for SPS WIM Sites. However, since the site is measuring axle spacing length with a mean error of 0.0 feet, and the speed and axle spacing measurements are based on the distance between the axle detector sensors, it can be concluded that the distance factor is set correctly.

This site is providing research quality vehicle classification data for heavy trucks (Class 6 – 13). The heavy truck misclassification rate of 0.0% is within the 2.0% acceptability criterion for

LTPP SPS WIM sites. The overall misclassification rate of 1.0% from the 100 truck sample (Class 4 – 13) was due to one Class 5 vehicle that was identified by the WIM system as a Class 8 vehicle.

There were two test trucks used for the post-validation. They were configured and loaded as follows:

- The *Primary* truck was a Class 9 vehicle with air suspension on the tractor and trailer tandems, and standard (4 feet) tandem spacings. It was loaded with trash.
- The *Secondary* truck was a Class 9 vehicle with air suspension on the tractor tandem, air on the trailer tandem, standard tandem spacing on the tractor and standard tandem on the trailer. The Secondary truck was loaded with trash.

Prior to the validation, the test trucks were weighed and measured, cold tire pressures were taken, and photographs of the trucks, loads and suspensions were obtained (see Section 7). Axle length (AL) was measured from the center hub of the first axle to the center hub of the last axle. Overall length (OL) was measured from the edge of the front bumper to the edge of the rear bumper. The test trucks were re-weighed at the conclusion of the validation. The average post-validation test truck weights and measurements are provided in Table 1-2.

Table 1-2 – Post-Validation Test Truck Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	72.6	11.0	15.2	15.2	15.6	15.6	14.5	4.3	33.4	4.0	56.2	63.6
2	62.8	10.3	12.8	12.8	13.4	13.4	14.5	4.3	33.1	4.0	55.9	61.5

The posted speed limit at the site is 75 mph. During the testing, the speed of the test trucks ranged from to 54 to 70 mph, a variance of 16 mph.

During test truck runs, pavement temperature was collected using a hand-held infrared temperature device. The post-validation pavement surface temperatures varied from 80.0 to 121.2 degrees Fahrenheit, a range of 41.2 degrees Fahrenheit. The sunny weather conditions provided the desired 30 degree range in temperatures.

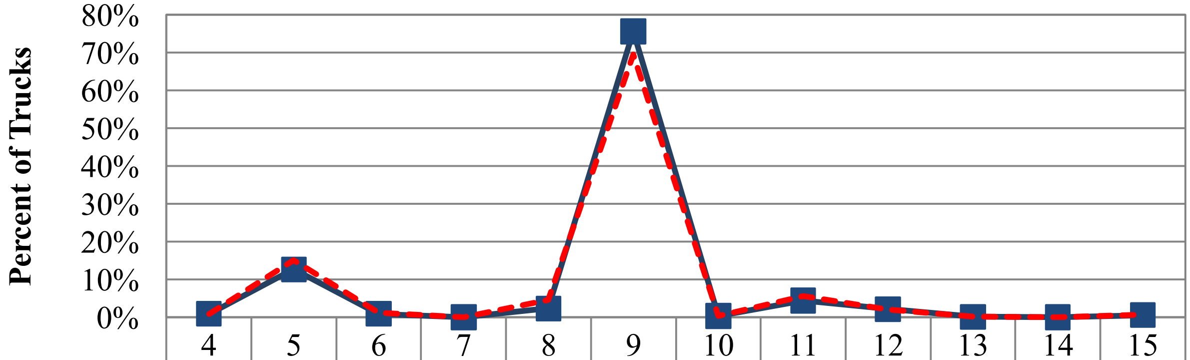
A review of the LTPP Standard Release Database 24 shows that there are 24 months of level “E” WIM data for this site. This site requires at least 3 additional years of data to meet the minimum of five years of research quality data.

2 WIM System Data Availability and Pre-Visit Data Analysis

To assess the quality of the current data, a pre-visit analysis was conducted by comparing a two-week data sample from June 14, 2010 (Data) to the most recent Comparison Data Set (CDS) from February 18, 2008. The assessments performed prior to the site visits are used to develop reasonable expectations for the validation. The results of further investigations performed as a result of the analyses are provided in Section 5 of this report.

2.1 Classification Data Analysis

The traffic data was analyzed to determine the expected truck distributions. This analysis provides a basis for the classification distribution study that was conducted on site. Figure 2-1 provides a comparison of the truck type distributions for the two datasets.



	4	5	6	7	8	9	10	11	12	13	14	15
Data	0.9%	12.7%	0.9%	0.0%	2.3%	75.6%	0.4%	4.4%	2.1%	0.1%	0.0%	0.5%
CDS	0.9%	15.1%	1.1%	0.0%	4.6%	69.5%	0.4%	5.5%	2.0%	0.1%	0.0%	0.7%

Figure 2-1 – Comparison of Truck Distribution

Table 2-1 provides statistics for the truck distributions at the site for the two periods represented by the two datasets. The table shows that according to the most recent data, the most frequent truck types crossing the WIM scale are Class 9 (75.6%) and Class 5 (12.7%). It also indicates that 0.5 percent of the vehicles at this site are unclassified. Table 2-1 also provides data for vehicle Classes 14 and 15. Class 14 vehicles are vehicles that are reported by the WIM equipment as having irregular measurements and cannot be classified properly, such as negative speeds from vehicles passing in the opposite direction of a two-lane road. Class 15 vehicles are unclassified vehicles.

Table 2-1 – Truck Distribution from W-Card

Vehicle Classification	CDS		Data		Change
	Date				
	2/18/2008		6/14/2010		
4	603	0.9%	560	0.9%	0.0%
5	10683	15.1%	7979	12.7%	-2.4%
6	809	1.1%	577	0.9%	-0.2%
7	3	0.0%	6	0.0%	0.0%
8	3272	4.6%	1463	2.3%	-2.3%
9	49145	69.5%	47656	75.6%	6.1%
10	269	0.4%	238	0.4%	0.0%
11	3918	5.5%	2790	4.4%	-1.1%
12	1427	2.0%	1352	2.1%	0.1%
13	67	0.1%	53	0.1%	0.0%
14	0	0.0%	0	0.0%	0.0%
15	527	0.7%	346	0.5%	-0.2%

From the table it can be seen that the number of Class 9 vehicles has increased by 6.1 percent from February 2008 and June 2010. During the same time period, the number of Class 5 trucks decreased by 2.4 percent.

2.2 Speed Data Analysis

The traffic data received from the Phase II Contractor was analyzed to determine the expected truck speed distributions. This will provide a basis for the speed of the test trucks during validation testing. The CDS distribution of speeds is shown in Figure 2-2.

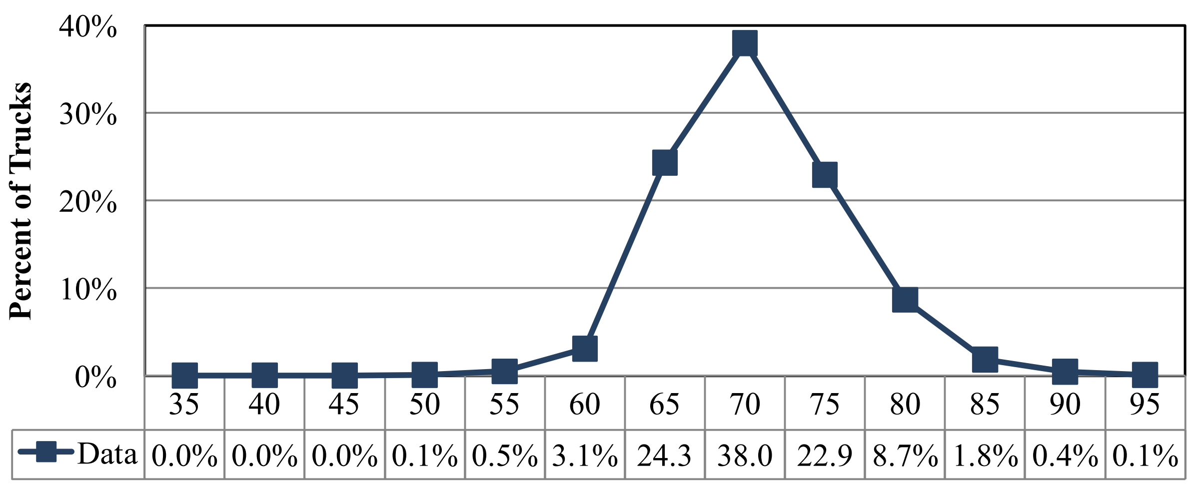


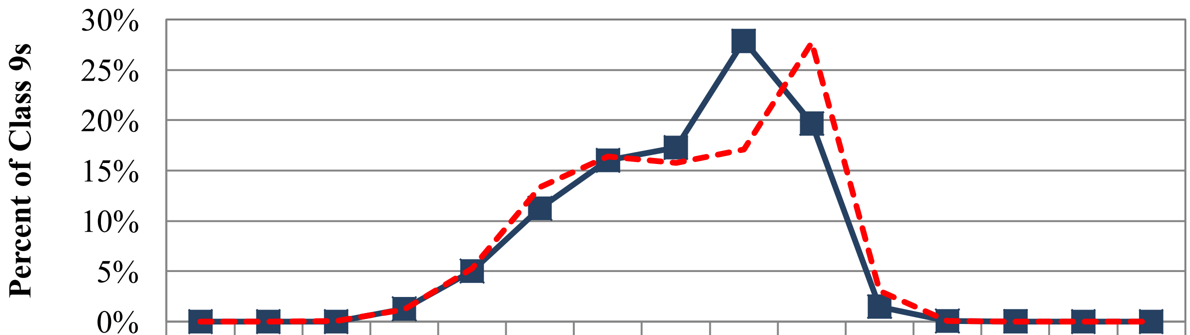
Figure 2-2 – Truck Speed Distribution – 27-Aug-10

As shown in Figure 2-2, the majority of the trucks at this site are traveling between 65 and 75 mph. The posted speed limit at this site is 75 and the 85th percentile speed for trucks at this site is 73 mph. The coverage of truck speeds for the validation will be from 60 to 70 mph. Since the 85th percentile speeds for trucks is above the posted speed limit, the post-visit applied calibration will be used to develop compensation factors for speed points from 70 to 75 mph.

2.3 GVW Data Analysis

The traffic CDS data received from the Regional Support Contractor was analyzed to determine the expected Class 9 GVW distributions. Figure 2-3 shows a comparison between GVW plots generated using a two-week W-card sample from June 2010 and the Comparison Data Set from February 2008.

As shown in Figure 2-3, there is a shift to the left for the loaded peak between the February 2008 Comparison Data Set (CDS) and the June 2010 two-week sample W-card dataset (Data). An unloaded peak is not distinguishable for either set of data.



	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
Data	0.0%	0.0%	0.0%	1.3%	5.0%	11.2	16.0	17.3	27.9	19.7	1.5%	0.1%	0.0%	0.0%	0.0%
CDS	0.0%	0.0%	0.1%	1.2%	5.3%	13.4	16.4	15.8	17.1	27.7	3.0%	0.0%	0.0%	0.0%	0.0%

Figure 2-3 – Comparison of Class 9 GVW Distribution

Table 2-2 is provided to show the statistical comparison between the Comparison Data Set and the current dataset.

Table 2-2 – Class 9 GVW Distribution from W-Card

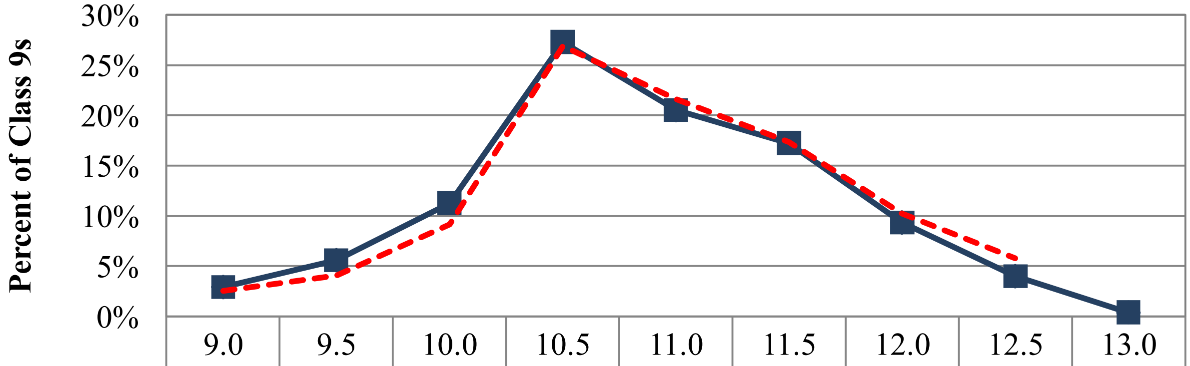
GVW weight bins (kips)	CDS		Data		Change
	Date				
	2/18/2008		6/14/2010		
8	0	0.0%	0	0.0%	0.0%
16	0	0.0%	0	0.0%	0.0%
24	27	0.1%	5	0.0%	0.0%
32	597	1.2%	609	1.3%	0.1%
40	2575	5.3%	2384	5.0%	-0.3%
48	6497	13.4%	5340	11.2%	-2.1%
56	7963	16.4%	7615	16.0%	-0.4%
64	7667	15.8%	8213	17.3%	1.5%
72	8305	17.1%	13247	27.9%	10.8%
80	13452	27.7%	9348	19.7%	-8.0%
88	1474	3.0%	702	1.5%	-1.6%
96	21	0.0%	29	0.1%	0.0%
104	4	0.0%	8	0.0%	0.0%
112	0	0.0%	5	0.0%	0.0%
120	0	0.0%	0	0.0%	0.0%
Average =	60.7		60.8		0.1

As shown in the table, the number of unloaded class 9 trucks in the 32 to 40 kips range decreased by 0.3 percent while the number of loaded class 9 trucks in the 72 to 80 kips range decreased by 8.0 percent. The number of overweight trucks decreased during this time period by 1.5 percent and the overall GVW average for this site increased from 60.7 kips to 60.8 kips.

2.4 Class 9 Front Axle Weight Data Analysis

The CDS data received from the Regional Support Contractor was analyzed to determine the expected average front axle weight. This will provide a basis for the evaluation of the quality of the data by comparing the observed average front axle weight with the expected average front axle weight average for Class 9 trucks of 10.3 kips.

Figure 2-4 shows a comparison between Class 9 front axle weight plots generated by using the two week W-card sample from June 2010 and the Comparison Data Set from February 2008.



	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0
Data	2.9%	5.6%	11.3%	27.3%	20.5%	17.2%	9.3%	4.0%	0.4%
CDS	2.5%	4.1%	9.2%	26.9%	21.6%	17.4%	10.2%	5.8%	

Figure 2-4 – Distribution of Class 9 Front Axle Weights

It can be seen in the figure that the front axle weight plots for the February 2008 Comparison Data Set (CDS) and the June 2010 dataset (Data) are nearly identical.

Table 2-3 provides the Class 9 front axle weight distribution data for the February 2008 Comparison Data Set (CDS) and the June 2010 dataset (Data).

Table 2-3 – Class 9 Front Axle Weight Distribution from W-Card

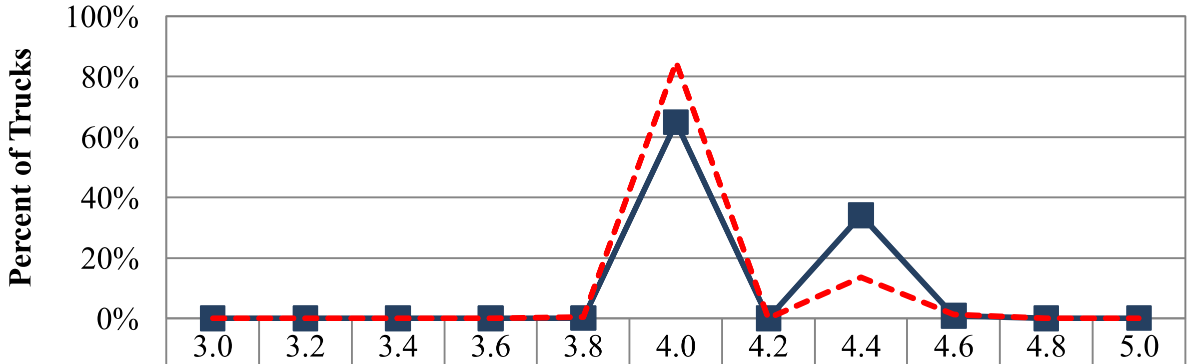
F/A weight bins (kips)	CDS		Data		Change
	Date				
	2/18/2008		6/14/2010		
9.0	674	1.4%	671	1.4%	0.0%
9.5	1220	2.5%	1380	2.9%	0.4%
10.0	1970	4.1%	2651	5.6%	1.5%
10.5	4419	9.2%	5345	11.3%	2.1%
11.0	12963	26.9%	12930	27.3%	0.4%
11.5	10409	21.6%	9722	20.5%	-1.1%
12.0	8380	17.4%	8170	17.2%	-0.1%
12.5	4922	10.2%	4423	9.3%	-0.9%
13.0	2792	5.8%	1895	4.0%	-1.8%
13.5	462	1.0%	192	0.4%	-0.6%
Average =	11.2		11.1		-0.1

The table shows that the average front axle weight for Class 9 trucks has decreased by 0.1 kips, or -1.0 percent. According to the current data, the majority of the Class 9 front axle weights are between 11.0 and 11.5 kips and the average front axle weight for Class 9 trucks is 11.1 kips.

