WIM System Field Calibration and Validation Summary Report - Amended

Illinois SPS-6
SHRP ID – 170600

Validation Date: December 08, 2010
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Table of Contents

List of Figures

List of Tables

1 Executive Summary

A WIM validation was performed on December 7 and 8, 2010 at the Illinois SPS-6 site located on route I-57 at milepost 225.6, 8.5 miles south of Interstate 72.

This site was installed on July 27, 2005. The in-road sensors are installed in the northbound 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 July 10, 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 there is a significant transverse crack at a location 396 feet prior to WIM scales. There is faulting at this location. Also, there is a transition from asphalt to concrete located 421 feet prior to scales. Neither of these distresses appear to affect the performance of the WIM scales. Observations of trucks passing over the site did not detect any motions by the trucks that would affect WIM system accuracies. Further pavement condition discussion is provided in Section 4.

Validation results indicated that the GVW measurement errors marginally exceeded the 95% confidence limit of error by 1.5% (± 10% limit versus the observed range of +0.9% to +11.5%). However, the confidence limits of error for the individual axle groups were not exceeded.

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

Table 1-1 – Post-Validation Results – 08-Dec-10

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-2.2 ± 5.4%	Pass
Tandem Axles	±15 percent	-0.8 ± 5.9%	Pass
GVW	±10 percent	-0.8 ± 4.9%	Pass
Vehicle Length	±3 percent (1.5 ft)	-0.1 ± 0.9 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.1 ± 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 -0.3 ± 3.5 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 0.1 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 misclassification rate of 0.0% is within the 2.0% acceptability criterion for LTPP SPS WIM sites. The rate for unclassified vehicles was 1.0% which is within the established criteria of 2.0% for LTTP SPS WIM sites.

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 gravel loaded evenly along the trailer.

- The *Secondary* truck was a Class 9 vehicle with air suspension on the tractor tandem, steel spring on the trailer tandem, standard tandem spacing on the tractor and standard tandem on the trailer. The Secondary truck was loaded with gravel loaded evenly along the trailer.

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	76.3	11.2	14.0	14.0	18.6	18.6	14.5	4.3	24.3	4.1	47.2	55.0
2	66.0	10.0	12.2	12.2	15.8	15.8	14.5	4.3	15.4	4.1	38.3	46.0

The posted speed limit at the site is 65 mph. During the testing, the speed of the test trucks ranged from to 54 to 65 mph, a variance of 11 mph.

During test truck runs, pavement temperature was collected using a hand-held infrared temperature device. The post-validation pavement surface temperatures varied from 2.6 to 28.6 degrees Fahrenheit, a range of 26.0 degrees Fahrenheit. The mostly sunny weather conditions nearly provided the desired 30 degree range in temperatures.

2 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 November 15, 2010 (Data) to the most recent Comparison Data Set (CDS) from July 10, 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 LTPP WIM Data Availability

A review of the LTPP Standard Release Database 24 shows that there are 48 consecutive months of level "E" WIM data for this site. This site requires 1 additional year of data to meet the minimum of five years of research quality data. The data does not meet the 210-day minimum requirement for the 2005 and 2009 calendar years, however, the continuous data for the last 5 months of 2007 and the first 7 months of 2009 provide more than 210 days data for each of the four 12-month periods, and therefore provide for four periods in which 210 days of WIM data has been collected. Table 2-1 provides a breakdown of the available data for years 2005 through 2009.

Table 2-1 – LTPP Data Availability

Year	Total Number of Days in Year	Number of Months
2005	135	5
2006	316	12
2007	347	12
2008	365	12
2009	200	7

2.2 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.

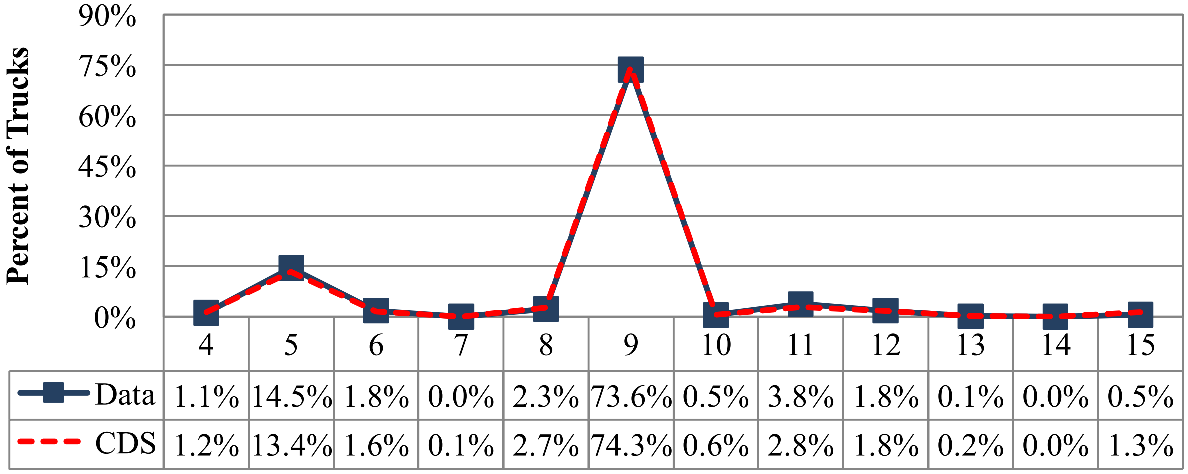


Figure 2-1 – Comparison of Truck Distribution

Table 2-2 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 (73.6%) and Class 5 (14.5%). It also indicates that 0.5 percent of the vehicles at this site are unclassified. Table 2-2 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 2-2 – Truck Distribution from W-Card

Vehicle Classification	CDS		Data		Change
	Date				
	7/10/2008		11/15/2010		
4	598	1.2%	392	1.1%	-0.1%
5	6433	13.4%	5010	14.5%	1.1%
6	766	1.6%	610	1.8%	0.2%
7	32	0.1%	13	0.0%	0.0%
8	1295	2.7%	796	2.3%	-0.4%
9	35633	74.3%	25470	73.6%	-0.7%
10	271	0.6%	166	0.5%	-0.1%
11	1354	2.8%	1299	3.8%	0.9%
12	865	1.8%	621	1.8%	0.0%
13	78	0.2%	38	0.1%	-0.1%
14	0	0.0%	0	0.0%	0.0%
15	620	1.3%	182	0.5%	-0.8%

From the table it can be seen that the number of Class 9 vehicles has decreased by 0.7 percent from July 2008 and November 2010. Small decrease in the number of heavier trucks may be attributed to seasonal variations in truck distributions. During the same time period, the number of Class 5 trucks increased by 1.1 percent. These differences may be attributed to small sample size used to develop vehicle class distributions, decreased use of the roadway for local deliveries, cross-classifications of type 3 and 5 vehicles, as well as natural variations in truck volumes.

2.3 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.

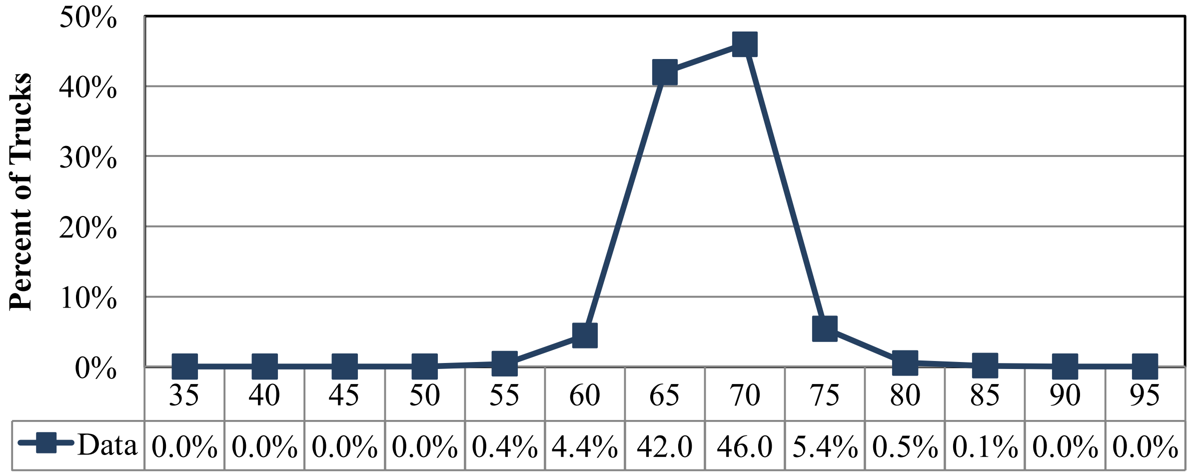


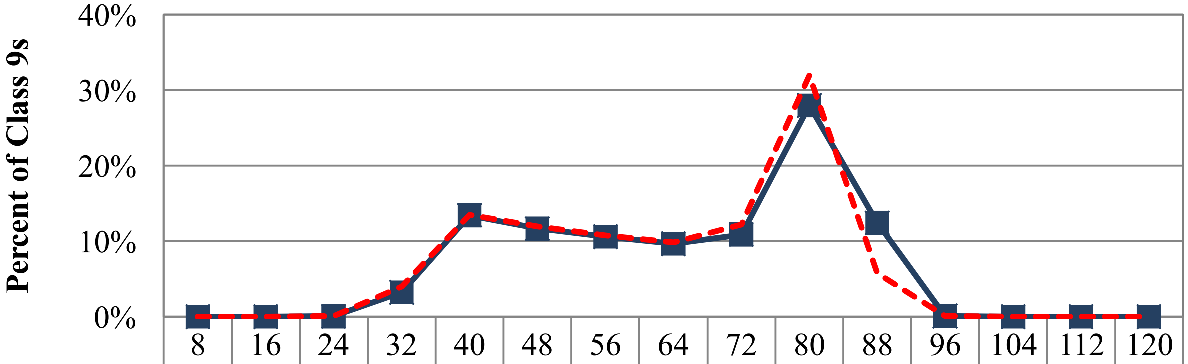
Figure 2-2 – Truck Speed Distribution – 05-Nov-10