2.5 Class 9 Tractor Tandem Spacing Data Analysis

The CDS data received from the Regional Support Contractor was analyzed to determine the expected average tractor tandem spacing. This will provide a basis for the evaluation of the accuracy of the equipment distance and speed measurements by comparing the observed average tractor tandem spacing with the expected average tractor tandem spacing of 4.25 feet.

The class 9 tractor tandem spacing plots in Figure 2-5 are provided to indicate possible shifts in WIM system distance and speed measurement accuracies.



	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0
Data	0.0%	0.0%	0.0%	0.0%	0.1%	64.9%	0.0%	34.1%	0.8%	0.0%	0.1%
CDS	0.0%	0.0%	0.1%	0.0%	0.4%	84.7%	0.0%	13.5%	1.2%	0.0%	0.1%

Figure 2-5 – Comparison of Class 9 Tractor Tandem Spacing

As seen in the figure, the Class 9 tractor tandem spacing for the February 2008 Comparison Data Set and the June 2010 Data there appears to be a 20 percent shift of the tandem spacings from approximately 4.0 feet to 4.4 feet.

Table 2-4 shows the Class 9 axle spacings between the second and third axles for the power unit.

Table 2-4 – Class 9 Axle 3 to 4 Spacing from W-Card

Tandem 1 spacing bins (feet)	CDS		Data		Change
	Date				
	2/18/2008		6/14/2010		
3.0	20	0.0%	0	0.0%	0.0%
3.2	6	0.0%	1	0.0%	0.0%
3.4	32	0.1%	12	0.0%	0.0%
3.6	0	0.0%	0	0.0%	0.0%
3.8	173	0.4%	24	0.1%	-0.3%
4.0	41157	84.7%	30845	64.9%	-19.8%
4.2	0	0.0%	0	0.0%	0.0%
4.4	6579	13.5%	16189	34.1%	20.5%
4.6	573	1.2%	387	0.8%	-0.4%
4.8	0	0.0%	0	0.0%	0.0%
5.0	43	0.1%	47	0.1%	0.0%
Average =	4.0		4.1		0.1

From the table it can be seen that the spacing of the tractor tandems for Class 9 trucks at this site is between 3.8 and 4.6 feet. The average tractor tandem spacing is 4.1 feet, which is below the expected average of 4.25 feet. Further analyses are performed during the validation and post-validation analysis.

2.6 Data Analysis Summary

Historical data analysis involved the comparison of the most recent Comparison Data Set (February 2008) based on the last calibration with the most recent two-week WIM data sample from the site (June 2010). Comparison of vehicle class distribution data indicates a 6.1 percent increased in the number of Class 9 vehicles. Analysis of Class 9 weight data indicates that front axle weights have decreased by 0.1 percent and average Class 9 GVW has increased by 0.2 percent for the June 2010 data. The data indicates an average truck tandem spacing of 4.1 feet, which is below the expected average of 4.25 feet.

3 WIM Equipment Discussion

From a comparison between the report of the most recent validation of this equipment on January 00, 1900 and this validation visit, it appears that no changes have occurred during this time to the basic operating condition of the equipment.

3.1 Description

This site was installed on November 28, 2006 by International Road Dynamics. It is instrumented with bending plate weighing sensors and IRD iSINC WIM Controller. As the installation contractor, IRD also performs routine equipment maintenance and data quality checks of the WIM data.

3.2 Physical Inspection

Prior to the pre-validation test truck runs, a physical inspection of all WIM equipment and support services equipment was conducted. No deficiencies were noted. Photographs of all system components were taken and are presented in Section 7.

3.3 Electronic and Electrical Testing

Electronic and electrical checks of all system components were conducted prior to the pre-validation test truck runs. Dynamic and static electronic checks of the in-road sensors were performed none. All values for the WIM sensors and inductive loops were within tolerances. Electronic tests of the power and communication devices indicated that they were operating normally.

3.4 Equipment Troubleshooting and Diagnostics

The WIM system appeared to collect, analyze and report vehicle measurements normally. No troubleshooting actions were taken.

3.5 Recommended Equipment Maintenance

No equipment maintenance actions are recommended.

4 Pavement Discussion

4.1 Pavement Condition Survey

During a visual distress survey of the pavement conducted from the shoulder, an old WIM installation was noted approximately 330 feet prior to the current installation.

Photo 4-1 - WIM Installation 330 Feet Prior to Current WIM Scales

4.2 Profile and Vehicle Interaction

Profile data was collected on January 26, 2010 by the Western Regional Support Contractor using a high-speed profiler, where the operator measures the pavement profile over the entire one-thousand foot long WIM Section, 900 feet prior to WIM scales and 100 feet after the WIM scales. Each pass collects International Roughness Index (IRI) values in both the left and right wheel paths. For this site, 10 profile passes were made, 4 in the center of the travel lane and 6 that were shifted to the left and to the right of the center of the travel lane.

From a pre-visit review of the IRI values for the center, right, and left profile runs, the highest IRI value within the 1000 foot WIM section is 769 in/mi and the 400 foot approach section is located approximately 330 feet prior to the WIM scale. This area of pavement was closely investigated during the validation visit. An old WIM installation was noted approximately 330 feet prior to the current installation.

Additionally, a visual observation of the trucks as they approach, traverse and leave the sensor area was performed. Trucks demonstrated vertical movement in the area of the old WIM installation mentioned above, however, the adverse truck dynamics appear to diminish prior to entering the WIM scale area. Trucks appear to track down the center of the lane.

4.3 LTPP Pavement Profile Data Analysis

The IRI data files are processed using the WIM Smoothness Index software. The indices produced by the software provide an indication of whether or not the pavement roughness may affect the operation of the WIM equipment. The recommended thresholds for WIM Site pavement smoothness are provided in Table 4-1.

Table 4-1 – Recommended WIM Smoothness Index Thresholds

Index	Lower Threshold (m/km)	Upper Threshold (m/km)
Long Range Index (LRI)	0.50	2.1
Short Range Index (SRI)	0.50	2.1
Peak LRI	0.50	2.1
Peak SRI	0.75	2.9

When all values are less than the lower threshold shown in Table 4-1, it is unlikely that pavement conditions will significantly influence sensor output. Values between the threshold values may or may not influence the accuracy of the sensor output and values above the upper threshold would lead to sensor output that would preclude achieving the research quality loading data.

The profile analysis was based on four different indices: Long Range Index (LRI), which represents the pavement roughness starting 25.8 m prior to the scale and ending 3.2 m after the scale in the direction of travel; Short Range Index (SRI), which represents the pavement roughness beginning 2.74 m prior to the WIM scale and ending 0.46 m after the scale; Peak LRI – the highest value of LRI within 30 m prior to the scale; and Peak SRI – the highest value of SRI between 2.45 m prior to the scale and 1.5 m after the scale. The results from the analysis for each of the indices for the right wheel path (RWP) and left wheel path (LWP) values for the 3 left, 3 right and 4 center profiler runs are presented in Table 4-2.

Table 4-2 – WIM Index Values

Profiler Passes			**Pass 1**	**Pass 2**	**Pass 3**	**Pass 4**	**Pass5**	**Avg**
Left	LWP	LRI (m/km)	1.265	1.323	1.101			1.230
		SRI (m/km)	0.774	1.048	0.834			0.885
		Peak LRI (m/km)	1.468	1.519	1.244			1.410
		Peak SRI (m/km)	1.069	1.225	1.255			1.183
	RWP	LRI (m/km)	0.635	0.582	0.553			0.590
		SRI (m/km)	*0.405*	*0.212*	*0.450*			*0.356*
		Peak LRI (m/km)	0.814	0.778	0.723			0.772
		Peak SRI (m/km)	*0.579*	*0.379*	*0.522*			*0.493*
Center	LWP	LRI (m/km)	0.506	0.539	0.543	0.513		0.525
		SRI (m/km)	*0.344*	*0.420*	*0.354*	*0.471*		*0.397*
		Peak LRI (m/km)	0.688	0.702	0.683	0.853		0.732
		Peak SRI (m/km)	*0.551*	*0.474*	*0.505*	*0.589*		*0.530*
	RWP	LRI (m/km)	0.573	0.602	0.533	0.624		0.583
		SRI (m/km)	*0.483*	*0.466*	*0.343*	*0.363*		*0.414*
		Peak LRI (m/km)	0.696	0.699	0.828	0.664		0.722
		Peak SRI (m/km)	*0.631*	*0.523*	*0.383*	*0.710*		*0.562*
Right	LWP	LRI (m/km)	0.655	0.678	0.615			0.649
		SRI (m/km)	0.730	0.761	0.507			0.666
		Peak LRI (m/km)	0.734	0.692	0.645			0.690
		Peak SRI (m/km)	*0.740*	0.761	*0.645*			*0.715*
	RWP	LRI (m/km)	0.783	0.813	0.773			0.790
		SRI (m/km)	*0.315*	*0.334*	*0.260*			*0.303*
		Peak LRI (m/km)	0.967	0.929	1.073			0.990
		Peak SRI (m/km)	*0.565*	*0.520*	*0.520*			*0.535*

From Table 4-2 it can be seen that most of the indices computed from the profiles are between the upper and lower threshold values, with the remaining values under the lower threshold. The highest values, on average, are the Peak LRI values in the left wheel path of the left shift passes..

4.4 Recommended Pavement Remediation

Pavement remediation in the area of the old WIM installation is recommended.

5 Statistical Reliability of the WIM Equipment

The following section provides summaries of data collected during the pre-validation, the calibration, and the post-validation test truck runs, as well as information resulting from the classification and speed studies. All analyses of test truck data and information on necessary equipment adjustments are provided.

5.1 Pre-Validation

The first set of test runs provides a general overview of system performance prior to any calibration adjustments for the given environmental, vehicle speed and other conditions.

The 40 pre-validation test truck runs were conducted on September 12, 2010, beginning at approximately 7:43 AM and continuing until 1:15 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with trash, and equipped with air suspension on truck and trailer tandems and with standard tandem spacings on both the tractor and trailer.
- A Class 9, 5-axle truck, loaded with trash, and equipped with air suspension on the tractor, air suspension on the trailer, with standard tandem spacing on the tractor and standard tandem spacing on the trailer.

The test trucks were weighed prior to the pre-validation and were re-weighed at the conclusion of the pre-validation. The average test truck weights and measurements are provided in Table 5-1.

Table 5-1 - Pre-Validation Test Truck Weights and Measurements

Test Truck	Weights (kips)						Spacings (feet and tenths)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	73.4	11.0	15.3	15.3	15.8	15.8	14.5	4.3	33.4	4.0	56.2	63.6
2	63.9	10.4	13.0	13.0	13.7	13.7	14.5	4.3	33.1	4.0	55.9	61.5

Test truck speeds varied by 17 mph, from 55 to 72 mph. The measured pre-validation pavement temperatures varied 44.5 degrees Fahrenheit, from 76.3 to 120.8. The sunny weather conditions provided for reaching the desired 30 degree temperature range. Table 5-2 provides a summary of the pre-validation results.

Table 5-2 – Pre-Validation Overall Results – 13-Sep-10

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-3.2 ± 6.2%	Pass
Tandem Axles	±15 percent	-5.7 ± 6.7%	Pass
GVW	±10 percent	-5.2 ± 5.3%	FAIL
Vehicle Length	±3 percent (1.9 ft)	4.7 ± 1.2 ft	FAIL
Axle Spacing Length	± 0.5 ft [150mm]	1.3 ± 0.4 ft	FAIL

Truck speed was manually collected for each test run using a radar gun and compared with the speed reported by the WIM equipment. For this site, the average error in speed measurement over all speeds was 1.3 ± 2.5 mph, which is greater than the ±1.0 mph tolerance established by the LTPP Field Guide. Since the site is measuring axle spacing length with a mean error of 1.3 feet, and the speed and axle spacing measurements are based on the distance between the axle detector sensors, it can be concluded that the distance factor is not set correctly and requires an adjustment.

5.1.1 Statistical Speed Analysis

Statistical analysis was conducted on the test truck run data to investigate whether a relationship exists between speed and WIM equipment weight and distance measurement accuracy. The posted speed limit at this site is 75 mph. The test runs were divided into three speed groups - low, medium and high speeds, as shown in Table 5-3 below.

Table 5-3 – Pre-Validation Results by Speed – 13-Sep-10

Parameter	95% Confidence Limit of Error	Low	Medium	High
		55.0 to 60.7 mph	60.8 to 66.4 mph	66.5 to 72.0 mph
Steering Axles	±20 percent	-3.1 ± 3.8%	-3.1 ± 10.9%	-3.5 ± 4.6%
Tandem Axles	±15 percent	-5.2 ± 6.0%	-6.6 ± 7.3%	-5.7 ± 8.8%
GVW	±10 percent	-4.7 ± 4.3%	-5.9 ± 7.1%	-5.3 ± 6.3%
Vehicle Length	±3 percent (1.9 ft)	4.6 ± 1.1 ft	4.5 ± 1.6 ft	4.9 ± 1.2 ft
Vehicle Speed	± 1.0 mph	1.0 ± 2.6 mph	1.5 ± 1.1 mph	1.6 ± 3.9 mph
Axle Spacing Length	± 0.5 ft [150mm]	1.2 ± 0.5 ft	1.3 ± 0.5 ft	1.3 ± 0.2 ft

From the table, it can be seen that the WIM equipment underestimates all weights at all speeds. The range of steering axle weight errors is much greater at the medium speeds. For tandem axle weights, the range of error increases as speed increases. The range in error for GVW is lower at the low speeds. There appears to be a relationship between weight estimates and speed at this site, where the range in weight errors generally increase as speed increases.

To aid in the speed analysis, several graphs were developed to illustrate the possible effects of speed on GVW, single axle, and axle group weights, and axle and overall length distance measurements, as discussed in the following sections.

5.1.1.1 GVW Errors by Speed

As shown in Figure 5-1, the equipment underestimated GVW at all speeds. The range in error appears to be smaller at the low speeds. Distribution of errors is shown graphically in the following figure.

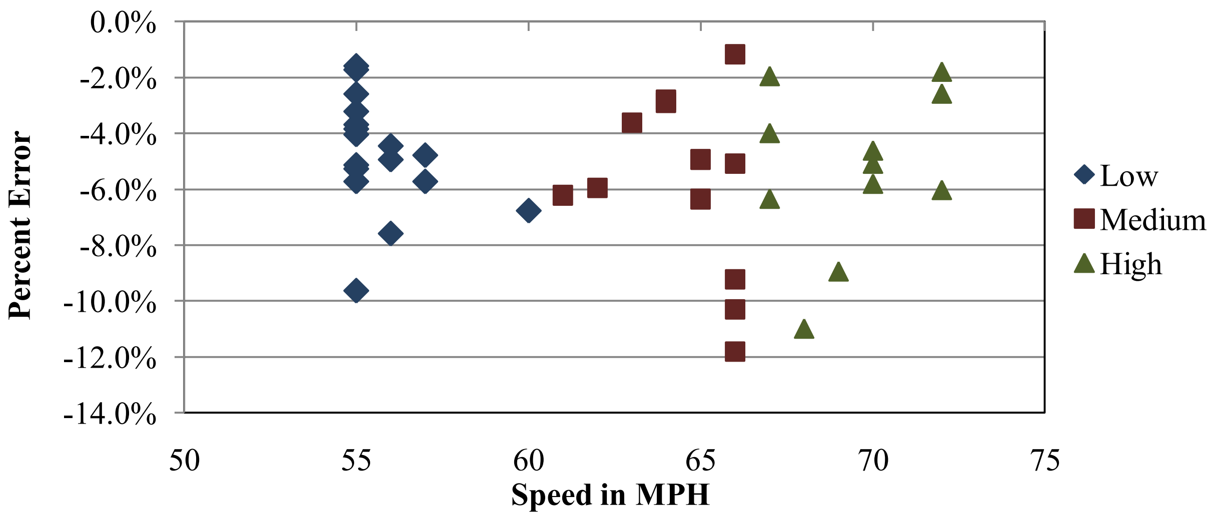


Figure 5-1 – Pre-Validation GVW Error by Speed – 13-Sep-10

5.1.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-2, the equipment generally underestimates steering axle weights at all speeds. The range in error appears to be much greater at the medium speeds.