As shown in Figure 2-2, the majority of the trucks at this site are traveling between 65 and 70 mph. The posted speed limit at this site is 65 and the 85th percentile speed for trucks at this site is 68 mph. The coverage of truck speeds for the validation will be between 55 and 65 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 60 to 70 mph.

2.4 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 November 2010 and the Comparison Data Set from July 2008.

As shown in Figure 2-3, the unloaded and loaded peaks for the July 2008 Comparison Data Set (CDS) and the November 2010 two-week sample W-card dataset (Data) are similar.



	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
Data	0.0%	0.0%	0.0%	3.2%	13.4	11.7	10.6	9.6%	10.9	28.0	12.4	0.1%	0.0%	0.0%	0.0%
CDS	0.0%	0.0%	0.1%	4.0%	13.4	11.9	10.8	9.8%	12.2	31.9	5.8%	0.1%	0.0%	0.0%	0.0%

Figure 2-3 – Comparison of Class 9 GVW Distribution

Table 2-3 is provided to show the statistical comparison between the Comparison Data Set and the current dataset.

Table 2-3 – Class 9 GVW Distribution from W-Card

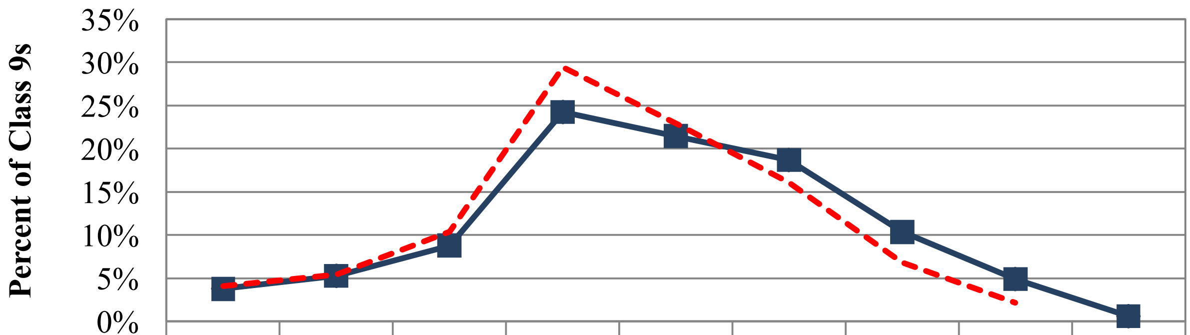
GVW weight bins (kips)	CDS		Data		Change
	Date				
	7/10/2008		11/15/2010		
24	20	0.1%	12	0.0%	0.0%
32	1421	4.0%	820	3.2%	-0.8%
40	4768	13.4%	3413	13.4%	0.0%
48	4234	11.9%	2967	11.7%	-0.3%
56	3823	10.8%	2694	10.6%	-0.2%
64	3477	9.8%	2451	9.6%	-0.2%
72	4323	12.2%	2768	10.9%	-1.3%
80	11328	31.9%	7114	28.0%	-3.9%
88	2056	5.8%	3158	12.4%	6.6%
96	32	0.1%	24	0.1%	0.0%
104	5	0.0%	0	0.0%	0.0%
Average =	60.3		61.4		1.1

As shown in the table, the number of unloaded class 9 trucks in the 32 to 40 kips range remained constant while the number of loaded class 9 trucks in the 72 to 80 kips range decreased by 3.9 percent. The number of overweight trucks increased during this time period by 6.6 percent and the overall GVW average for this site increased from 60.3 kips to 61.4 kips.

2.5 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 November 2010 and the Comparison Data Set from July 2008.



	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0
Data	3.7%	5.3%	8.8%	24.2%	21.5%	18.7%	10.4%	4.9%	0.6%
CDS	4.1%	5.4%	10.4%	29.4%	23.0%	16.1%	6.8%	2.1%	

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

It can be seen in the figure that although the greatest percentage of trucks have front axle weights averaging 10.5, the percentage of trucks at this weight have decreased between the July 2008 Comparison Data Set (CDS) and the November 2010 dataset (Data).

Table 2-4 provides the Class 9 front axle weight distribution data for the July 2008 Comparison Data Set (CDS) and the November 2010 dataset (Data).

Table 2-4 – Class 9 Front Axle Weight Distribution from W-Card

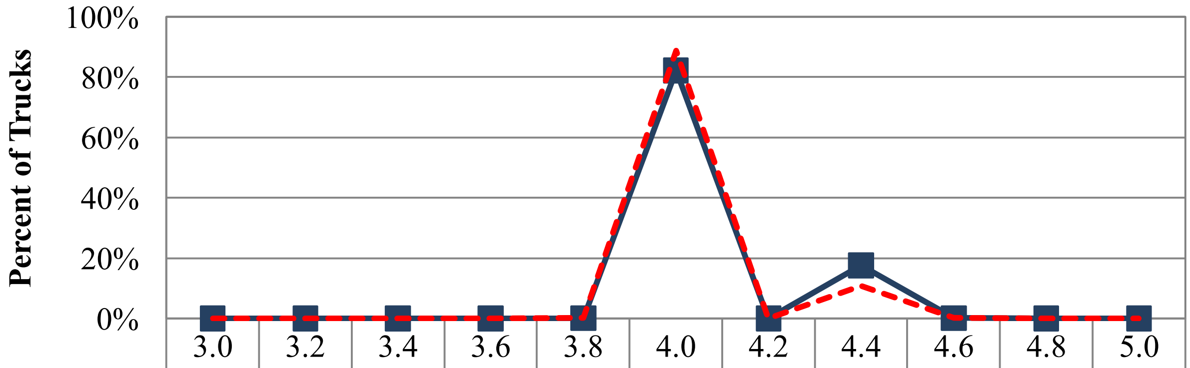
F/A weight bins (kips)	CDS		Data		Change
	Date				
	7/10/2008		11/15/2010		
9.0	866	2.4%	498	2.0%	-0.5%
9.5	1437	4.1%	950	3.7%	-0.3%
10.0	1911	5.4%	1339	5.3%	-0.1%
10.5	3679	10.4%	2223	8.8%	-1.6%
11.0	10430	29.4%	6144	24.2%	-5.2%
11.5	8129	23.0%	5442	21.5%	-1.5%
12.0	5709	16.1%	4735	18.7%	2.6%
12.5	2410	6.8%	2626	10.4%	3.6%
13.0	756	2.1%	1244	4.9%	2.8%
13.5	90	0.3%	146	0.6%	0.3%
Average =	11.0		11.2		0.2

The table shows that the average front axle weight for Class 9 trucks has increased by 0.2 kips, or 1.8 percent. According to the November 21010 data, the majority of the Class 9 front axle weights are between 10.5 and 11.0 kips and the average front axle weight for Class 9 trucks is 11.1 kips.

2.6 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%	82.2%	0.0%	17.5%	0.1%	0.0%	0.0%
CDS	0.0%	0.0%	0.0%	0.0%	0.1%	88.9%	0.0%	10.8%	0.2%	0.0%	0.0%

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

As seen in the figure, the Class 9 tractor tandem spacing for the July 2008 Comparison Data Set and the November 2010 Data are nearly identical.

Table 2-5 shows the Class 9 axle spacings between the second and third axles for the power unit.

Table 2-5 – Class 9 Axle 3 to 4 Spacing from W-Card

Tandem 1 spacing bins (feet)	CDS		Data		Change
	Date				
	7/10/2008		11/15/2010		
3.0	3	0.0%	0	0.0%	0.0%
3.2	10	0.0%	0	0.0%	0.0%
3.4	4	0.0%	1	0.0%	0.0%
3.6	0	0.0%	0	0.0%	0.0%
3.8	40	0.1%	15	0.1%	-0.1%
4.0	31543	88.9%	20908	82.2%	-6.6%
4.2	0	0.0%	0	0.0%	0.0%
4.4	3817	10.8%	4459	17.5%	6.8%
4.6	67	0.2%	32	0.1%	-0.1%
4.8	0	0.0%	0	0.0%	0.0%
5.0	3	0.0%	6	0.0%	0.0%
Average =	4.0		4.0		0.0

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 4.0 feet, which is below the expected average of 4.25 feet. Further analyses are performed during the validation and post-validation analysis.

2.7 Data Analysis Summary

Historical data analysis involved the comparison of the most recent Comparison Data Set (July 2008) based on the last calibration with the most recent two-week WIM data sample from the site (November 2010). Comparison of vehicle class distribution data indicates a 0.7 percent decreased in the number of Class 9 vehicles. Analysis of Class 9 weight data indicates that front axle weights have increased by 0.2 percent and average Class 9 GVW has increased by 1.8 percent for the November 2010 data. The data indicates an average truck tandem spacing of 4.0 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 July 10, 2008 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 July 27, 2005 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. 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, no areas of pavement distress that may affect the accuracy of the WIM sensors were noted.

4.2 Profile and Vehicle Interaction

Profile data was collected on June 16, 2010 by the North Central 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, 11 profile passes were made, 5 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 as well as the 400 foot approach section was 435 in/mi and is located approximately 393 feet prior to the WIM scale. This area of pavement was closely investigated during the validation visit, and truck dynamics in this area were closely observed. Although a severe transverse crack was noted, the distresses observed did not appear to influence truck dynamics in the WIM scale area.

Additionally, a visual observation of the trucks as they approach, traverse and leave the sensor area did not indicate any visible motion of the trucks that would affect the performance of the WIM scales. 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 5 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)	*0.496*	0.570	0.553			0.540
		SRI (m/km)	*0.386*	0.531	*0.481*			*0.466*
		Peak LRI (m/km)	0.599	0.607	0.594			0.600
		Peak SRI (m/km)	*0.485*	0.727	0.601			0.604
	RWP	LRI (m/km)	*0.000*	*0.000*	*0.000*			*0.000*
		SRI (m/km)	*0.000*	*0.000*	*0.000*			*0.000*
		Peak LRI (m/km)	*0.000*	*0.000*	*0.000*			*0.000*
		Peak SRI (m/km)	*0.000*	*0.000*	*0.000*			*0.000*
Center	LWP	LRI (m/km)	*0.441*	*0.470*	0.509	*0.464*	*0.454*	*0.471*
		SRI (m/km)	*0.348*	0.509	*0.421*	*0.398*	*0.409*	*0.419*
		Peak LRI (m/km)	*0.493*	0.550	0.523	0.535	0.545	0.525
		Peak SRI (m/km)	*0.565*	*0.716*	*0.679*	*0.674*	*0.670*	*0.659*
	RWP	LRI (m/km)	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
		SRI (m/km)	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
		Peak LRI (m/km)	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
		Peak SRI (m/km)	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
Right	LWP	LRI (m/km)	0.504	0.547	0.553			0.535
		SRI (m/km)	*0.468*	*0.370*	*0.481*			*0.440*
		Peak LRI (m/km)	0.523	0.598	0.594			0.572
		Peak SRI (m/km)	*0.490*	*0.549*	*0.601*			*0.547*
	RWP	LRI (m/km)	*0.000*	*0.000*	*0.000*			*0.000*
		SRI (m/km)	*0.000*	*0.000*	*0.000*			*0.000*
		Peak LRI (m/km)	*0.000*	*0.000*	*0.000*			*0.000*
		Peak SRI (m/km)	*0.000*	*0.000*	*0.000*			*0.000*

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 SRI values in the left wheel path of the center passes..

4.4 Recommended Pavement Remediation

No pavement remediation 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 41 pre-validation test truck runs were conducted on December 7, 2010, beginning at approximately 7:30 AM and continuing until 4:03 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with gravel loaded evenly along the trailer, 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 gravel loaded evenly along the trailer, and equipped with air suspension on the tractor, steel spring suspension on the trailer, with a standard tandem spacing on the tractor and a 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)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	76.3	11.1	13.7	13.7	18.9	18.9	14.5	4.3	24.3	4.1	47.2	55.0
2	66.0	10.0	12.2	12.2	15.8	15.8	14.5	4.3	15.4	4.1	38.3	46.0

Test truck speeds varied by 13 mph, from 52 to 65 mph. The measured pre-validation pavement temperatures varied 27.0 degrees Fahrenheit, from 4.0 to 31.0. The mostly sunny weather conditions nearly provided the desired 30 degree temperature range. Table 5-2 provides a summary of the pre-validation results.

Table 5-2 – Pre-Validation Overall Results – 07-Dec-10

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	1.8 ± 5.4%	Pass
Tandem Axles	±15 percent	7.2 ± 6.2%	Pass
GVW	±10 percent	6.2 ± 5.3%	FAIL
Vehicle Length	±3 percent (1.5 ft)	2.1 ± 0.7 ft	FAIL
Axle Length	± 0.5 ft [150mm]	0.1 ± 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 over all speeds was -0.1 ± 0.9 mph, which is within 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 0.1, 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 and that the speeds being reported by the WIM equipment are within acceptable ranges.

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 65 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 – 07-Dec-10

Parameter	95% Confidence Limit of Error	Low	Medium	High
		52.0 to 56.3 mph	56.4 to 60.8 mph	60.9 to 65.0 mph
Steering Axles	±20 percent	1.3 ± 7.2%	2.6 ± 3.6%	1.5 ± 6.0%
Tandem Axles	±15 percent	6.1 ± 6.7%	7.3 ± 5.8%	8.0 ± 6.6%
GVW	±10 percent	5.3 ± 6.1%	6.4 ± 4.8%	6.9 ± 5.7%
Vehicle Length	±3 percent (1.5 ft)	2.0 ± 0.0 ft	2.0 ± 0.9 ft	2.2 ± 0.9 ft
Vehicle Speed	± 1.0 mph	-0.2 ± 0.8 mph	-0.2 ± 0.8 mph	-0.1 ± 1.1 mph
Axle Length	± 0.5 ft [150mm]	0.1 ± 0.4 ft	0.0 ± 0.3 ft	0.1 ± 0.2 ft

From the table, it can be seen that *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 sections.

5.1.1.1 GVW Errors by Speed

As shown in Figure 5-1, the equipment overestimated GVW at all speeds. The range in error and bias is greater at the lower and higher speeds when compared with the medium speeds. Distribution of errors is shown graphically in the following figure.

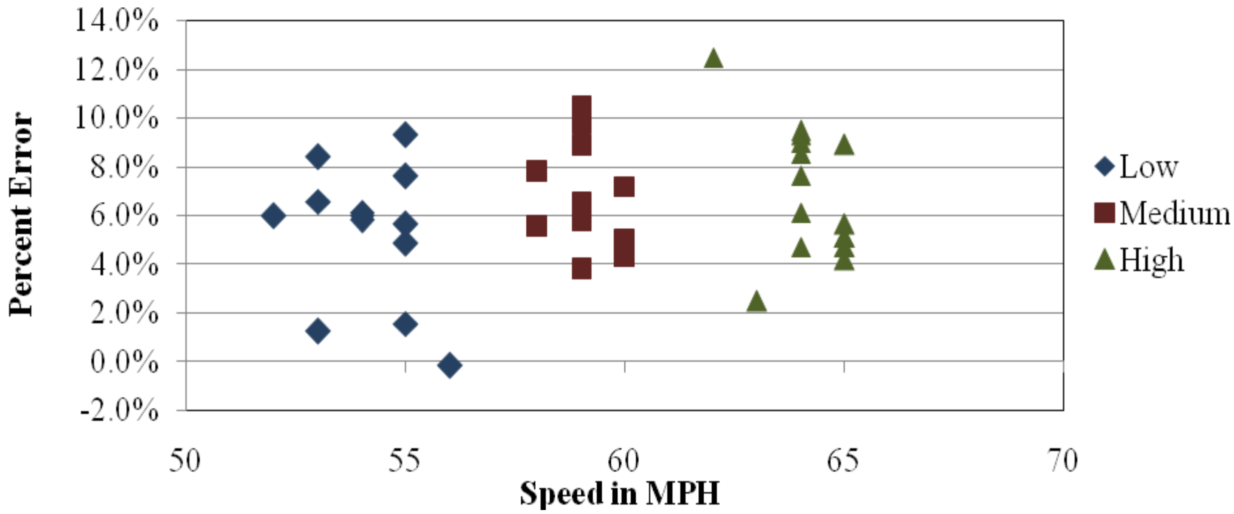


Figure 5-1 – Pre-Validation GVW Error by Speed – 07-Dec-10

5.1.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-2, the equipment overestimates steering axle weights with similar accuracy at all speeds. The range in error appears to be greater at the lower and higher speeds when compared with medium speeds. Distribution of errors is shown graphically in the following figure.