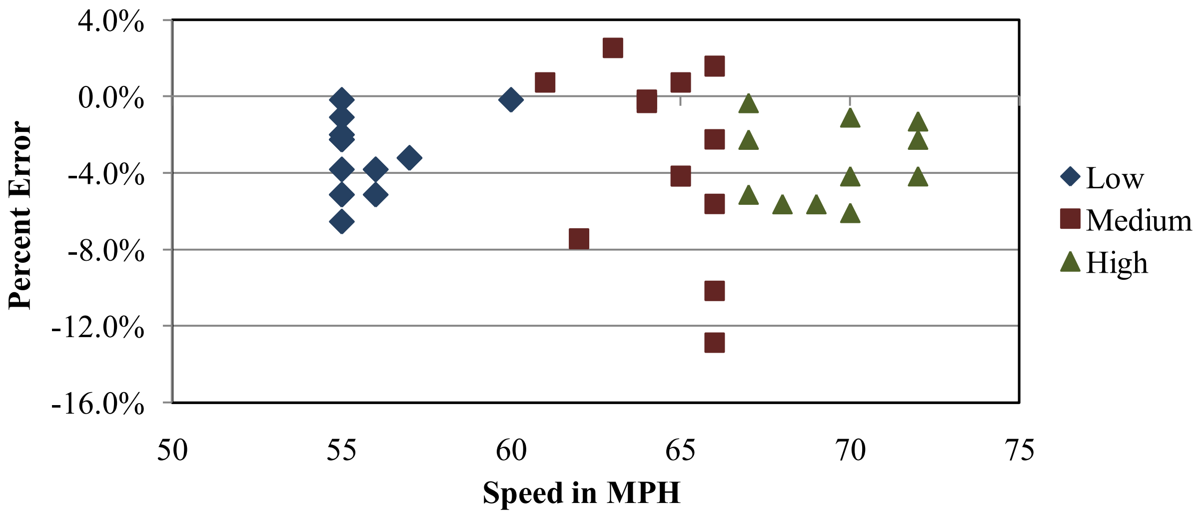


Figure 5-2 – Pre-Validation Steering Axle Weight Errors by Speed – 13-Sep-10

5.1.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 5-3, the equipment generally underestimates tandem axle weights at all speeds. The range in error is similar throughout the entire speed range.

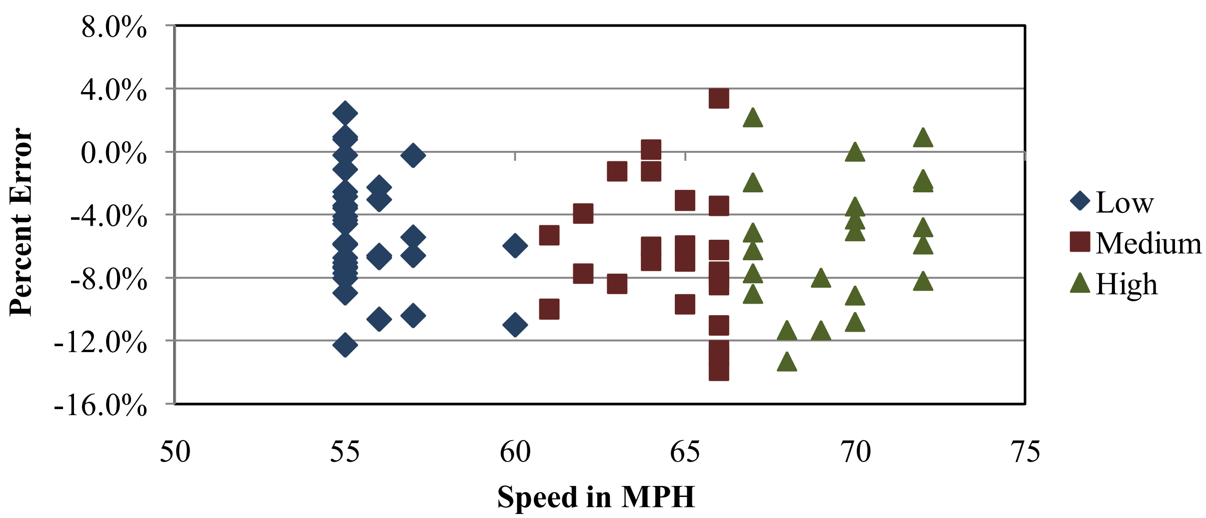


Figure 5-3 – Pre-Validation Tandem Axle Weight Errors by Speed – 13-Sep-10

5.1.1.4 GVW Errors by Speed and Truck Type

As shown in Figure 5-4, when the GVW error for each truck is analyzed as a function of speed, it can be seen that the WIM equipment underestimates GVW for the heavily loaded (Primary) truck by a greater degree than the partially loaded (Secondary) truck. Distribution of errors is shown graphically in.

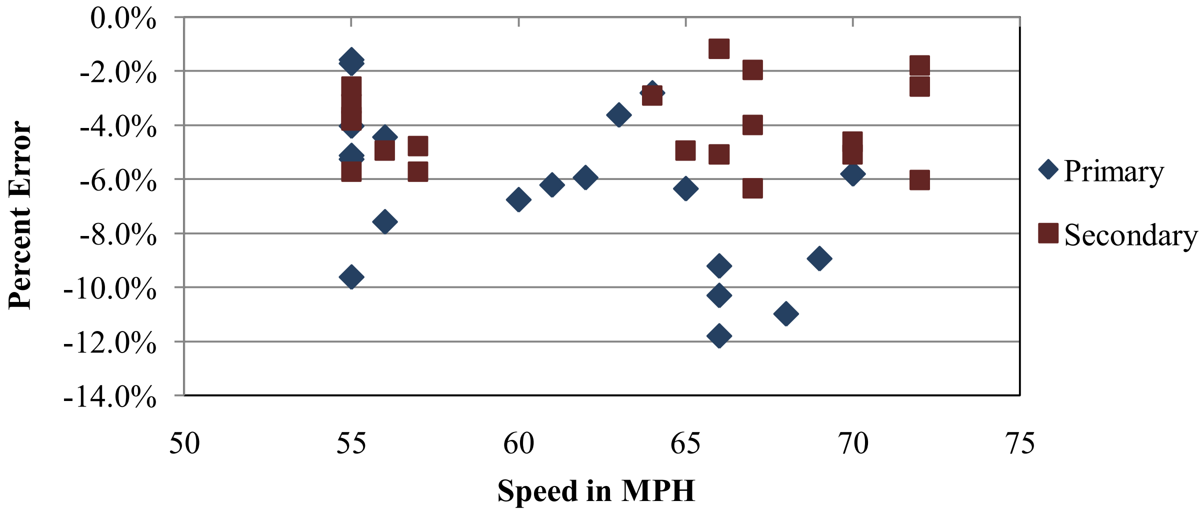


Figure 5-4 – Pre-Validation GVW Errors by Truck and Speed – 13-Sep-10

5.1.1.5 Axle Length Errors by Speed

For this site, the equipment overestimated axle length at all speeds. The range in axle length measurement error ranged from 1.0 feet to 1.8 feet. Distribution of errors is shown graphically in Figure 5-5.

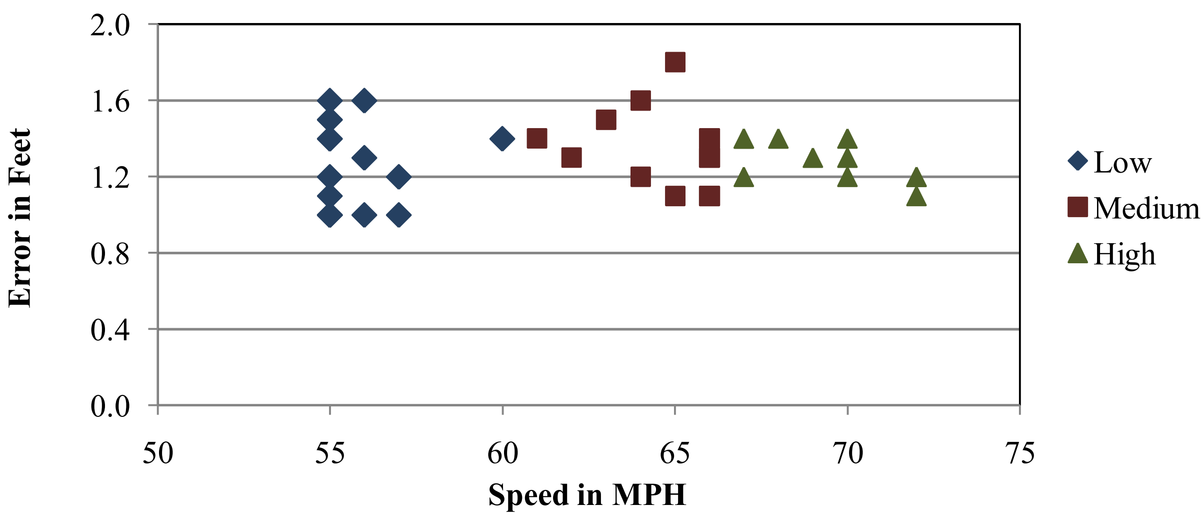


Figure 5-5 – Pre-Validation Axle Length Errors by Speed – 13-Sep-10

5.1.1.6 Overall Length Errors by Speed

For this system, the WIM equipment overestimated overall vehicle length consistently over the entire range of speeds, with an error range of 3.4 to 5.5 feet. Distribution of errors is shown graphically in Figure 5-6.

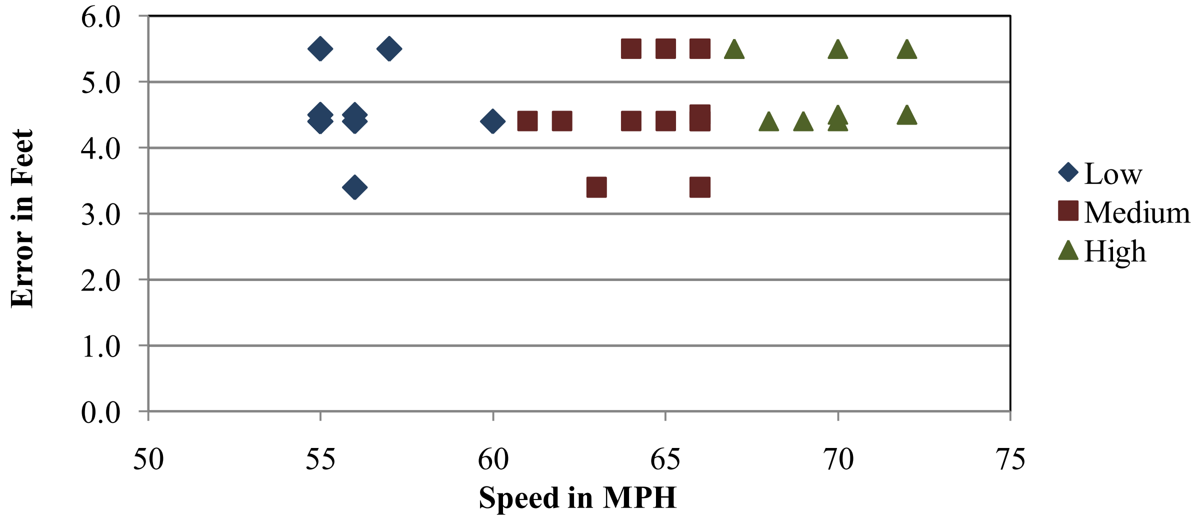


Figure 5-6 – Pre-Validation Overall Length Error by Speed – 13-Sep-10

5.1.2 Statistical Temperature Analysis

Statistical analysis was performed for the test truck run data to investigate whether there is a relation between pavement temperature and WIM equipment weight and distance measurement accuracy. The range of pavement temperatures varied 44.5 degrees, from 76.3 to 120.8 degrees Fahrenheit. The pre-validation test runs are being reported under three temperature groups as shown in Table 5-4.

Table 5-4 – Pre-Validation Results by Temperature – 13-Sep-10

Parameter	**95% Confidence Limit of Error**	**Low**	**Medium**	**High**
		76.3 to 91.1 degF	**91.2 to 106.1 degF**	**106.2 to 120.8 degF**
Steering Axles	±20 percent	-4.5 ± 5.7%	-4.1 ± 8.2%	-1.9 ± 5.8%
Tandem Axles	±15 percent	-6.9 ± 7.6%	-7.1 ± 7.8%	-4.2 ± 5.6%
GVW	±10 percent	-6.4 ± 6.3%	-6.4 ± 6.1%	-3.8 ± 3.7%
Vehicle Length	±3 percent (1.9 ft)	4.5 ± 1.4 ft	4.9 ± 1.3 ft	4.6 ± 1.2 ft
Vehicle Speed	± 1.0 mph	1.4 ± 3.6 mph	1.4 ± 2.2 mph	1.3 ± 2.5 mph
Axle Spacing Length	± 0.5 ft [150mm]	1.2 ± 0.4 ft	1.3 ± 0.5 ft	1.3 ± 0.4 ft

To aid in the analysis, several graphs were developed to illustrate the possible effects of temperature on GVW, single axle, and axle group weights.

5.1.2.1 GVW Errors by Temperature

From Figure 5-7, it can be seen that the equipment appears to underestimate GVW across the range of temperatures observed in the field. There appears to be a correlation between temperature and weight estimates where temperature causes weight estimates to rise as temperature rises.

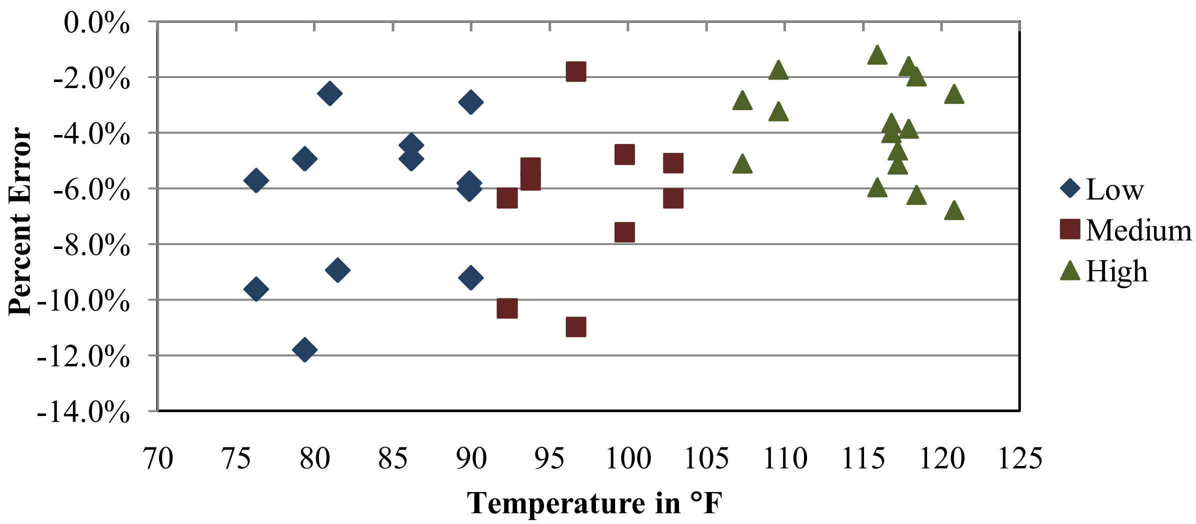


Figure 5-7 – Pre-Validation GVW Errors by Temperature – 13-Sep-10

5.1.2.2 Steering Axle Weight Errors by Temperature

Figure 5-8 demonstrates that for steering axles, the WIM equipment appears to demonstrate the same trend as with GVW estimates, where as the temperature rises, the underestimation of steering axle weight decreases. The range in error is similar for different temperature groups. Distribution of errors is shown graphically in the following figure.