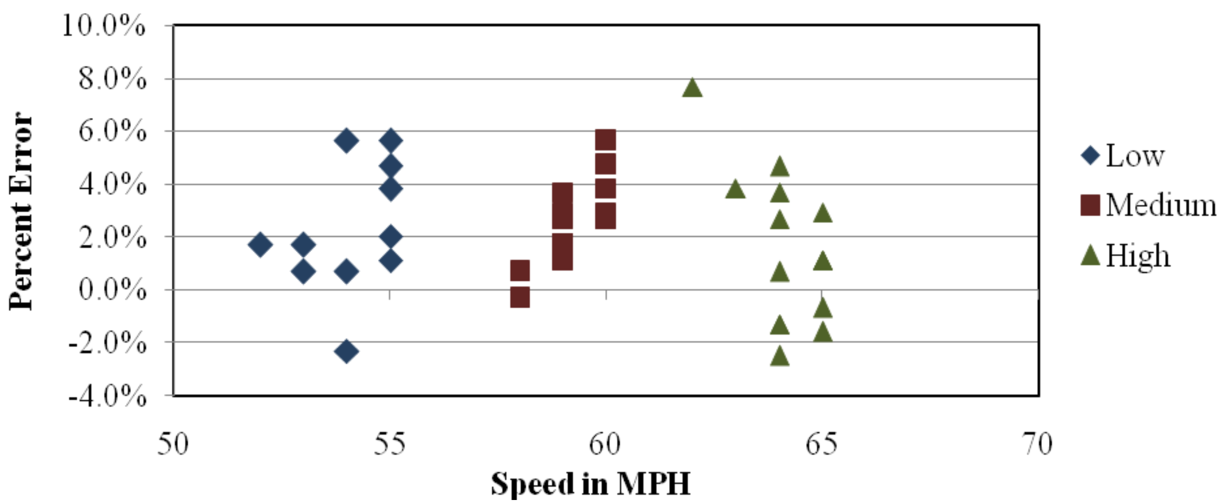


Figure 5-2 – Pre-Validation Steering Axle Weight Errors by Speed – 07-Dec-10

5.1.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 5-3, the equipment overestimates tandem axle weights at all speeds. The range in error appears to be greater at the lower and higher speeds when compared with the medium speeds. Distribution of errors is shown graphically in the following figure.

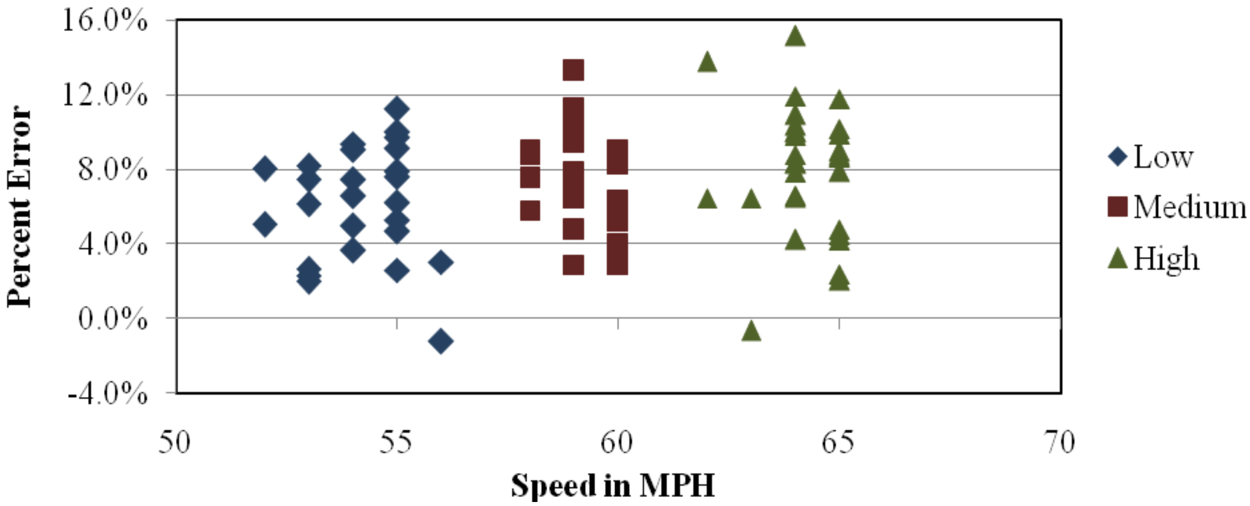


Figure 5-3 – Pre-Validation Tandem Axle Weight Errors by Speed – 07-Dec-10

5.1.1.4 GVW Errors by Speed and Truck Type

When the GVW error for each truck is analyzed as a function of speed, it can be seen that the WIM equipment overestimates GVW for the Secondary truck by a greater degree than the Primary truck. Distribution of errors appears to be greater at the lower speeds for both trucks as shown graphically in Figure 5-4.

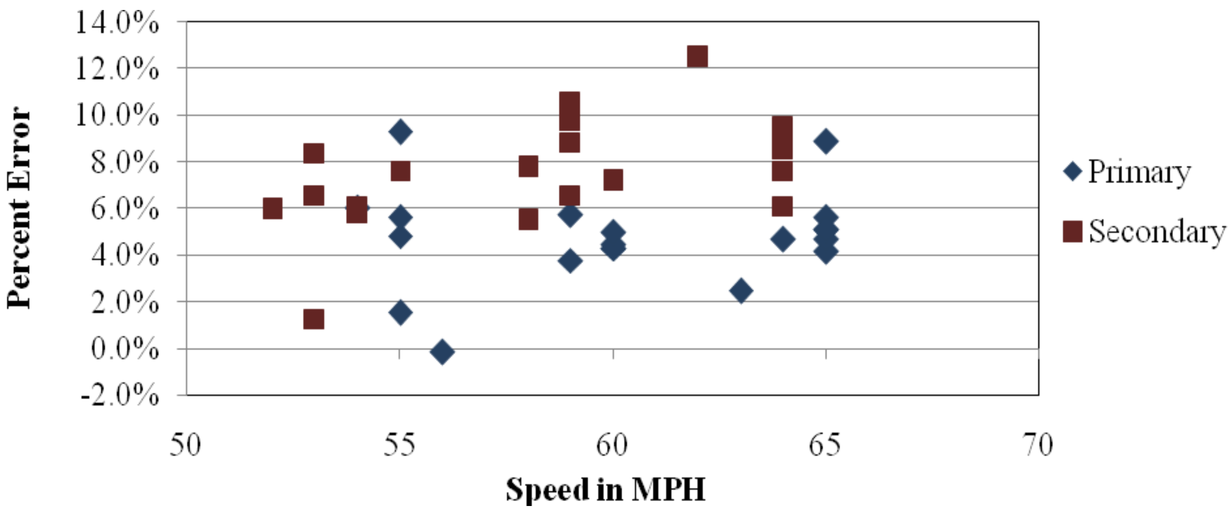


Figure 5-4 – Pre-Validation GVW Errors by Truck and Speed – 07-Dec-10

5.1.1.5 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 -0.2 feet to 0.4 feet. Distribution of errors is shown graphically in Figure 5-5.

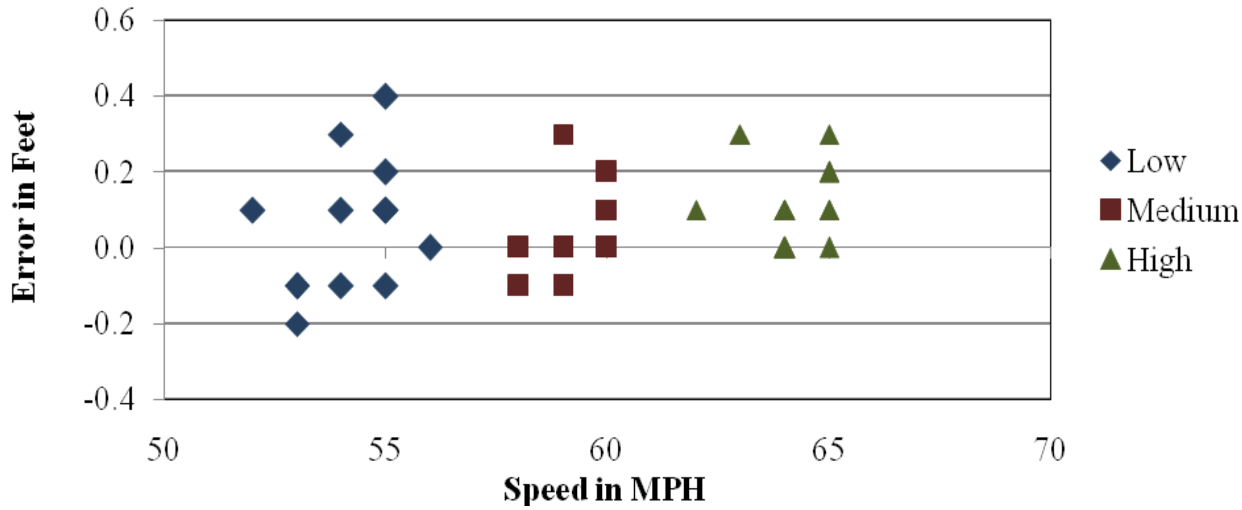


Figure 5-5 – Pre-Validation Axle Length Errors by Speed – 07-Dec-10

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 1.0 to 3.0 feet. Distribution of errors is shown graphically in Figure 5-6.