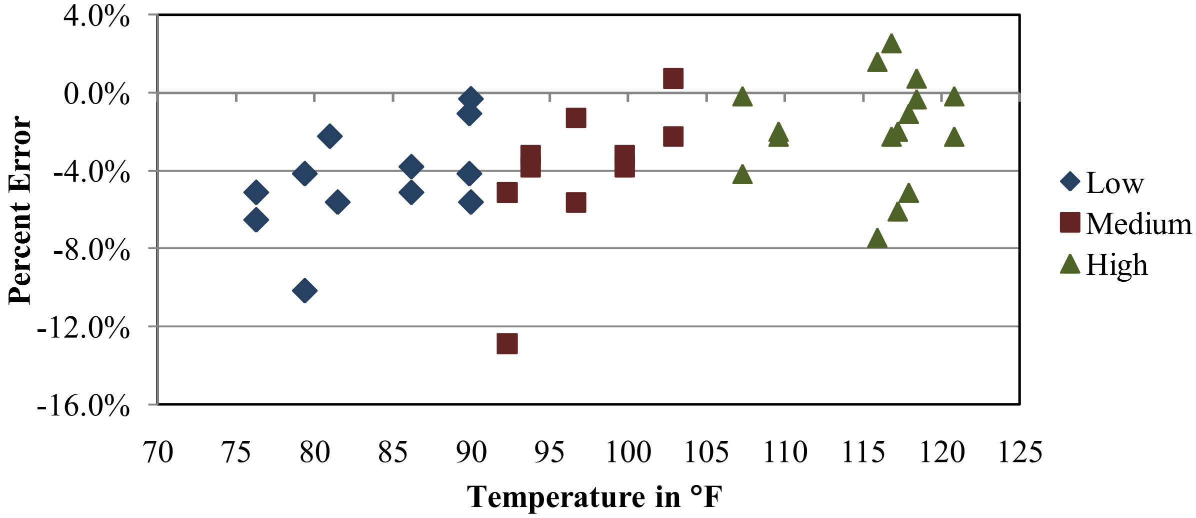


Figure 5-8 – Pre-Validation Steering Axle Weight Errors by Temperature – 13-Sep-10

5.1.2.3 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-9, the same relationship that exists between other equipment weight estimates and temperature appears to exist between loaded tandem axle measurement and temperature, where the weight of loaded axle groups increases as temperature increases. The range in tandem axle errors is consistent for the three temperature groups.

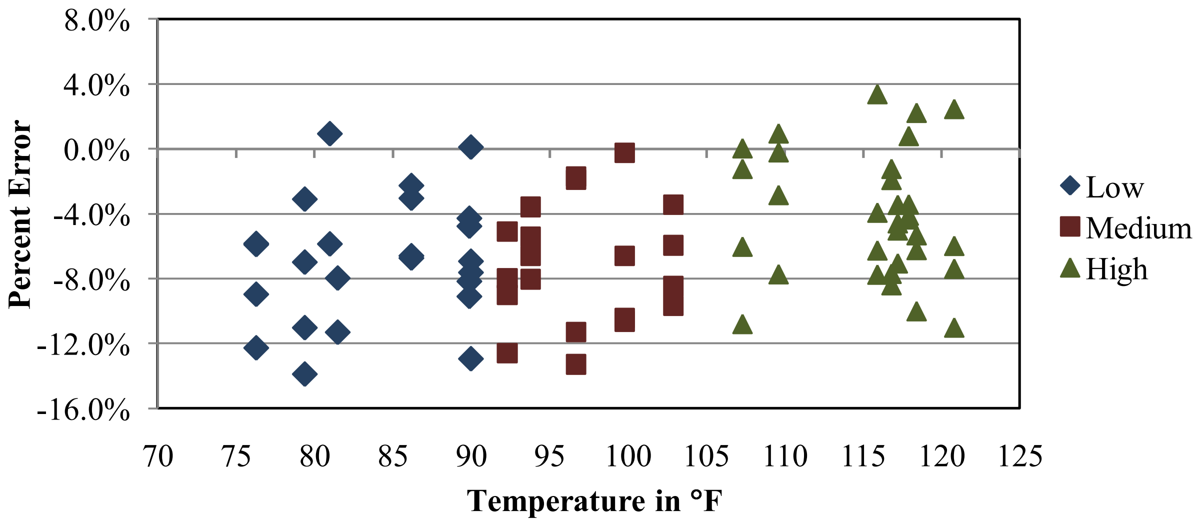


Figure 5-9 – Pre-Validation Tandem Axle Weight Errors by Temperature – 13-Sep-10

5.1.2.4 GVW Errors by Temperature and Truck Type

When analyzed for each test truck, GVW measurement errors for both trucks follow similar patterns: GVW for both trucks increases as temperature increases. For both trucks, the range of errors and bias are reasonably consistent over the range of temperatures. Distribution of errors is shown graphically in Figure 5-10.

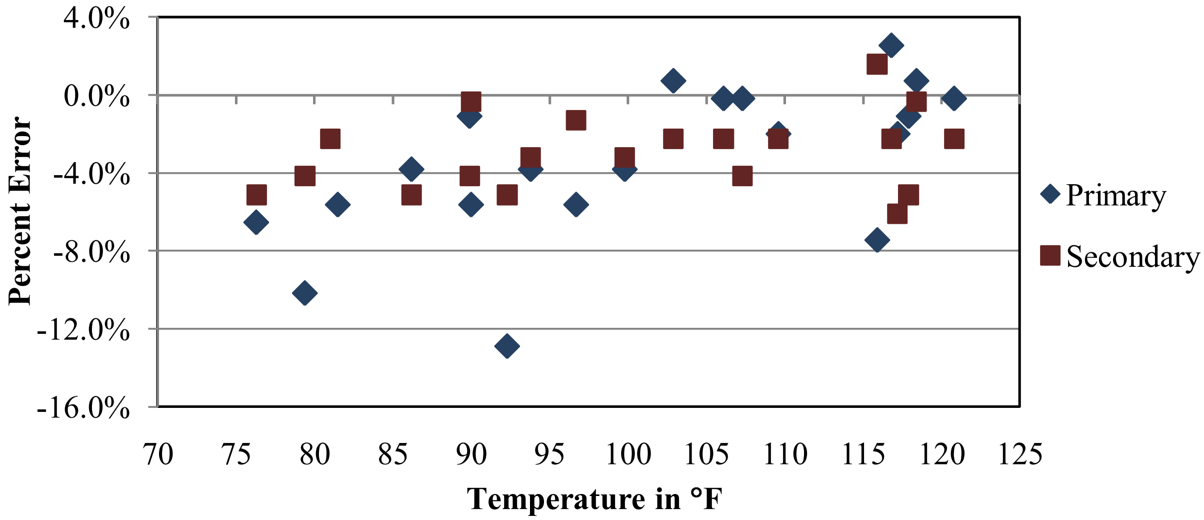


Figure 5-10 – Pre-Validation GVW Error by Truck and Temperature – 13-Sep-10

5.1.3 Classification and Speed Evaluation

The pre-validation classification and speed study involved the comparison of vehicle classification and speed data collected manually with the information for the same vehicles reported by the WIM equipment.

For the pre-validation classification study at this site, a manual sample of 100 vehicles including 100 trucks (Class 4 through 13) was collected. Video was collected during the study to provide a means for further analysis of misclassifications and vehicles whose classifications could not be determined with a high degree of certainty in the field. Table 5-5 illustrates the breakdown of vehicles observed and identified by the WIM equipment for the manual classification study.

Table 5-5 – Pre-Validation Classification Study Results – 13-Sep-10

Class	4	5	6	7	8	9	10	11	12	13
WIM Count	0	8	5	0	2	80	0	2	1	0
Observed Count	2	11	3	0	1	80	0	2	1	0
WIM Distribution (%)	0	8	5	0	2	80	0	2	1	0
Obs. Distribution (%)	2	11	3	0	1	80	0	2	1	0
Misclass/Unclass	2	3	0	0	0	0	0	0	0	0
Misclassified (%)	100	27	0	N/A	0	0	N/A	0	0	N/A

Misclassified vehicles are defined as those vehicles that are manually classified by observation as one class of vehicle but identified by the WIM equipment as another class of vehicle. The misclassified percentage represents the percentage of the misclassified vehicles in the manual sample. The misclassifications by pair are provided in Table 5-6.

Table 5-6 – Pre-Validation Misclassifications by Pair – 13-Sep-10

Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs
3/5	0	8/9	0
3/8	0	9/5	0
4/5	0	9/8	0
4/6	2	9/10	0
5/3	2	10/9	0
5/4	0	10/13	0
5/8	1	11/12	0
6/4	0	12/11	0
7/6	0	13/10	0
8/3	0	13/11	0
8/5	0		

Based on the vehicles observed during the pre-validation study, the misclassification percentage is 0.0% for heavy trucks (6 – 13), which is within the 2.0% acceptability criteria for LTPP SPS WIM sites. The overall misclassification rate for all vehicles (3 – 15) is 5.0%.

As shown in the table, a total of 5 vehicles, including zero heavy trucks (6 – 13) were misclassified by the equipment. The misclassifications were Class 5s identified by the WIM equipment as Class 3 or Class 8, and Class 4 vehicles identified by the equipment as Class 6.

Unclassified vehicles are defined as those vehicles that cannot be identified by the WIM equipment algorithm. These are typically trucks with unusual trailer tandem configurations and are identified as Class 15 by the WIM equipment. The unclassified vehicles by pair are provided in Table 5-7.

Table 5-7 – Pre-Validation Unclassified Trucks by Pair – 13-Sep-10

Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs
3/15	0	9/15	0
4/15	0	10/15	0
5/15	0	11/15	0
6/15	0	12/15	0
7/15	0	13/15	0
8/15	0		

Based on the manually collected sample of the 100 trucks, 0.0% of the vehicles at this site were reported as unclassified during the study. This is within the established criteria of 2.0% for LTTP SPS WIM sites.

For speed, the mean error for WIM equipment speed measurement was 1.3 mph; the range of errors was 1.5 mph.

5.2 Calibration

The WIM equipment required one calibration iteration between the pre- and post-validations. Information regarding the basis for changing equipment compensation factors, supporting data for the changes, and the resulting WIM accuracies from the calibrations are provided in this section.

The operating system weight compensation parameters that were in place prior to the pre-validation are shown in Table 5-8.

Table 5-8 – Initial System Parameters – 14-Sep-10

Speed Point	MPH	Right
88	55	3222
96	60	3112
104	65	3195
112	70	3055
120	75	3306
		Left
88	55	3644
96	60	3520
104	65	3613
112	70	3456
120	75	3739
Axle Distance (cm)	381	
Dynamic Comp (%)	101	

5.2.1 Calibration Iteration 1

5.2.1.1 Equipment Adjustments

For GVW, the pre-validation test truck runs produced an overall error of -5.2% and errors of -4.7%, -5.9%, and -5.3% at the 55, 65 and 70 mph speed points respectively. The errors for 55 mph and 70 mph speeds were extrapolated to derive new compensation factors for the 50 and 75 mph speed points. To compensate for these errors, the changes in Table 5-9 were made to the compensation factors.

Table 5-9 – Calibration 1 Equipment Factor Changes – 14-Sep-10

Speed Points	Error	Old Factors		New Factors	
		Left	Right	Left	Right
88	-4.61%	3644	3222	3820	3378
96	-6.31%	3520	3112	3757	3321
104	-6.02%	3613	3195	3844	3400
112	-5.73%	3456	3055	3666	3241
120	-5.73%	3739	3306	3966	3507
Axle Distance (cm)	-2.29%	381		372	
Dynamic Comp (%)	-3.19%	101		99	

5.2.1.2 Calibration 1 Results

The results of the 26 first calibration verification runs are provided in Table 5-10 and Figure 5-11. As can be seen in the table, the mean error of all weight estimates was reduced as a result of the first calibration iteration.

Table 5-10 – Calibration 1 Results – 14-Sep-10

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-3.6 ± 6.7%	Pass
Tandem Axles	±15 percent	-2.1 ± 7.6%	Pass
GVW	±10 percent	-2.4 ± 5.9%	Pass
Vehicle Length	±3 percent (1.9 ft)	2.9 ± 1.4 ft	FAIL
Axle Spacing Length	± 0.5 ft [150mm]	-0.1 ± 0.3 ft	Pass

Figure 5-11 shows that the WIM equipment is estimating GVW with acceptable accuracy at all speeds.

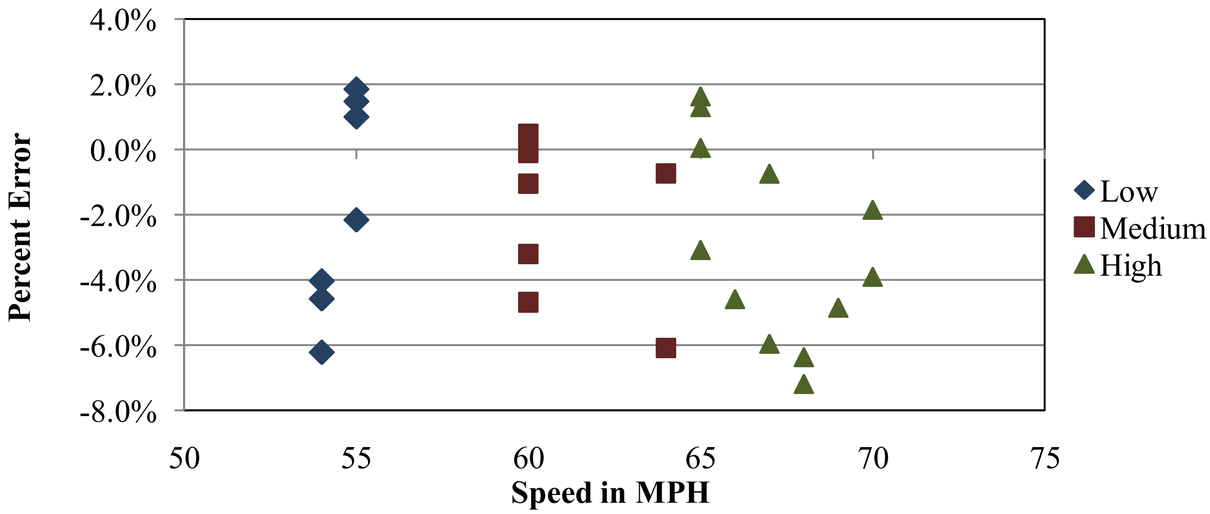


Figure 5-11 – Calibration 1 GVW Error by Speed – 14-Sep-10

Table 5-11 – Calibration 1 Results – 14-Sep-10

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-3.6 ± 6.7%	Pass
Tandem Axles	±15 percent	-2.1 ± 7.6%	Pass
GVW	±10 percent	-2.4 ± 5.9%	Pass
Vehicle Length	±3 percent (1.9 ft)	2.9 ± 1.4 ft	FAIL
Axle Spacing Length	± 0.5 ft [150mm]	-0.1 ± 0.3 ft	Pass

Based on the results of the first calibration, where weight estimate bias decreased to less than 2.5 percent, and due to the expected increase in weights due to increase in temperature, a second calibration was not considered to be necessary. The 26 calibration runs were combined with 14 additional post-validation runs to complete the WIM system validation.

5.3 Post-Validation

The 40 post-validation test truck runs were conducted on September 14, 2010, beginning at approximately 7:11 AM and continuing until 1:01 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with refuse, and equipped with air suspension on truck and trailer tandems and with standard tandem spacings on both the tractor and trailer.

- A Class 9, 5-axle truck, loaded with refuse, and equipped with air suspension on the tractor, air suspension on the trailer, with standard tandem spacing on the tractor and standard tandem spacing on the trailer.

The test trucks were weighed prior to the post-validation and re-weighed at the conclusion of the post-validation. The average test truck weights and measurements are provided in Table 5-12.

Table 5-12 - Post-Validation Test Truck Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	72.6	11.0	15.2	15.2	15.6	15.6	14.5	4.3	33.4	4.0	56.2	63.6
2	62.8	10.3	12.8	12.8	13.4	13.4	14.5	4.3	33.1	4.0	55.9	61.5

Test truck speeds varied by 16 mph, from 54 to 70 mph. The measured post-validation pavement temperatures varied 41.2 degrees Fahrenheit, from 80.0 to 121.2. The sunny weather conditions provided for reaching the desired 30 degree temperature range. Table 5-13 is a summary of post validation results.

Table 5-13 – Post-Validation Overall Results – 14-Sep-10

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-0.5 ± 7.5%	Pass
Tandem Axles	±15 percent	-0.6 ± 8.1%	Pass
GVW	±10 percent	-0.6 ± 6.5%	Pass
Vehicle Length	±3 percent (1.9 ft)	3.0 ± 1.3 ft	FAIL
Axle Spacing Length	± 0.5 ft [150mm]	0.0 ± 0.3 ft	Pass

Truck speed was manually collected for each test run using a radar gun and compared with the speed reported by the WIM equipment. For this site, the average error in speed measurement for all speeds was 0.1 ± 1.3 mph, which is greater than the ±1.0 mph tolerance established by the LTPP Field Guide. However, since the site is measuring axle spacing length with a mean error of 0.0 feet, and the speed and axle spacing length measurements are based on the distance between the axle detector sensors, it can be concluded that the distance factor is set correctly and that the speeds being reported by the WIM equipment are within acceptable ranges.

5.3.1 Statistical Speed Analysis

Statistical analysis was conducted on the test truck run data to investigate whether a relation exists between speed and WIM equipment weight and distance measurement accuracy. The posted speed limit at this site is 75 mph. The test runs were divided into three speed groups - low, medium and high speeds, as shown in Table 5-14 below.

Table 5-14 – Post-Validation Results by Speed – 14-Sep-10

Parameter	95% Confidence Limit of Error	Low 54.0 to 59.3 mph	Medium 59.4 to 64.8 mph	High 64.9 to 70.0 mph
Steering Axles	±20 percent	-0.1 ± 6.4%	0.4 ± 8.4%	-1.7 ± 8.7%
Tandem Axles	±15 percent	-0.4 ± 9.9%	0.1 ± 8.0%	-1.3 ± 8.2%
GVW	±10 percent	-0.2 ± 6.8%	0.1 ± 6.9%	-1.5 ± 7.1%
Vehicle Length	±3 percent (1.9 ft)	2.8 ± 1.1 ft	3.0 ± 1.5 ft	3.0 ± 1.4 ft
Vehicle Speed	± 1.0 mph	0.0 ± 1.6 mph	-0.2 ± 0.8 mph	0.3 ± 1.5 mph
Axle Spacing Length	± 0.5 ft [150mm]	-0.1 ± 0.3 ft	0.0 ± 0.4 ft	0.0 ± 0.2 ft

From the table, it can be seen that *the WIM equipment estimates all weights with reasonable accuracy and the range of errors is consistent at all speeds. There does not appear to be a relationship between weight estimates and speed at this site.*

To aid in the speed analysis, several graphs were developed to illustrate the possible effects of speed on GVW, single axle, and axle group weights, and axle and overall length distance measurements, as discussed in the following paragraphs.

5.3.1.1 GVW Errors by Speed

As shown in Figure 5-12, the equipment estimated GVW with reasonable accuracy at all speeds. The range in error and bias is similar throughout the entire speed range. Distribution of errors is shown graphically in the figure.

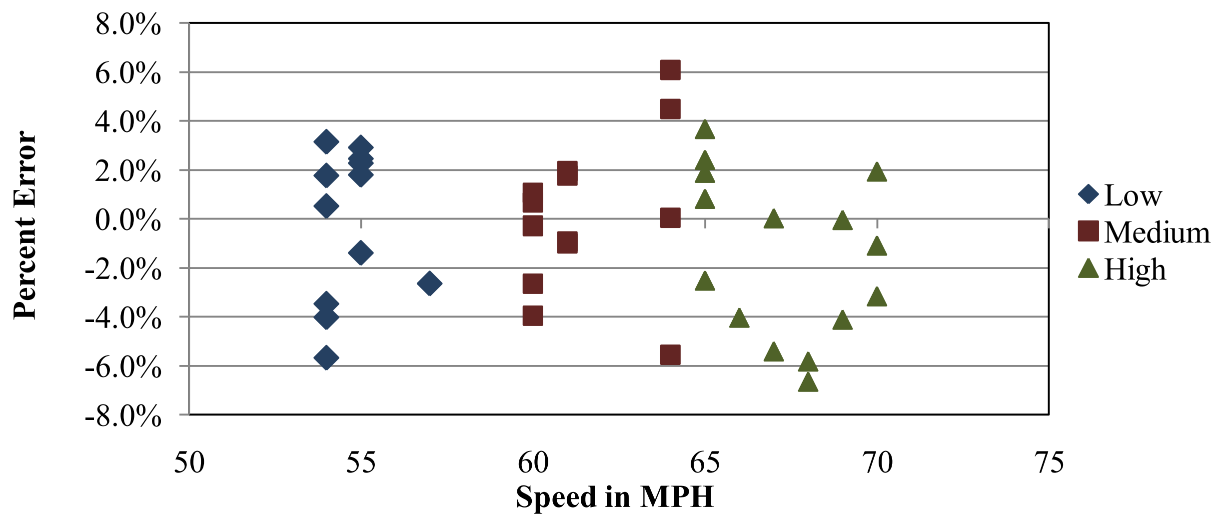


Figure 5-12 – Post-Validation GVW Errors by Speed – 14-Sep-10

5.3.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-13, the equipment estimated steering axle weights with reasonable accuracy at all speeds. The range in error and bias is similar throughout the entire speed range. Distribution of errors is shown graphically in the figure.

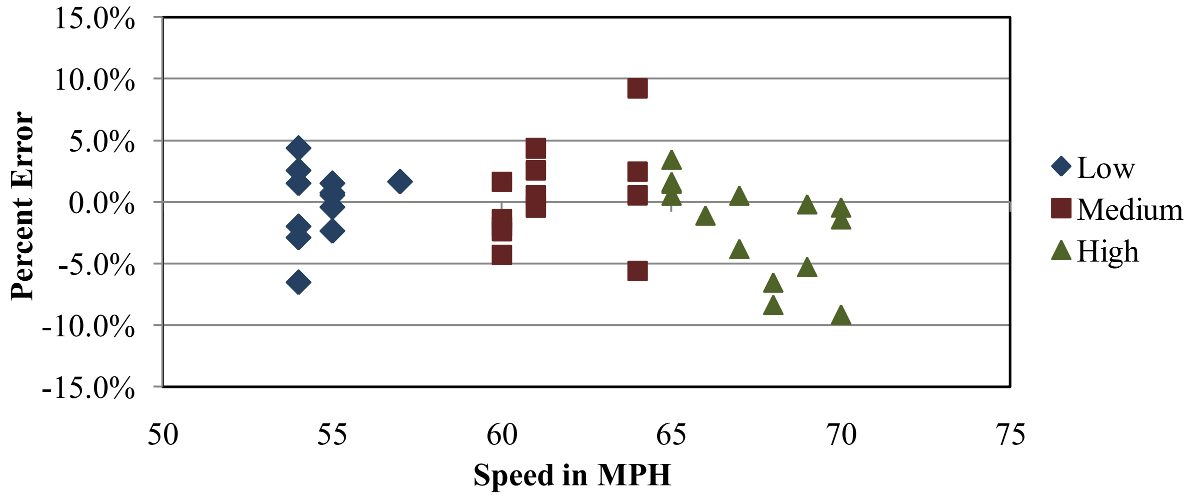


Figure 5-13 – Post-Validation Steering Axle Weight Errors by Speed – 14-Sep-10

5.3.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 5-14, the equipment estimated tandem axle weights with reasonable accuracy at all speeds. The range in error and bias is similar throughout the entire speed range. Distribution of errors is shown graphically in the figure.

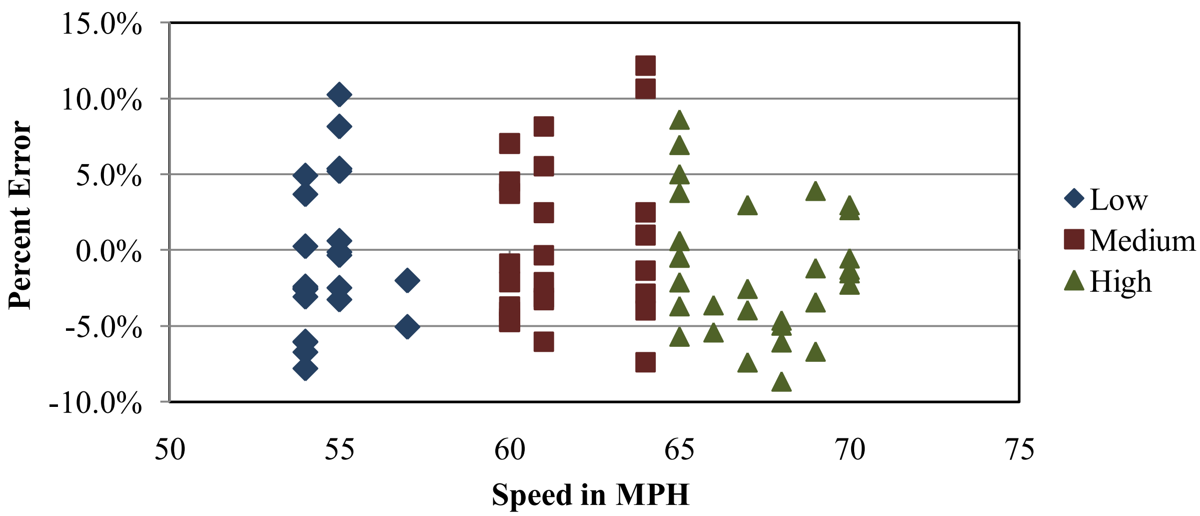


Figure 5-14 – Post-Validation Tandem Axle Weight Errors by Speed – 14-Sep-10

5.3.1.4 GVW Errors by Speed and Truck Type

It can be seen in Figure 5-15 that when the GVW errors are analyzed by truck type, the WIM equipment precision and bias is similar for both the heavily loaded (Primary) truck and the partially loaded (Secondary) truck. Distribution of errors is shown graphically in the figure.

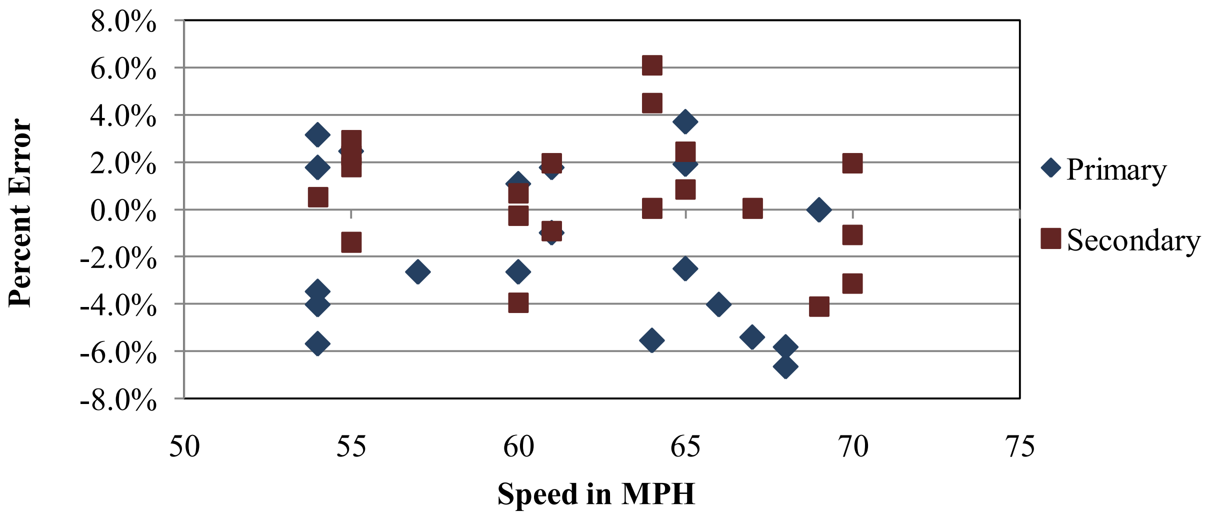


Figure 5-15 – Post-Validation GVW Error by Truck and Speed – 14-Sep-10

5.3.1.5 Axle Length Errors by Speed

For this site, the error in axle length measurement was consistent at all speeds. The range in axle length measurement error ranged from -0.4 feet to 0.3 feet. Distribution of errors is shown graphically in Figure 5-16.

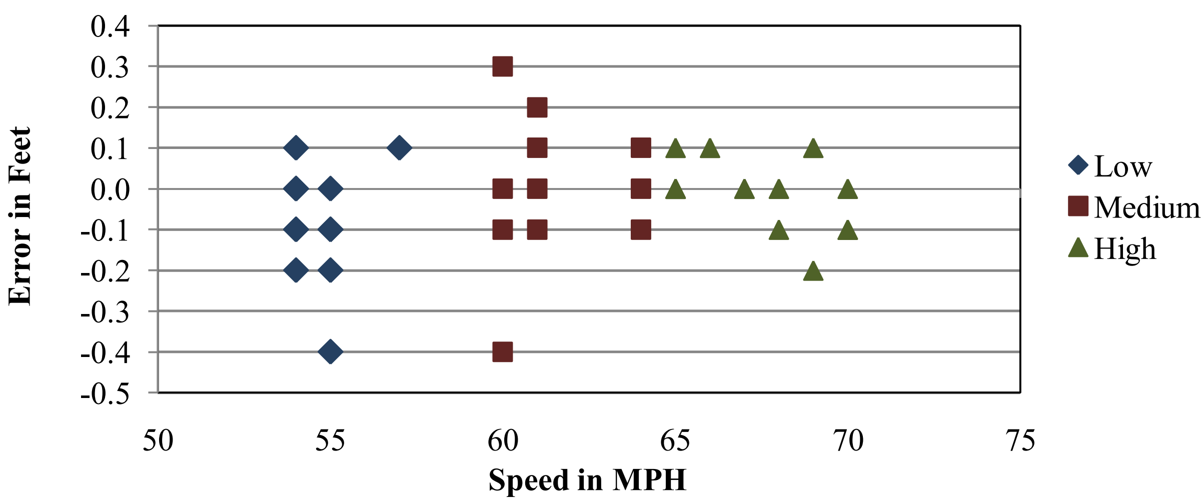


Figure 5-16 – Post-Validation Axle Length Error by Speed – 14-Sep-10

5.3.1.6 Overall Length Errors by Speed

For this system, the WIM equipment demonstrates a consistent positive bias in overall length measurement over the entire range of speeds, with errors ranging from 1.4 to 4.5 feet. Distribution of errors is shown graphically in Figure 5-17.

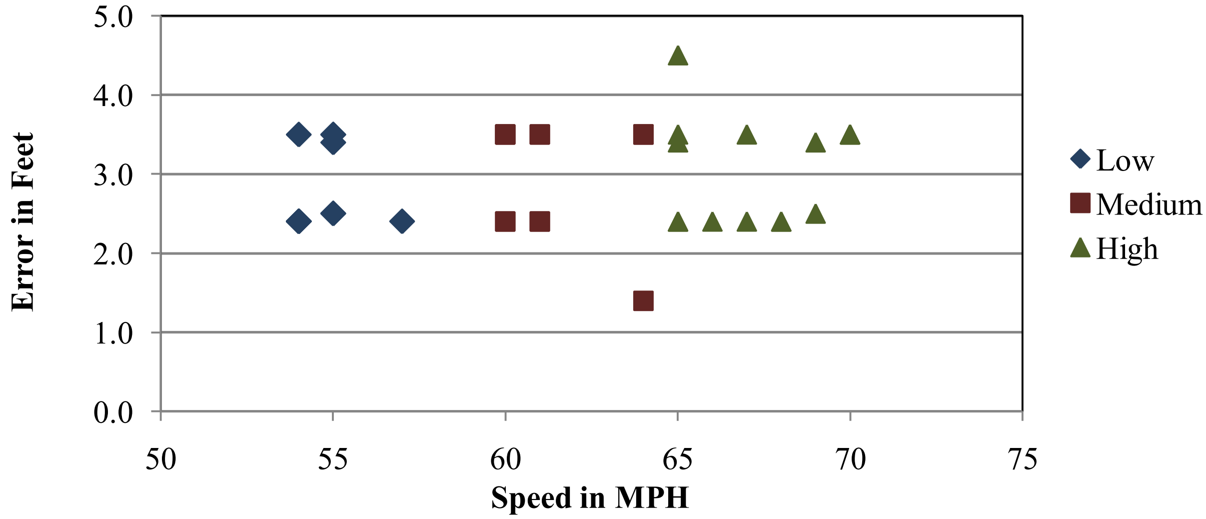


Figure 5-17 – Post-Validation Overall Length Error by Speed – 14-Sep-10

5.3.2 Statistical Temperature Analysis

Statistical analysis was performed for the test truck run data to investigate whether there is a relationship between pavement temperature and WIM equipment weight and distance measurement accuracy. The range of pavement temperatures varied 41.2 degrees, from 80.0 to 121.2 degrees Fahrenheit. The post-validation test runs are being reported under three temperature groups as shown in Table 5-15 below.