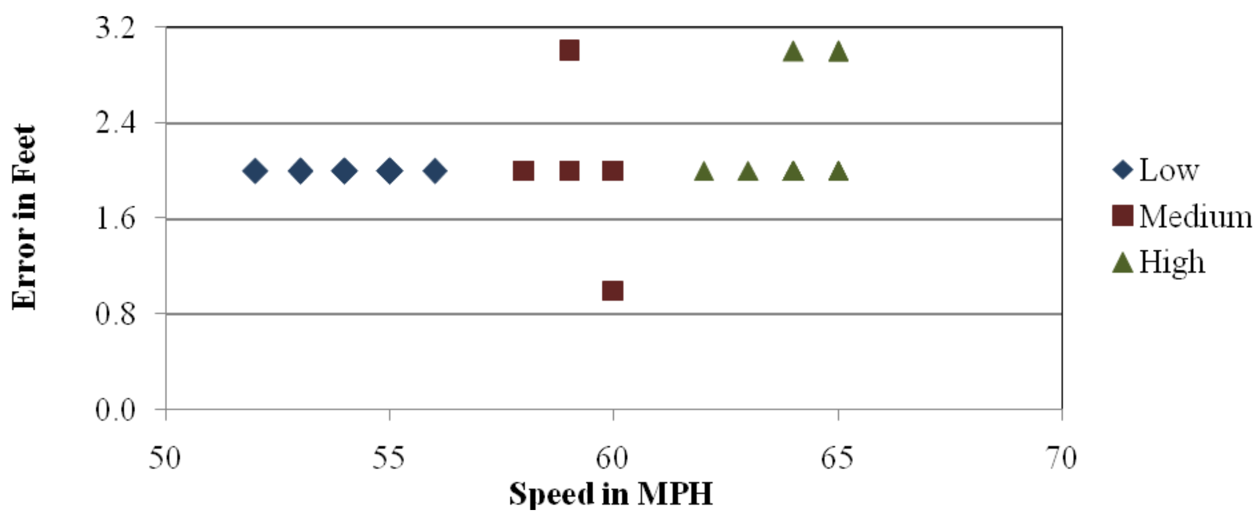


Figure 5-6 – Pre-Validation Overall Length Error by Speed – 07-Dec-10

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 27.0 degrees, from 4.0 to 31.0 degrees Fahrenheit. The pre-validation test runs are being reported under two temperature groups as shown in Table 5-4.

Table 5-4 – Pre-Validation Results by Temperature – 07-Dec-10

Parameter	95% Confidence Limit of Error	Low	High
		4.0 to 17.5 degF	17.6 to 31.1 degF
Steering Axles	±20 percent	1.8 ± 5.3%	1.8 ± 5.9%
Tandem Axles	±15 percent	7.0 ± 5.7%	7.3 ± 6.8%
GVW	±10 percent	6.1 ± 4.8%	6.3 ± 5.9%
Vehicle Length	±3 percent (1.5 ft)	2.0 ± 0.7 ft	2.1 ± 0.7 ft
Vehicle Speed	± 1.0 mph	-0.2 ± 0.8 mph	-0.1 ± 0.9 mph
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.2 ft	0.1 ± 0.3 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 overestimates GVW across the range of temperatures observed in the field. There does not appear to be a correlation between temperature and GVW estimates for the temperature range.

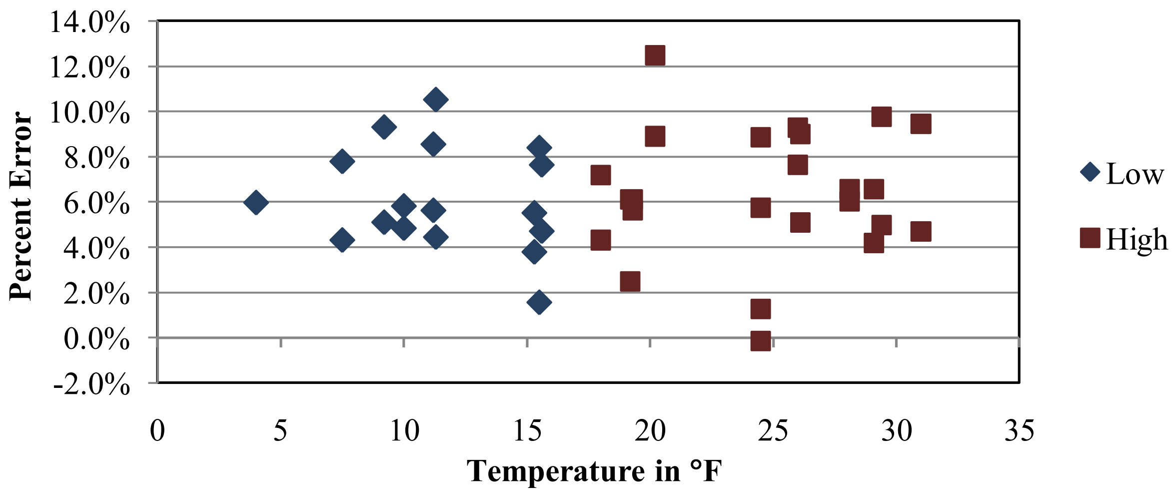


Figure 5-7 – Pre-Validation GVW Errors by Temperature – 07-Dec-10

5.1.2.2 Steering Axle Weight Errors by Temperature

Figure 5-8 demonstrates that for steering axles, the equipment overestimates the weights across the range of temperatures observed in the field. There does not appear to be a correlation between temperature and steering axle weight estimates for the temperature range.

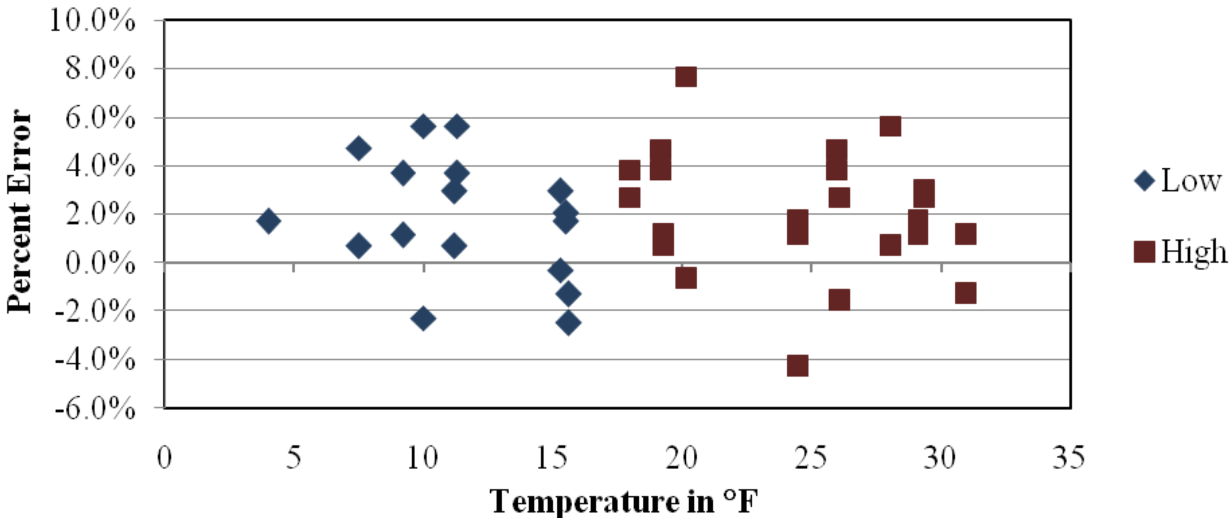


Figure 5-8 – Pre-Validation Steering Axle Weight Errors by Temperature – 07-Dec-10

5.1.2.3 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-9, it can be seen that the equipment overestimates tandem axle weights across the range of temperatures observed in the field. There does not appear to be a correlation between temperature and GVW estimates for the temperature range.