Table 5-15 – Post-Validation Results by Temperature – 14-Sep-10

Parameter	95% Confidence Limit of Error	Low	Medium	High
		80.0 to 93.7 degF	93.8 to 110.0 degF	110.1 to 121.2 degF
Steering Axles	±20 percent	-2.6 ± 8.6%	-1.8 ± 7.1%	1.6 ± 5.9%
Tandem Axles	±15 percent	-2.4 ± 7.5%	-1.2 ± 9.9%	0.9 ± 7.6%
GVW	±10 percent	-2.4 ± 6.6%	-1.7 ± 7.4%	1.3 ± 4.9%
Vehicle Length	±3 percent (1.9 ft)	2.8 ± 1.5 ft	3.1 ± 1.7 ft	3.0 ± 1.2 ft
Vehicle Speed	± 1.0 mph	-0.3 ± 1.4 mph	0.3 ± 1.5 mph	0.1 ± 1.2 mph
Axle Spacing Length	± 0.5 ft [150mm]	-0.1 ± 0.3 ft	-0.1 ± 0.3 ft	0.0 ± 0.3 ft

To aid in the analysis, several graphs were developed to illustrate the possible effects of temperature on GVW, single axle weights, and axle group weights.

5.3.2.1 GVW Errors by Temperature

From Figure 5-18, it can be seen that the equipment appears to estimate GVW with acceptable accuracy across the range of temperatures observed in the field. There appears to be a correlation between temperature and weight estimates where the higher temperature caused weight estimates to rise.

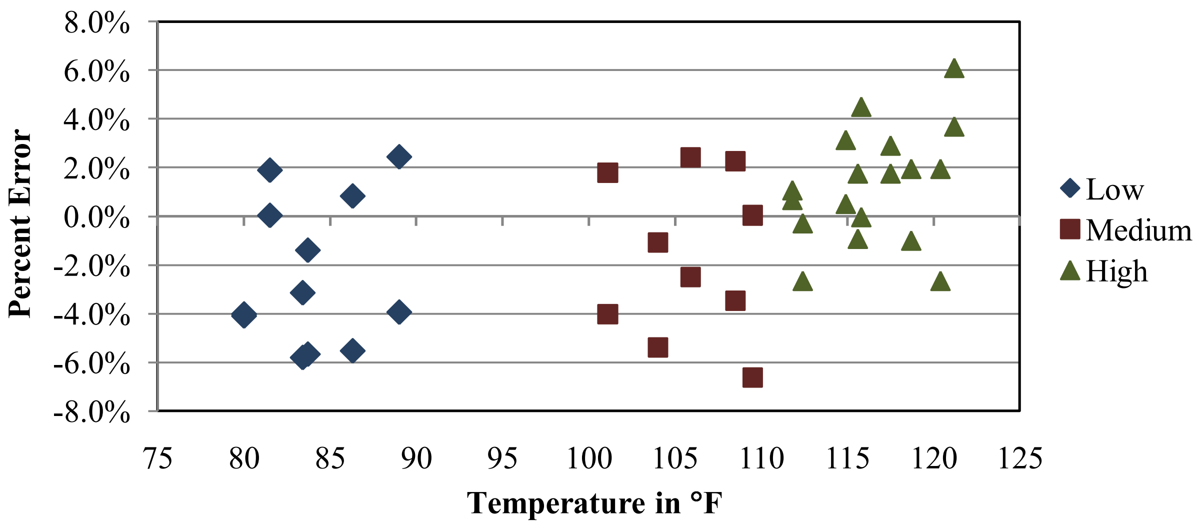


Figure 5-18 – Post-Validation GVW Errors by Temperature – 14-Sep-10

5.3.2.2 Steering Axle Weight Errors by Temperature

Figure 5-19 demonstrates that for steering axles, the WIM equipment appears to demonstrate the same trend as with GVW estimates, where at the higher temperatures, steering axle weight bias increases. The range in error is similar for different temperature groups. Distribution of errors is shown graphically in the following figure.

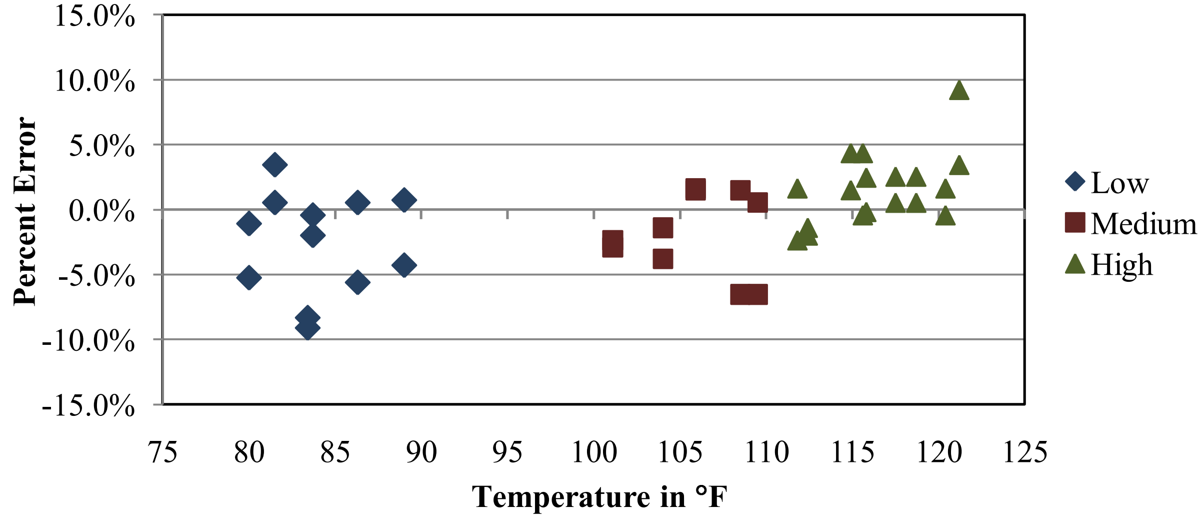


Figure 5-19 – Post-Validation Steering Axle Weight Errors by Temperature – 14-Sep-10

5.3.2.3 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-20, the same relationship that exists between other equipment weight estimates and temperature appears to exist between loaded tandem axle measurement and temperature, where the weight of loaded axle groups increases at the higher temperatures. The range in tandem axle errors is consistent for the three temperature groups.

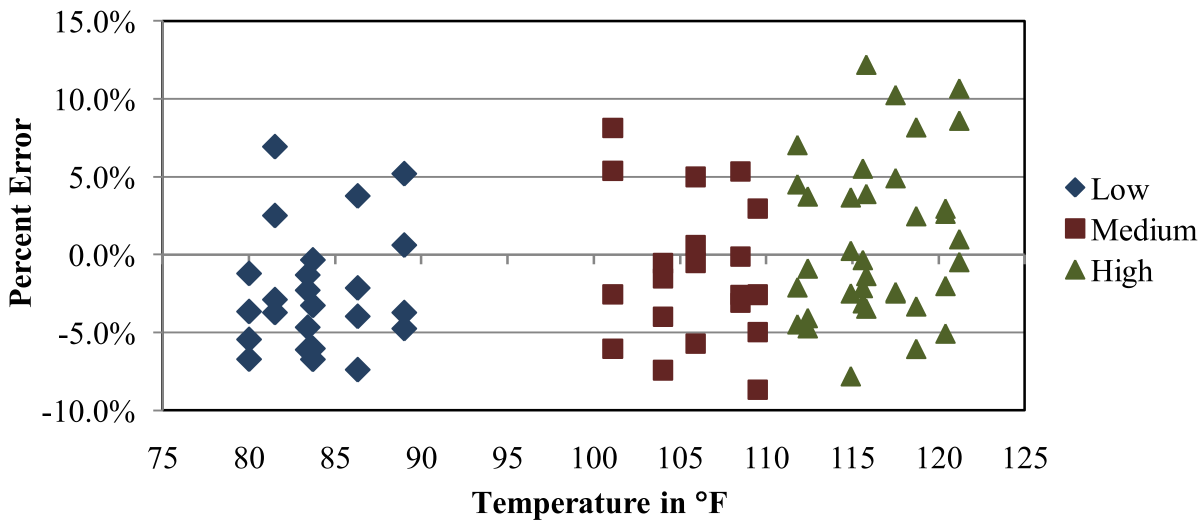


Figure 5-20 – Post-Validation Tandem Axle Weight Errors by Temperature – 14-Sep-10

5.3.2.4 GVW Errors by Temperature and Truck Type

As shown in Figure 5-21, when analyzed by truck type, GVW measurement errors for both trucks follow similar patterns: GVW for both trucks increases at the higher temperatures. For both trucks, the range of errors and bias are reasonably consistent over the range of temperatures. Distribution of errors is shown graphically in the following figure.

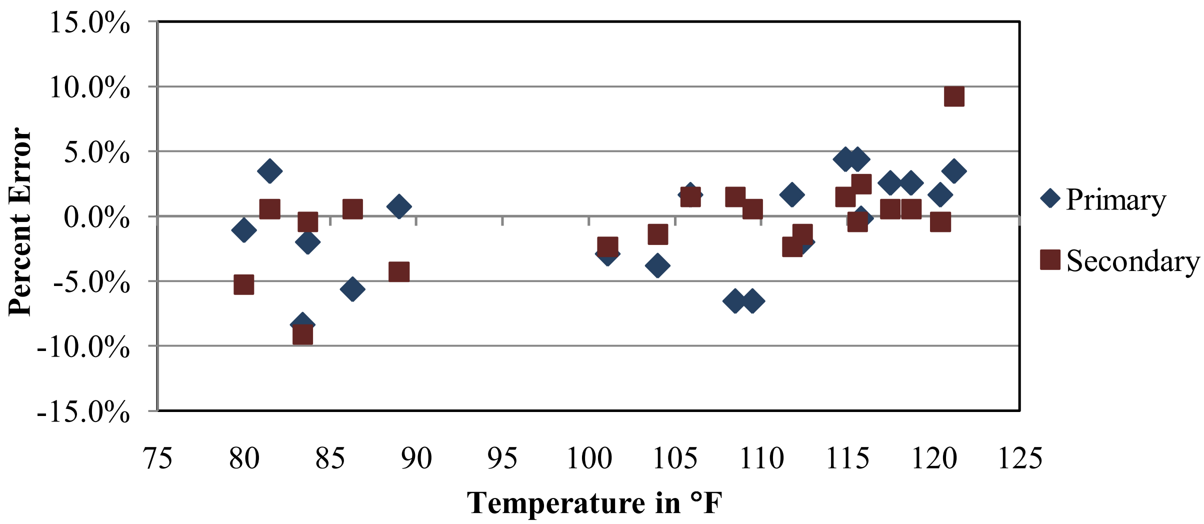


Figure 5-21 – Post-Validation GVW Error by Truck and Temperature – 14-Sep-10

5.3.3 Multivariable Analysis

This section provides additional analysis of post-validation results using a multivariable statistical technique of multiple linear regressions. The same calibration data analyzed and discussed previously are analyzed again, but this time using a more sophisticated statistical methodology. The objective of the additional analysis is to investigate if the trends identified using previous analyses are statistically significant, and to quantify these trends.

Multivariable analyses provide additional insight on how speed, temperature, and truck type affect weight measurement errors for a specific site. It is expected that multivariable analyses done systematically for many sites will reveal overall trends.

5.3.3.1 Data

All errors from the weight measurement data collected by the equipment during the validation were analyzed. The percent error is defined as percentage difference between the weight measured by the WIM system and the static weight. Compared to analysis described previously, the weight of "axle group" was evaluated separately for tandem axles on tractors and trailers. The separate evaluation was carried out because the tandem axles on trailers may have different dynamic response to loads than tandem axles on tractors. The measurement errors were statistically attributed to the following variables or factors:

- Truck type. Primary truck and secondary truck.
- Truck test speed. Truck test speed ranged from 54 to 70 mph.
- Pavement temperature. Pavement temperature ranged from 80.0 to 121.2 degrees Fahrenheit.
- Interaction between the factors such as the interaction between speed and pavement temperature.

5.3.3.2 Results

For analysis of GVW, the value of regression coefficients and their statistical properties are summarized in Table 5-16. The value of regression coefficients defines the slope of the relationship between the % error in GVW and the predictor variables. The values of the t-distribution (for the regression coefficients) given in Table 5-16 table are for the null hypothesis that assumes that the coefficients are equal to zero. The effects of temperature and truck type were found statistically significant. The probabilities that the effect of truck type and temperature on the observed GVW errors occurred by chance alone are less than 1 percent.

Table 5-16 – Table of Regression Coefficients for Measurement Error of GVW

Parameter	Regression coefficients	Standard error	Value of t-distribution	Probability value
Intercept	-5.5392	6.2238	-0.8900	0.3794
Speed	-0.0767	0.0783	-0.9788	0.3342
Temperature	0.1044	0.0297	3.5217	0.0012
Truck type	-2.3257	0.8319	-2.7956	0.0083

The relationship between temperature and measurement errors for GWV is shown in Figure 5-22. The figure includes trend line for the predicted percent error. Besides the visual assessment of the relationship, Figure 5-22 provides quantification and statistical assessment of the relationship.

The quantification is provided by the value of the regression coefficient, in this case 0.1044 (in Table 5-16). This means, for example, that for a 20 degree increase in temperature, the % error is increased by about 2.1 % (0.1044 x 20). The statistical assessment of the relationship is provided by the probability value of the regression coefficient.

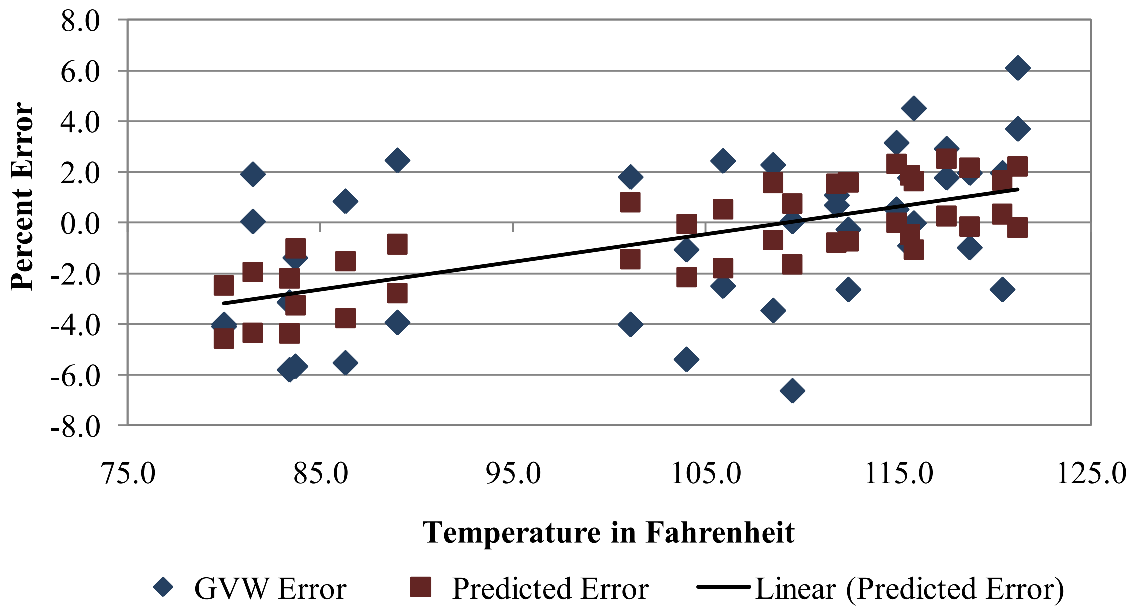


Figure 5-22 – Influence of Temperature (in Fahrenheit) on the Measurement Error of GVW

The effect of speed on GVW was not statistically significant. The probability that the regression coefficient for speed (-0.0767 in Table 5-166) is not different from zero was 0.334. In other words, there is about 33 percent chance that the value of the regression coefficient is due to the chance alone.

The interaction between speed, temperature, and truck type was investigated by adding an interactive variable (or variables) such as the product of speed and temperature. No interactive variables were statistically significant. The intercept was not statistically significant and does not have practical meaning.

5.3.3.3 Summary Results

Table 5-17 lists regression coefficients and their probability values for all combinations of factors and % errors evaluated. Not listed in the table are factor interactions because the interactions were not statistically significant. Entries in the table are provided only if the probability value was smaller than 0.20. The dash in Table 5-17 indicates that the relationship was not statistically significant (the probability that the relationship can occur by chance alone was greater than 20 percent).