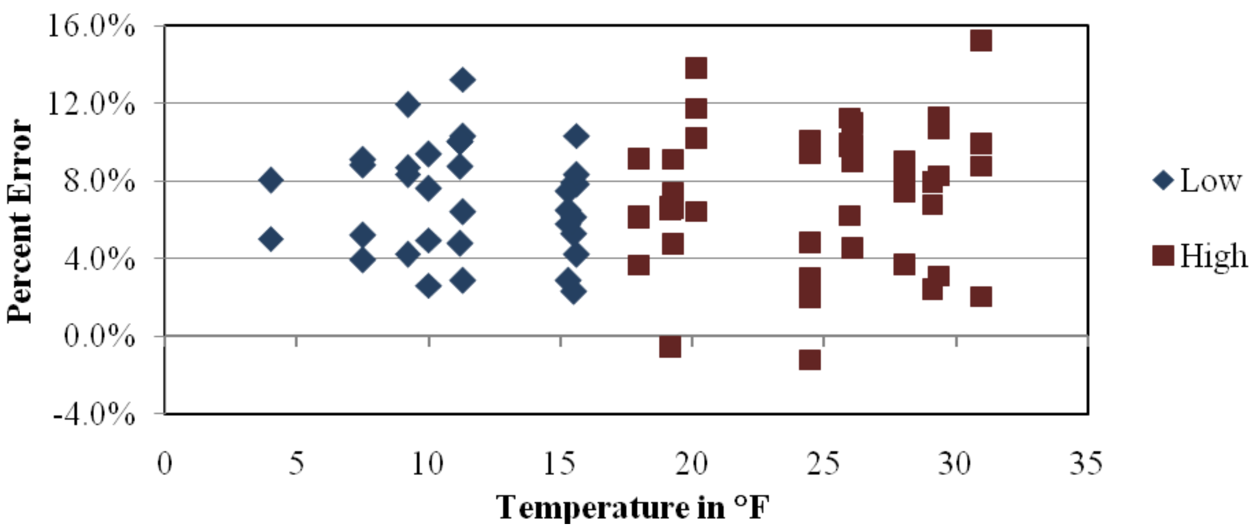


Figure 5-9 – Pre-Validation Tandem Axle Weight Errors by Temperature – 07-Dec-10

5.1.2.4 GVW Errors by Temperature and Truck Type

When analyzed for each test truck, GVW measurement is inconsistent, where GVW for the Secondary truck is overestimated by a greater degree than GVW for the Primary truck. The range in error for both trucks appears to be greater at the higher temperatures. Distribution of errors is shown graphically in Figure 5-10.

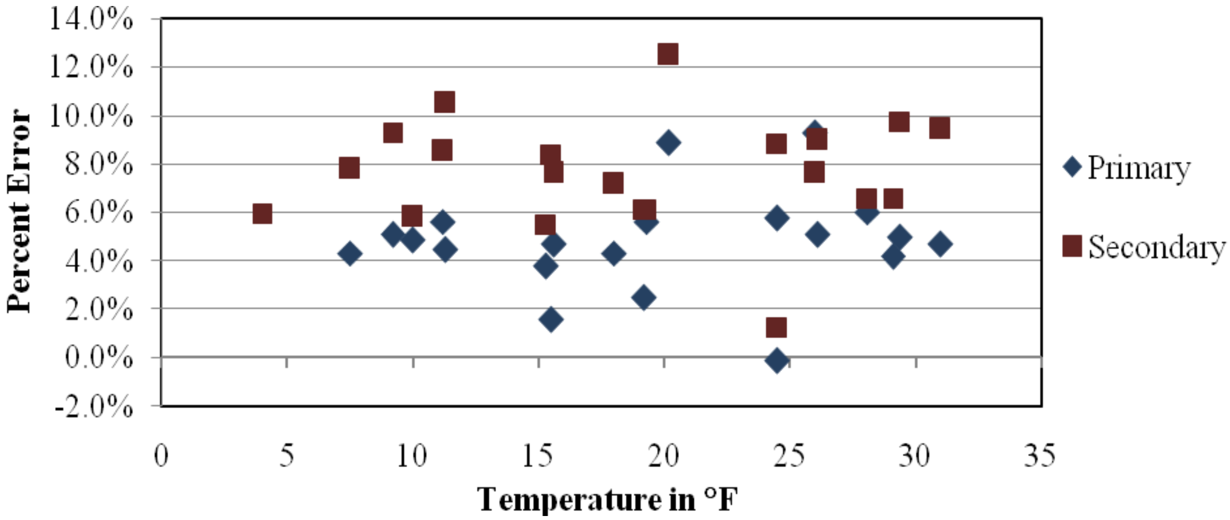


Figure 5-10 – Pre-Validation GVW Error by Truck and Temperature – 07-Dec-10

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 – 07-Dec-10

Class	4	5	6	7	8	9	10	11	12	13
Observed Count	0	12	1	0	1	80	1	2	1	2
WIM Count	0	12	1	0	1	81	0	2	1	2
Observed Percentage	0	12	1	0	1	80	1	2	1	2
WIM Percentage	0	12	1	0	1	81	0	2	1	2
Misclassified Count	0	0	0	0	0	0	1	0	0	0
Misclassified Percent	N/A	0	0	N/A	0	0	100	0	0	0
Unclassified Count	0	0	0	0	0	0	0	0	0	0
Unclassified Percent	N/A	0	0	N/A	0	0	N/A	0	0	0

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 – 07-Dec-10

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

Based on the vehicles observed during the pre-validation study, the misclassification percentage is 1.1% 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 1.0%.

As shown in the table, a total of 1 vehicle, including 1 heavy truck (6 – 13) was misclassified by the equipment. The single misclassification was a Class 10 vehicle which was identified by the equipment as a Class 9 vehicle. The cause of the misclassification was not investigated 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 5-7.

Table 5-7 – Pre-Validation Unclassified Trucks by Pair – 07-Dec-10

Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs
3/15	0	7/15	0	11/15	0
4/15	0	8/15	0	12/15	0
5/15	0	9/15	0	13/15	0
6/15	0	10/15	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 0.0 mph; the range of errors was 1.0 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 – 08-Dec-10

Speed Point	MPH	Right	Left
80	50	3275	3684
88	55	3462	3895
96	60	3420	3848
104	65	3399	3822
112	70	3219	3619
Axle Distance (cm)		310	
Dynamic Comp (%)		100	

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 6.2% and errors of 5.3%, 6.4%, and 6.9% at the 55, 60 and 65 mph speed points respectively. The errors for 55 mph and 65 mph speeds were extrapolated to derive new compensation factors for the 50 and 70 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 – 08-Dec-10

Speed Points	Old Factors		Error	New Factors	
	Right	Left		Right	Left
80	3275	3684	5.91%	3092	3478
88	3462	3895	5.91%	3269	3678
96	3420	3848	7.54%	3180	3578
104	3399	3822	7.15%	3172	3567
112	3219	3619	7.15%	3004	3377
Axle Distance (cm)	310		-0.15%	310	
Dynamic Comp (%)	100		1.80%	104	

5.2.1.2 Calibration 1 Results

The results of the 12 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 GVW estimates was reduced to 0.4 percent as a result of the first calibration iteration.

Table 5-10 – Calibration 1 Results – 08-Dec-10

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-1.1 ± 5%	Pass
Tandem Axles	±15 percent	0.4 ± 5.7%	Pass
GVW	±10 percent	0.4 ± 5.0%	Pass
Vehicle Length	±3 percent (1.5 ft)	0.0 ± 1.3 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.1 ± 0.3 ft	Pass

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

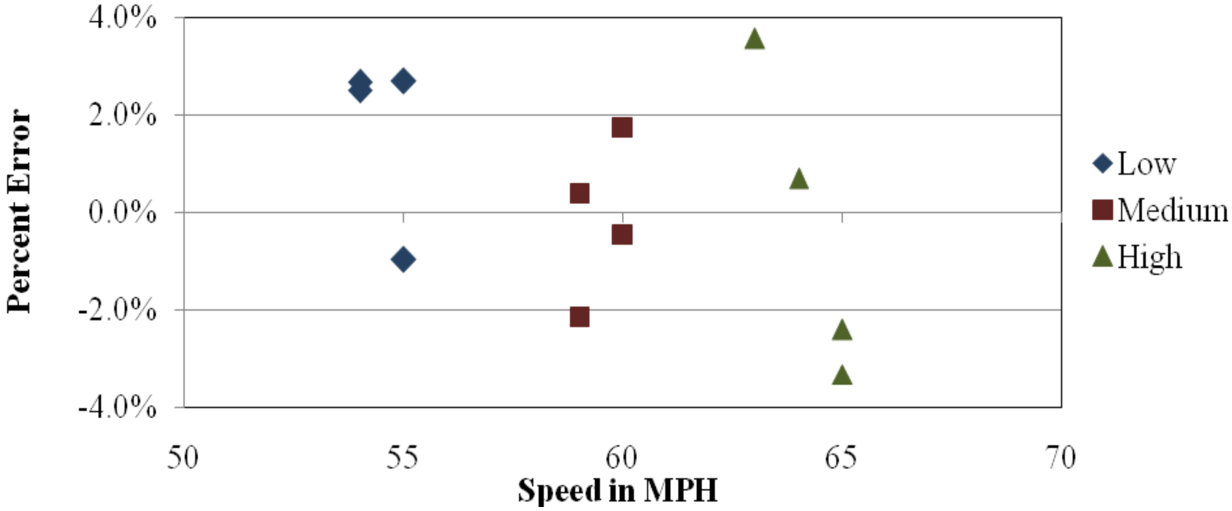


Figure 5-11 – Calibration 1 GVW Error by Speed – 08-Dec-10

Based on the results of the first calibration, where weight estimate bias decreased to less than 2.0 percent, a second calibration was not considered to be necessary. The 12 calibration runs were combined with 28 additional post-validation runs to complete the WIM system validation.