Table 5-17 – Summary of Regression Analysis

	Factor					
	Speed		Temperature		Truck type	
Weight, % error	Regression coefficient	Probability value	Regression coefficient	Probability value	Regression coefficient	Probability value
GVW	-	-	0.1044	0.0012	-2.3257	0.0083
Steering axle	-	-	0.1196	0.0031	-	-
Tandem axle tractor	-	-	0.1464	0.0054	-3.9086	0.0079
Tandem axle trailer	-	-	0.0489	0.1009	-2.7302	0.0019

5.3.3.4 Conclusions

1. Speed had no statistically significant effect on measurement errors for GVW and for the weight of all axle types.

2. Temperature affected measurement error of all axles and thus also the measurement error of the GVW. The regression coefficients ranged from 0.146 for the tandem axle on tractor to 0.05 for the tandem axel on trailer.

3. Truck type affected the GVW, the tandem weight measurement errors. The regression coefficients for truck type in Table 5-17, represent the difference between the mean errors for the primary and secondary trucks. (Truck type is an indicator variable with values of 0 or 1.). For example, the mean error in GVW for the secondary truck was about 2.3 % larger than the error for the primary truck.

4. Even though temperature and truck type had statistically significant effect on measurement errors, the practical significance of these factors is small and does not affect the validity of the calibration.

5.3.4 Classification and Speed Evaluation

The post-validation classification and speed study involved the comparison of vehicle classification and speed data collected manually with the information for the same vehicles reported by the WIM equipment.

For the post-validation classification study at this site, a manual sample of 100 vehicles including 100 trucks (Class 4 through 13) was collected. Video was collected during the study to provide a means for further analysis of misclassifications and vehicles whose classifications could not be determined with a high degree of certainty in the field. Table 5-18 illustrates the breakdown of vehicles observed and identified by the WIM equipment for the manual classification study.

Table 5-18 – Post-Validation Classification Study Results – 14-Sep-10

Class	4	5	6	7	8	9	10	11	12	13
WIM Count	0	10	2	0	5	71	1	5	4	0
Observed Count	0	11	4	0	3	72	1	5	4	0
WIM Distribution (%)	0	10	2	0	5	71	1	5	4	0
Obs. Distribution (%)	0	11	4	0	3	72	1	5	4	0
Misclass/Unclass	0	1	2	0	0	1	1	0	0	0
Misclassified (%)	N/A	9	50	N/A	0	1	100	0	0	N/A

Misclassified vehicles are defined as those vehicles that are manually classified by observation as one type of vehicle but identified by the WIM equipment as another type of vehicle. The misclassified percentage represents the percentage of the misclassified vehicles in the manual sample. The misclassifications by pair are provided in Table 5-19.

Table 5-19 – Post-Validation Misclassifications by Pair – 14-Sep-10

Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs
3/5	0	8/5	0
3/8	0	8/9	0
4/5	0	9/5	0
4/6	0	9/8	0
5/3	0	9/10	0
5/4	0	10/9	0
5/8	1	10/13	0
6/4	0	11/12	0
6/8	1	12/11	0
6/10	1	13/10	0
7/6	0	13/11	0
8/3	0		

Based on the vehicles observed during the post-validation study, the misclassification percentage is 5.0% for heavy trucks (6 – 13), which is not within the 2.0% acceptability criteria for LTPP SPS WIM sites. The overall misclassification rate for all vehicles (3 – 15) is 3.0%. As shown in the table, one Class 5 vehicle was identified by the WIM equipment as a Class 8. For heavy trucks, one Class 6 was identified as a Class 8 and one Class 6 was identified as a Class 10. The cause for the misclassifications could not be determined in the field.

Unclassified vehicles are defined as those vehicles that cannot be identified by the WIM equipment algorithm. These are typically trucks with unusual trailer tandem configurations and are identified as Class 15 by the WIM equipment. The unclassified vehicles by pair are provided in Table 5-20.

Table 5-20 – Post-Validation Unclassified Trucks by Pair – 14-Sep-10

Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs
3/15	0	9/15	1
4/15	0	10/15	1
5/15	0	11/15	0
6/15	0	12/15	0
7/15	0	13/15	0
8/15	0		

Based on the manually collected sample of the 100 trucks, 2.0% of the vehicles at this site were reported as unclassified during the study. This is within the established criteria of 2.0% for LTTP SPS WIM sites. The unclassified vehicles were a Class 9 and Class 10 which could not be identified by the WIM equipment. The cause of the unclassification was not investigated in the field.

For speed, the mean error for WIM equipment speed measurement was 1.0 mph; the range of errors was 1.3 mph.

5.4 Post Visit Applied Calibration

The 85th percentile speed for trucks, based on the CDS data, is 73 mph, 3 mph above the highest test truck speed. Consequently, applied calibration will be utilized and recommendations for changes to the 70 to 75 mph speed point compensation factors will be made.

Figure 5-23 is provided to illustrate the predicted GVW error with respect to the post-validation errors by speed. This provides a reasonable expectation for the applied errors.

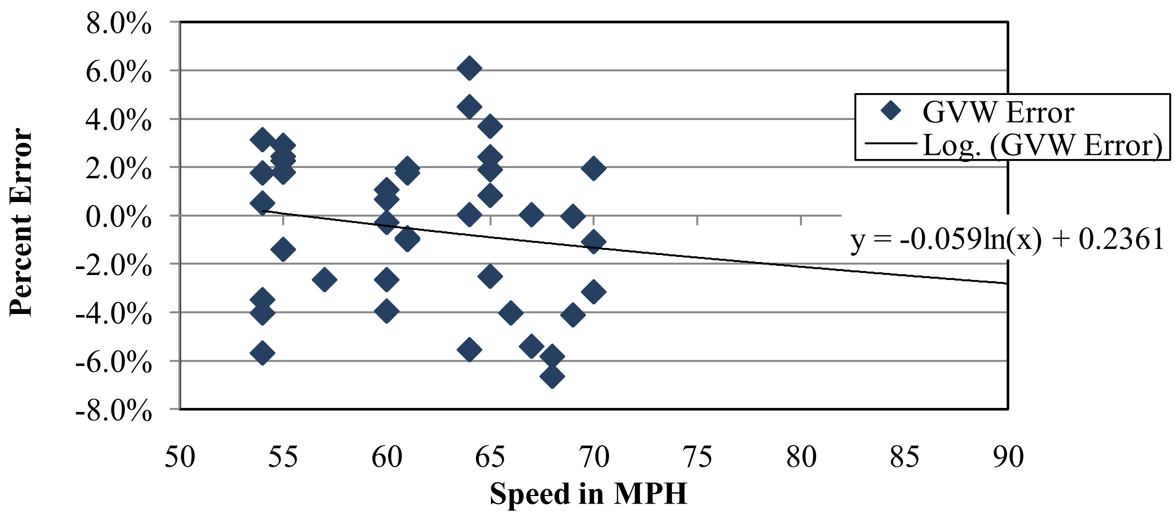


Figure 5-23 – GVW Error Trend

For the applied calibration, the post-validation and post-visit front axle and GVW averages for Class 9 trucks were compared with the most recent data comparison set and the errors were plotted in Figure 5-24.

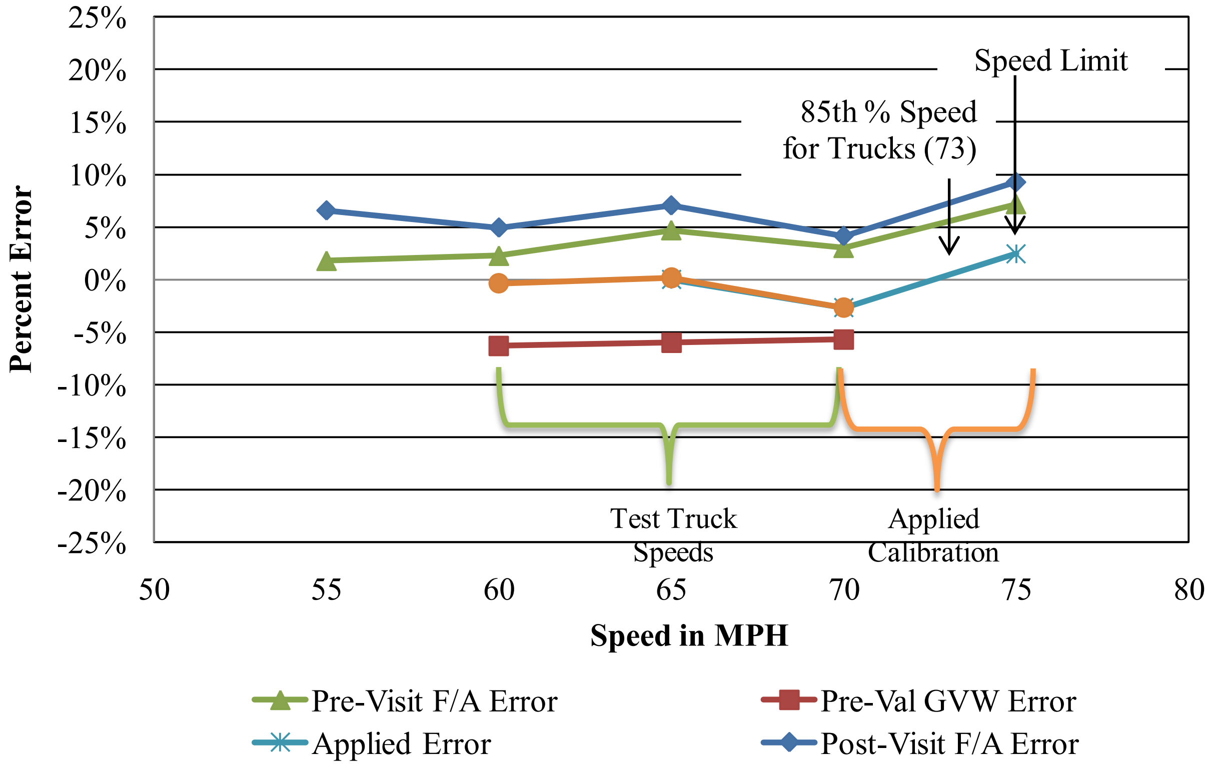


Figure 5-24 – Applied Calibration

Based on these errors and the GVW error trend developed from the post-validation test truck runs and shown in Figure 5-24, applied errors were calculated and are given in Table 5-21.

Table 5-21 – Recommended Factor Changes from Applied Error

Speed Point	Speed	Old Factors		Applied Error	New Factors	
		Right	Left		Right	Left
104	65	3400	3844	0.0%	3400	3844
112	70	3241	3666	-2.7%	3331	3768
120	75	3507	3966	2.5%	3419	3867

Considering the parameters left in place at the conclusion of the post-validation on September 14, 2010, along with the post-visit applied calibration recommendations shown above, the final factor recommendations are provided in Table 5-22.

Table 5-22 – Recommended Final Speed Factors

Speed Point	Speed	Old Factors		Applied Error	New Factors	
		Right	Left		Right	Left
88	55	3378	3820	0.0%	3378	3820
96	60	3321	3757	0.0%	3321	3757
104	65	3400	3844	0.0%	3400	3844
112	70	3241	3666	-2.7%	3331	3768
120	75	3507	3966	2.5%	3419	3867

6 Previous WIM Site Validation Information

The information reported in this section provides a summary of the performance of the WIM equipment since it was installed or since the first validation was performed on the equipment. The information includes historical data on weight and classification accuracies as well as a comparison of post-validation results.

6.1 Sheet 16s

This site has validation information from two previous visits as well as the current one as summarized in the tables below. Table 6-1 data was extracted from the most recent previous validation and was updated to include the results of this validation.

Table 6-1 – Classification Validation History

Date	Misclassification Percentage by Class										Pct Unclass
	4	5	6	7	8	9	10	11	12	13	
30-Apr-07	N/A	0	N/A	N/A	0	0	0	0	0	N/A	0.0
1-May-07	N/A	0	0	N/A	0	0	0	0	0	N/A	0.0
11-Feb-08	100	27	0	N/A	27	0	N/A	0	N/A	N/A	0.0
12-Feb-08	100	43	0	N/A	20	0	0	0	N/A	N/A	0.0
13-Sep-10	100	27	0	N/A	0	0	N/A	0	0	N/A	0.0
14-Sep-10	N/A	9	50	N/A	0	1	100	0	0	N/A	2.0

Table 6-2 data was extracted from the most recent previous validation and was updated to include the results of this validation.

Table 6-2 – Weight Validation History

Date	Mean Error and (SD)		
	GVW	Single Axles	Tandem
30-Apr-07	1.5 (3.0)	1.4 (4.3)	1.6 (4.0)
1-May-07	-0.2 (3.6)	1.1 (4.9)	-0.3 (5.4)
11-Feb-08	2.2 (3.2)	5.0 (3.1)	1.7 (4.0)
12-Feb-08	2.4 (2.9)	3.8 (2.9)	2.2 (4.1)
13-Sep-10	-5.2 (2.6)	-3.2 (3.1)	-5.7 (3.3)
14-Sep-10	-0.6 (3.2)	-0.5 (3.7)	-0.6 (4.0)

The variability of the weight errors appears to have remained reasonably consistent since the site was first validated. From this information, it appears that the system demonstrates a tendency for the equipment GVW estimates to drift over time. The table also demonstrates the effectiveness of the validations in bringing the weight estimations back to within LTPP SPS WIM equipment tolerances.

6.2 Comparison of Post-Validation Results

A comparison of the post-validation results from previous validation visits is provided in Table 6-3.

Table 6-3 – Comparison of Post-Validation Results

Parameter	95 %Confidence Limit of Error	Site Values		
		1-May-07	12-Feb-08	14-Sep-10
Single Axles	±20 percent	1.1 ± 4.9	3.8 ± 2.9	-0.5 ± 3.7
Tandem Axles	±15 percent	-0.3 ± 5.4	2.2 ± 4.1	-0.6 ± 4.0
GVW	±10 percent	-0.2 ± 3.6	2.4 ± 2.9	-0.6 ± 3.2

From the table, it appears that the variance for all weights has remained reasonably consistent since the equipment was installed.

7 Additional Information

The following information is provided in the attached appendix:

- Site Photographs
  - Equipment
  - Test Trucks
  - Pavement Condition
- Pre-validation Sheet 16 – Site Calibration Summary
- Post-validation Sheet 16 – Site Calibration Summary
- Pre-validation Sheet 20 – Classification and Speed Study
- Post-validation Sheet 20 – Classification and Speed Study

Additional information is available upon request through LTPP INFO at ltppinfo@dot.gov, or telephone (202) 493-3035. This information includes:

- Sheet 17 – WIM Site Inventory
- Sheet 18 – WIM Site Coordination
- Sheet 19 – Calibration Test Truck Data
- Sheet 21 – WIM System Truck Records
- Sheet 22 – Site Equipment Assessment plus Addendum
- Sheet 23 – WIM Troubleshooting Outline
- Sheet 24A/B/C – Site Photograph Logs
- Updated Handout Guide

WIM System Field Calibration and Validation - Photos

Arizona, SPS-2
SHRP ID: 040200

Validation Date: September 14, 2010
Submitted: 10/28/10

APPLIED RESEARCH ASSOCIATES, INC.

Photo 1 - Cabinet Exterior

Photo 2 - Cabinet Interior (Back)

Photo 3 - Cabinet Interior (Front) -

Photo 4 - Leading Loop -

Photo 5 - Leading WIM Sensor -

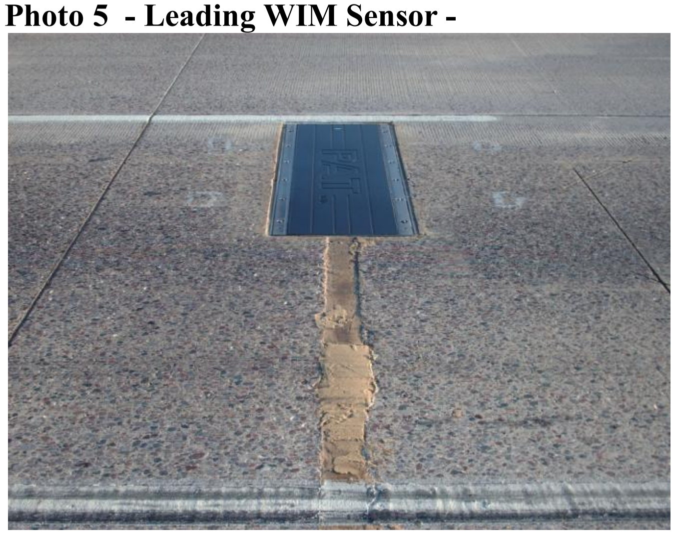


Photo 6 – 040200 – Trailing WIM Sensor –

Photo 7 - Trailing Loop Sensor -

Photo 9 - Downstream -

Photo 8 – Solar Panel -

Photo 10 - Upstream -

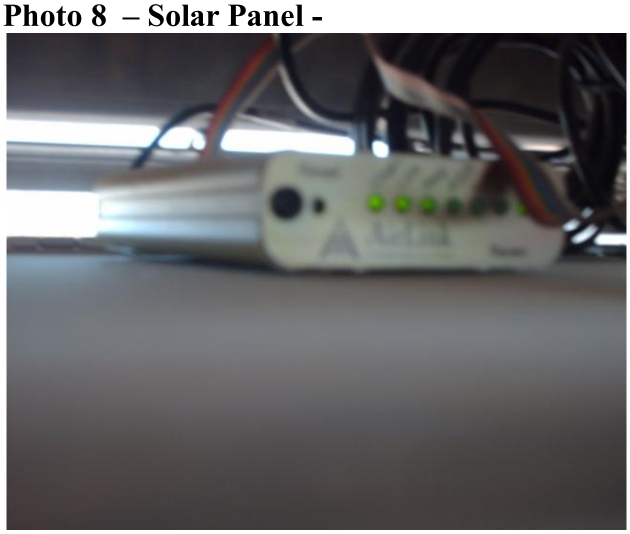


Photo 9 – Cellular Modem

Photo 11 – Old scales 330ft upstream

Photo 12 - Old sensors 320ft upstream

Photo 156 – Truck 1 Trailer and Load

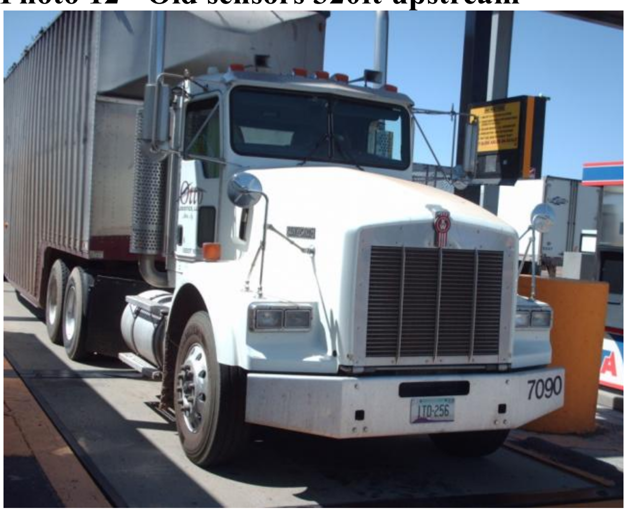


Photo 134 – Truck 1

Photo 167 – Truck 1 Suspension 1

Photo 145 – Truck 1 Tractor

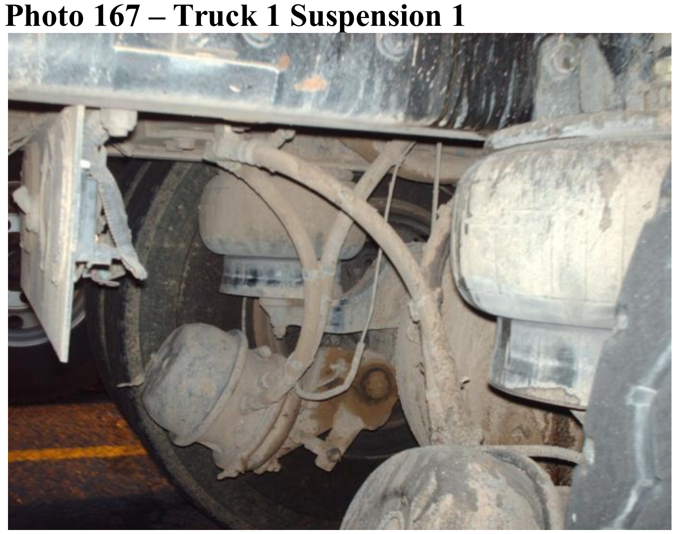


Photo 18 - Truck 1 Suspension 2/3

Photo 19 - Truck 1 Suspension 4

Photo 182 – Truck 2 Tractor

Photo 20 – Truck 1 Suspension 5

Photo 193 – Truck 2 Trailer and Load-

Photo 171 – Truck 2

Photo 204 – Truck 2 Suspension 1


Photo 25 - Truck 2 Suspension 2/3


Photo 26 - Truck 2 Suspension 4


Photo 27 - Truck 2 Suspension 5

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 04 SPS WIM ID: 040200 DATE (mm/dd/yyyy) 9/13/2010

SITE CALIBRATION INFORMATION

1. DATE OF CALIBRATION {mm/dd/yy} 9/13/10

2. TYPE OF EQUIPMENT CALIBRATED: Both

3. REASON FOR CALIBRATION: LTPP Validation

4. SENSORS INSTALLED IN LTPP LANE AT THIS SITE (Select all that apply):

a. Bending Plates
c. ______
b. Inductance Loops
d. ______

5. EQUIPMENT MANUFACTURER: IRD iSINC

WIM SYSTEM CALIBRATION SPECIFICS

6. CALIBRATION TECHNIQUE USED: Test Trucks

Number of Trucks Compared: ______
Number of Test Trucks Used: 2
Passes Per Truck: 20

	Type	Drive Suspension	Trailer Suspension
Truck 1:	9	air	air
Truck 2:	9	air	air
Truck 3:	0	0	0

7. SUMMARY CALIBRATION RESULTS (expressed as a %):

Mean Difference Between -

	Mean		Standard Deviation
Dynamic and Static GVW:	-5.2%	Standard Deviation:	2.6%
Dynamic and Static Single Axle:	-3.2%	Standard Deviation:	3.1%
Dynamic and Static Double Axles:	-5.7%	Standard Deviation:	3.3%

8. NUMBER OF SPEEDS AT WHICH CALIBRATION WAS PERFORMED: 3

9. DEFINE SPEED RANGES IN MPH:

			Low		High	Runs
a.	Low	-	55.0	to	60.7	17
b.	Medium	-	60.8	to	66.4	12
c.	High	-	66.5	to	72.0	11
d.	0	-		to		
e.	0	-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 04 SPS WIM ID: 040200 DATE (mm/dd/yyyy) 9/13/2010

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3507 | 3966

11. IS AUTO- CALIBRATION USED AT THIS SITE? No

If yes , define auto-calibration value(s):

> The Auto-cal feature is using a linear progression of numerical values, starting at 1000 for 0 degrees, with a value incremented by 4 for every degree up to 100 degrees.

CLASSIFIER TEST SPECIFICS

12. METHOD FOR COLLECTING INDEPENDENT VOLUME MEASUREMENT BY VEHICLE CLASS:

Manual

13. METHOD TO DETERMINE LENGTH OF COUNT: Number of Trucks

14. MEAN DIFFERENCE IN VOLUMES BY VEHICLES CLASSIFICATION:

FHWA Class 9:	0.0	FHWA Class	-	
FHWA Class 8:	100.0	FHWA Class	-	
		FHWA Class	-	
		FHWA Class	-	

Percent of "Unclassified" Vehicles: 0.0%

Validation Test Truck Run Set - Pre

Person Leading Calibration Effort: **Dean J. Wolf**

Contact Information: Phone: 717-512-6638

E-mail: dwolf@ara.com

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 04 SPS WIM ID: 040200 DATE (mm/dd/yyyy) 9/14/2010

SITE CALIBRATION INFORMATION

1. **DATE OF CALIBRATION** {mm/dd/yy} 9/14/10

2. **TYPE OF EQUIPMENT CALIBRATED:** Both

3. **REASON FOR CALIBRATION:** LTPP Validation

4. **SENSORS INSTALLED IN LTPP LANE AT THIS SITE** (Select all that apply):
   a. Bending Plates
   b. Inductance Loops
   c. ____
   d. ____

5. **EQUIPMENT MANUFACTURER:** IRD iSINC

WIM SYSTEM CALIBRATION SPECIFICS

6. **CALIBRATION TECHNIQUE USED:** Test Trucks

Number of Trucks Compared: ____
Number of Test Trucks Used: 2
Passes Per Truck: 20

	Type	Drive Suspension	Trailer Suspension
Truck 1:	9	air	air
Truck 2:	9	air	air
Truck 3:	0	0	0

7. **SUMMARY CALIBRATION RESULTS** (expressed as a %):

Mean Difference Between -

	Mean		Standard Deviation
Dynamic and Static GVW:	-0.6%	Standard Deviation:	3.2%
Dynamic and Static Single Axle:	-0.5%	Standard Deviation:	3.7%
Dynamic and Static Double Axles:	-0.6%	Standard Deviation:	4.0%

8. **NUMBER OF SPEEDS AT WHICH CALIBRATION WAS PERFORMED:** 3

9. **DEFINE SPEED RANGES IN MPH:**

			Low		High	Runs
a.	Low	-	54.0	to	59.3	12
b.	Medium	-	59.4	to	64.8	13
c.	High	-	64.9	to	70.0	15
d.	0	-		to		
e.	0	-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: SPS WIM ID: DATE (mm/dd/yyyy)	04 040200 9/14/2010

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3786 | 4282

11. IS AUTO- CALIBRATION USED AT THIS SITE? No

If yes , define auto-calibration value(s):

The Auto-cal feature is using a linear progression of numerical values, starting at 1000 for 0 degrees, with a value incremented by 4 for every degree up to 100 degrees.

CLASSIFIER TEST SPECIFICS

12. METHOD FOR COLLECTING INDEPENDENT VOLUME MEASUREMENT BY VEHICLE CLASS:

Manual

13. METHOD TO DETERMINE LENGTH OF COUNT: Number of Trucks

14. MEAN DIFFERENCE IN VOLUMES BY VEHICLES CLASSIFICATION:

FHWA Class 9:	-1.0	FHWA Class		-	
FHWA Class 8:	67.0	FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 2.0%

Validation Test Truck Run Set - Post

Person Leading Calibration Effort: **Dean J. Wolf**

Contact Information: Phone: 717-512-6638

E-mail: dwolf@ara.com

Traffic Sheet 20	STATE CODE:	04
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	040200
SPEED AND CLASSIFICATION STUDIES	DATE (mm/dd/yyyy)	9/13/2010

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
65	9	64861	64	9	76	9	279	74	9
65	6	64864	63	6	67	9	285	67	9
69	9	64871	68	9	71	9	286	69	9
70	9	64877	69	9	67	12	287	65	12
73	9	64880	72	9	65	9	289	64	9
65	9	64912	64	9	64	9	294	63	9
61	9	64914	60	9	73	9	298	72	9
77	9	64915	75	9	62	9	302	61	9
72	9	64920	72	9	58	9	313	58	9
64	9	64922	64	9	69	9	319	69	9
71	9	64923	70	9	65	9	320	64	9
68	9	64925	67	9	70	9	322	64	9
64	9	64927	64	9	67	9	326	65	9
70	9	64935	69	9	65	9	327	64	9
70	5	64945	68	5	64	9	334	63	9
70	9	64948	64	9	70	9	344	69	9
66	9	64949	67	9	66	9	350	64	9
72	9	64950	70	9	65	9	352	63	9
65	9	64957	62	9	66	9	353	65	9
64	8	64959	68	8	62	9	355	62	9
69	9	64968	66	9	60	9	359	59	9
71	9	33	69	9	60	3	360	58	5
77	9	39	77	9	67	5	364	67	5
73	9	40	74	9	69	9	369	67	9
64	9	42	64	9	62	9	382	63	9

Validation Test Truck Run Set - Pre

Sheet 1 - 0 to 50   Start: 10:02:00   Stop: 11:40:00

Recorded By: djw   Verified By: kt

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE:	04
	SPS WIM ID:	040200
	DATE (mm/dd/yyyy)	9/13/2010

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
65	9	399	65	9	73	9	504	72	9
62	8	401	60	5	65	9	510	64	9
81	5	402	77	5	64	9	513	63	9
64	9	405	63	9	73	9	514	72	9
59	9	413	58	9	68	5	516	67	5
74	9	419	68	9	68	9	522	68	9
71	9	426	70	9	65	5	525	64	5
74	9	427	73	9	73	6	537	72	4
65	3	432	68	5	68	5	545	65	5
80	9	439	80	9	63	9	546	62	9
64	11	443	61	11	71	9	549	69	9
64	9	444	61	9	55	5	550	53	5
71	9	448	70	9	70	9	551	69	9
68	9	450	66	9	75	9	555	71	9
67	9	452	66	9	73	9	594	70	9
70	9	457	69	9	71	9	596	72	9
70	9	461	68	9	70	9	598	68	9
78	9	462	77	9	64	9	602	61	9
70	9	465	69	9	67	9	603	65	9
70	9	469	67	9	67	6	605	65	4
67	9	471	65	9	60	6	615	60	6
62	9	472	60	9	72	9	616	70	9
66	9	474	68	9	55	6	617	55	6
65	9	501	64	9	66	5	623	62	5
68	9	503	67	9	63	11	626	62	11

Validation Test Truck Run Set - Pre

Sheet 2 - 51 to 100 Start: 11:43:00 Stop: 12:24:00

Recorded By: djw Verified By: kt

Traffic Sheet 20	STATE CODE: 04
LTPP MONITORED TRAFFIC DATA	SPS WIM ID: 040200
SPEED AND CLASSIFICATION STUDIES	DATE (mm/dd/yyyy) 9/14/2010

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
60	9	8074	61	9	62	5	8163	62	5
66	9	8078	66	9	56	9	8166	54	9
61	9	8084	61	9	64	9	8169	63	9
68	5	8085	67	5	64	11	8170	64	11
72	9	8087	72	9	62	9	8174	62	9
70	9	8088	70	9	73	9	8175	72	9
68	9	8089	67	9	69	9	8176	68	9
65	9	8092	65	9	64	9	8179	63	9
60	9	8093	61	9	65	15	8180	64	10
65	9	8094	64	9	62	9	8182	61	9
73	9	8096	72	9	75	9	8183	73	9
73	9	8098	71	9	64	9	8187	65	9
67	9	8099	67	9	74	9	8189	70	9
66	9	8100	66	9	64	9	8193	63	9
62	6	8101	62	6	65	9	8197	64	9
66	9	8102	67	9	74	9	8198	74	9
74	9	8103	70	9	62	5	8201	62	5
67	9	8104	67	9	72	6	8202	70	6
73	15	8105	71	9	73	5	8203	72	5
62	9	8106	60	9	64	12	8204	60	12
68	12	8107	67	12	64	8	8205	64	8
69	9	8117	68	9	64	9	8246	64	9
70	9	8188	69	9	65	11	8247	64	11
64	9	8125	62	9	74	9	8249	73	9
61	9	8127	60	9	61	9	8250	62	9

Validation Test Truck Run Set - Post

Sheet 1 - 0 to 50 Start: 11:37:00 Stop: 12:06:00

Recorded By: djw Verified By: kt

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 04 SPS WIM ID: 040200 DATE (mm/dd/yyyy) 9/14/2010

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
60	9	8258	60	9	64	9	8342	63	9
68	5	8271	67	5	65	8	8343	65	8
70	9	8272	68	9	67	9	8344	65	9
59	9	8273	59	9	67	9	8347	63	9
72	9	8275	72	9	68	5	8349	67	5
66	9	8277	66	9	67	5	8350	64	5
56	9	8278	53	9	73	9	8351	72	9
68	9	8282	68	9	75	9	8353	73	9
67	9	8283	65	9	75	9	8356	74	9
63	8	8286	63	5	64	9	8362	64	9
64	9	8288	64	9	65	9	8363	65	9
63	9	8289	62	9	62	9	8365	60	9
71	9	8290	69	9	62	9	8366	62	9
68	9	8291	67	9	63	9	8367	60	9
63	9	8292	62	9	69	9	8371	69	9
73	8	8297	69	8	77	5	8375	76	5
68	9	8300	65	9	75	12	8378	73	12
68	9	8302	64	9	64	12	8381	63	12
64	11	8303	63	11	64	11	8384	63	11
65	10	8305	65	6	67	9	8385	65	9
64	11	8306	67	11	68	9	8386	68	9
58	8	8331	57	6	65	9	8388	64	9
64	9	8336	63	9	52	5	8389	51	5
56	5	8338	53	5	76	9	8391	75	9
62	9	8339	59	9	80	9	8392	80	9

Validation Test Truck Run Set - Post

Sheet 2 - 51 to 100 Start: 12:07:00 Stop: 12:27:00

Recorded By: djw Verified By: kt