5.3 Post-Validation

The 40 post-validation test truck runs were conducted on December 08, 2010, beginning at approximately 6:53 AM and continuing until 2:19 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with gravel loaded evenly along the trailer, 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 gravel loaded evenly along the trailer, and equipped with air suspension on the tractor, steel spring 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 5-11.

Table 5-11 - 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	76.3	11.2	14.0	14.0	18.6	18.6	14.5	4.3	24.3	4.1	47.2	55.0
2	66.0	10.0	12.2	12.2	15.8	15.8	14.5	4.3	15.4	4.1	38.3	46.0

Test truck speeds varied by 11 mph, from 54 to 65 mph. The measured post-validation pavement temperatures varied 26.0 degrees Fahrenheit, from 2.6 to 28.6. The mostly sunny weather conditions prevented for reaching the desired 30 degree temperature range. Table 5-12 is a summary of post validation results.

Table 5-12 – Post-Validation Overall Results – 08-Dec-10

Parameter	**95% Confidence Limit of Error**	**Site Values**	**Pass/Fail**
Steering Axles	±20 percent	-2.2 ± 5.4%	Pass
Tandem Axles	±15 percent	-0.8 ± 5.9%	Pass
GVW	±10 percent	-0.8 ± 4.9%	Pass
Vehicle Length	±3 percent (1.5 ft)	-0.1 ± 0.9 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.1 ± 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 -0.3 ± 3.5 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 0.1, 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 65 mph. The test runs were divided into three speed groups - low, medium and high speeds, as shown in Table 5-13 below.

Table 5-13 – Post-Validation Results by Speed – 08-Dec-10

Parameter	95% Confidence Limit of Error	Low	Medium	High
		54.0 to 57.7 mph	57.8 to 61.4 mph	61.5 to 65.0 mph
Steering Axles	±20 percent	-1.5 ± 6.1%	-2.5 ± 6.5%	-2.7 ± 4.3%
Tandem Axles	±15 percent	-0.9 ± 5.6%	-1.5 ± 5.5%	0.0 ± 7.9%
GVW	±10 percent	-0.7 ± 5.3%	-1.5 ± 4.5%	-0.2 ± 6.2%
Vehicle Length	±3 percent (1.5 ft)	0.1 ± 1.0 ft	-0.1 ± 1.0 ft	-0.2 ± 0.9 ft
Vehicle Speed	± 1.0 mph	-0.6 ± 4.1 mph	-0.6 ± 4.5 mph	0.4 ± 1.1 mph
Axle Length	± 0.5 ft [150mm]	0 ± 0.3 ft	0.1 ± 0.3 ft	0.1 ± 0.3 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. Based on the post-validation results, 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, steering axle, and tandem axle 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 following figure.

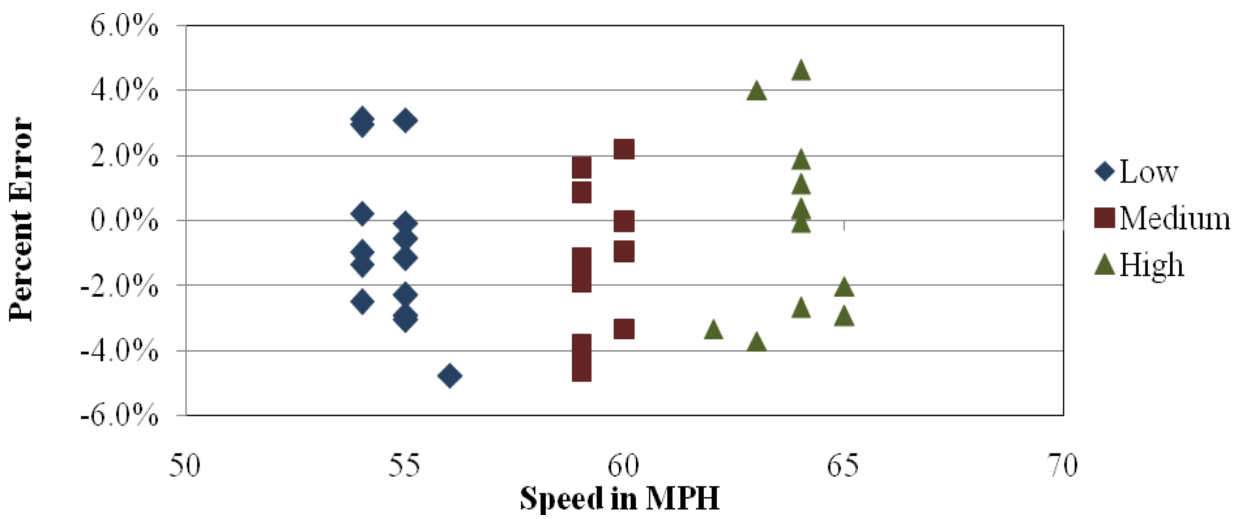


Figure 5-12 – Post-Validation GVW Errors by Speed – 08-Dec-10

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 following figure.

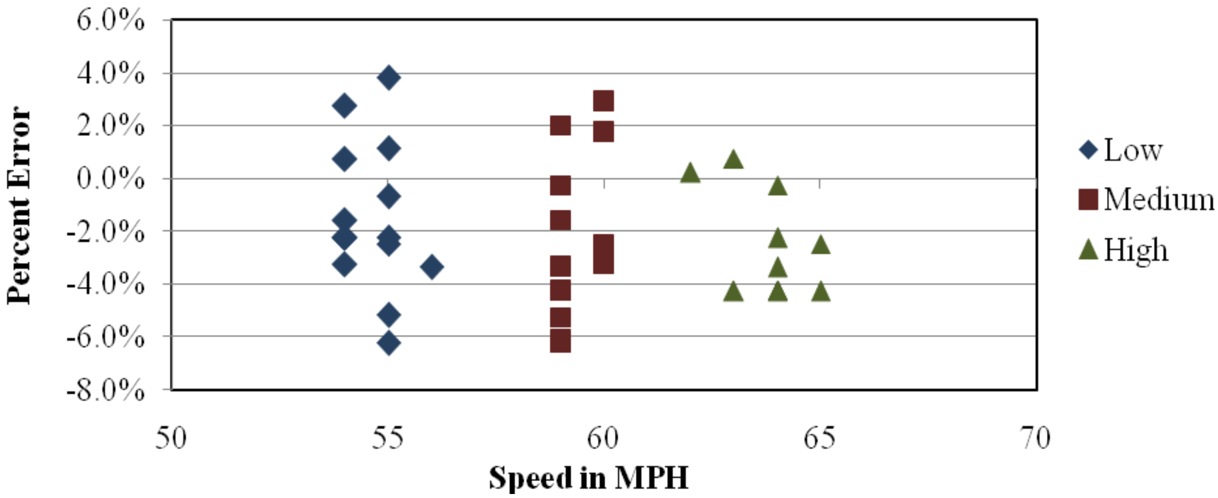


Figure 5-13 – Post-Validation Steering Axle Weight Errors by Speed – 08-Dec-10

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 following figure.

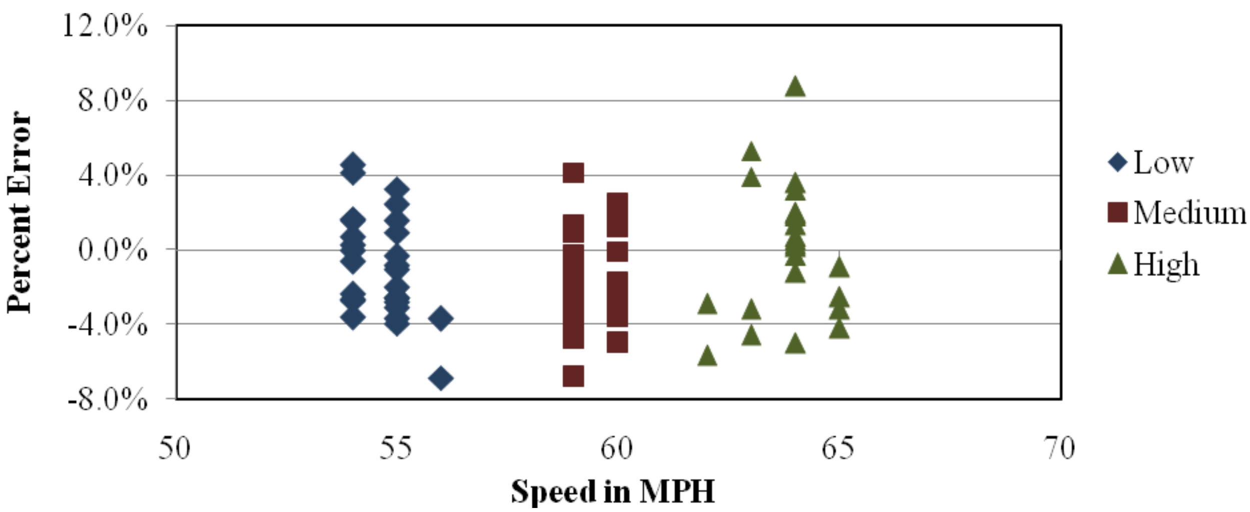


Figure 5-14 – Post-Validation Tandem Axle Weight Errors by Speed – 08-Dec-10

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 estimates GVW for both trucks with reasonable accuracy. However, it underestimates GVW for the Primary truck. Distribution of errors is shown graphically in the following figure.

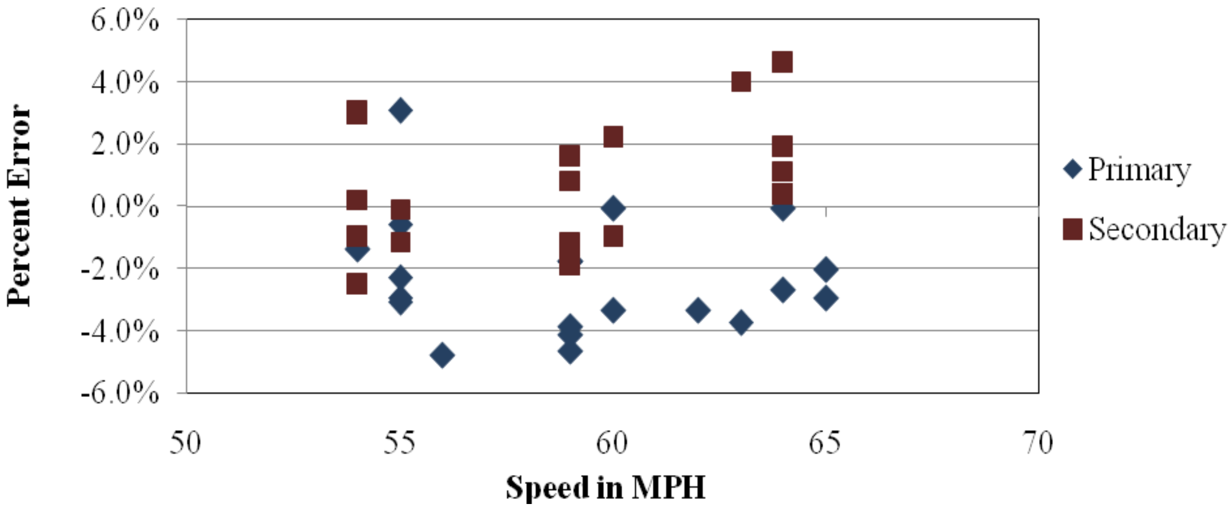


Figure 5-15 – Post-Validation GVW Error by Truck and Speed – 08-Dec-10

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 -0.2 feet to 0.3 feet. Distribution of errors is shown graphically in Figure 5-16.

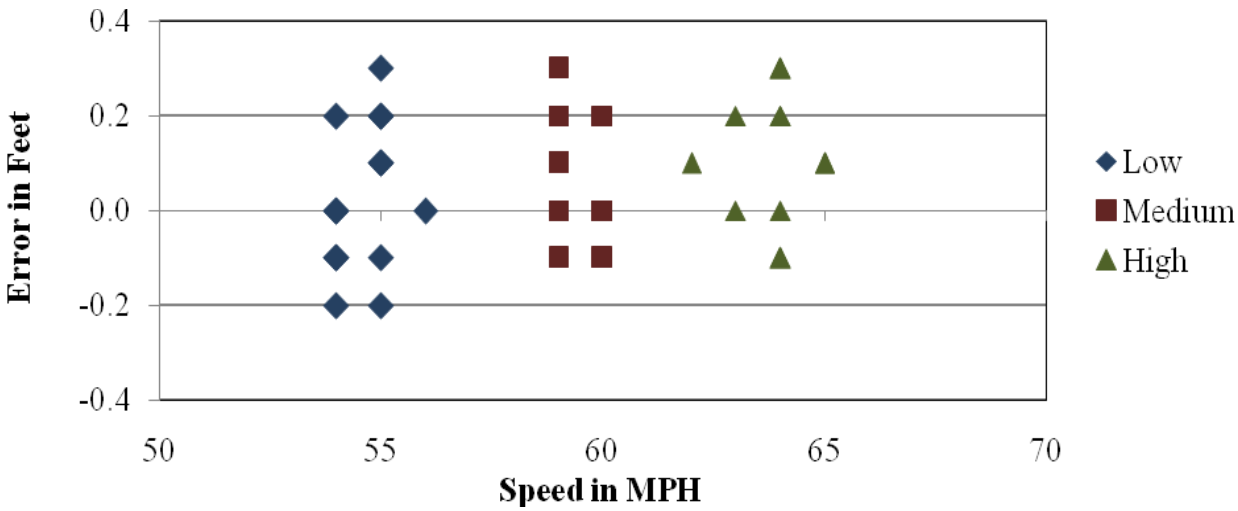


Figure 5-16 – Post-Validation Axle Length Error by Speed – 08-Dec-10

5.3.1.6 Overall Length Errors by Speed

For this system, the WIM equipment measures overall length consistently over the entire range of speeds, with errors ranging from -1.0 to 1.0 feet. Distribution of errors is shown graphically in Figure 5-17.

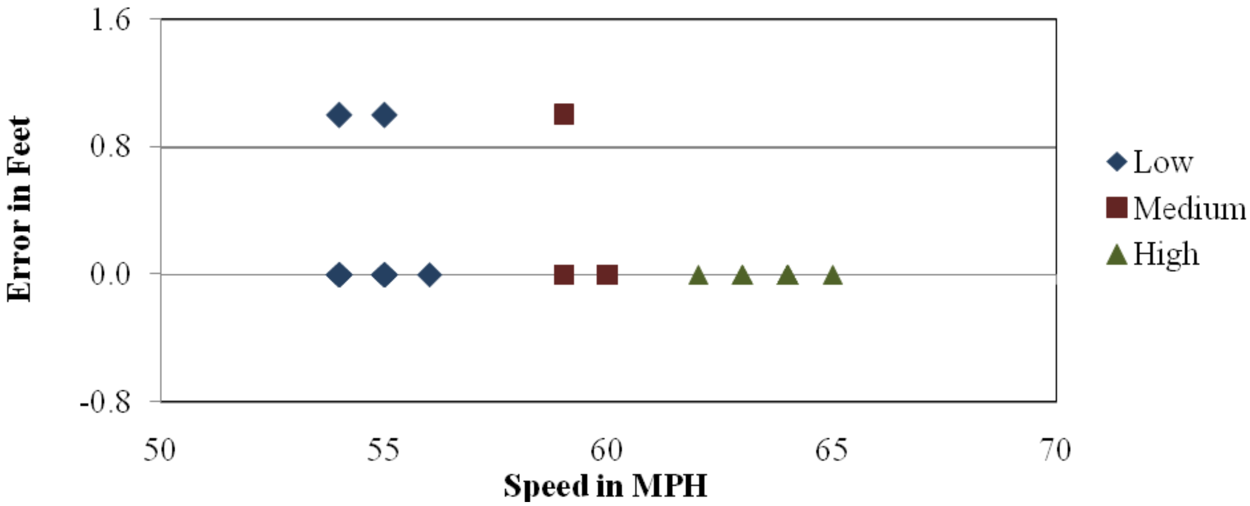


Figure 5-17 – Post-Validation Overall Length Error by Speed – 08-Dec-10

5.3.2 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 26.0 degrees, from 2.6 to 28.6 degrees Fahrenheit. The post-validation test runs are being reported under two temperature groups as shown in Table 5-14 below.

Table 5-14 – Post-Validation Results by Temperature – 08-Dec-10

Parameter	95% Confidence Limit of Error	Low	High
		2.6 to 15.6 degF	15.7 to 28.7 degF
Steering Axles	±20 percent	0.1 ± 5.9%	-3.4 ± 3.3%
Tandem Axles	±15 percent	0.3 ± 5.7%	-1.5 ± 6.0%
GVW	±10 percent	0.4 ± 5.2%	-1.5 ± 4.6%
Vehicle Length	±3 percent (1.5 ft)	-0.1 ± 1.3 ft	0.0 ± 0.7 ft
Vehicle Speed	± 1.0 mph	0.3 ± 1 mph	-0.6 ± 4.2 mph
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.3 ft	0.1 ± 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 at all temperatures. However, there appears to be a correlation between temperature and weight estimates where temperature causes weight estimates to decrease as temperature rises.

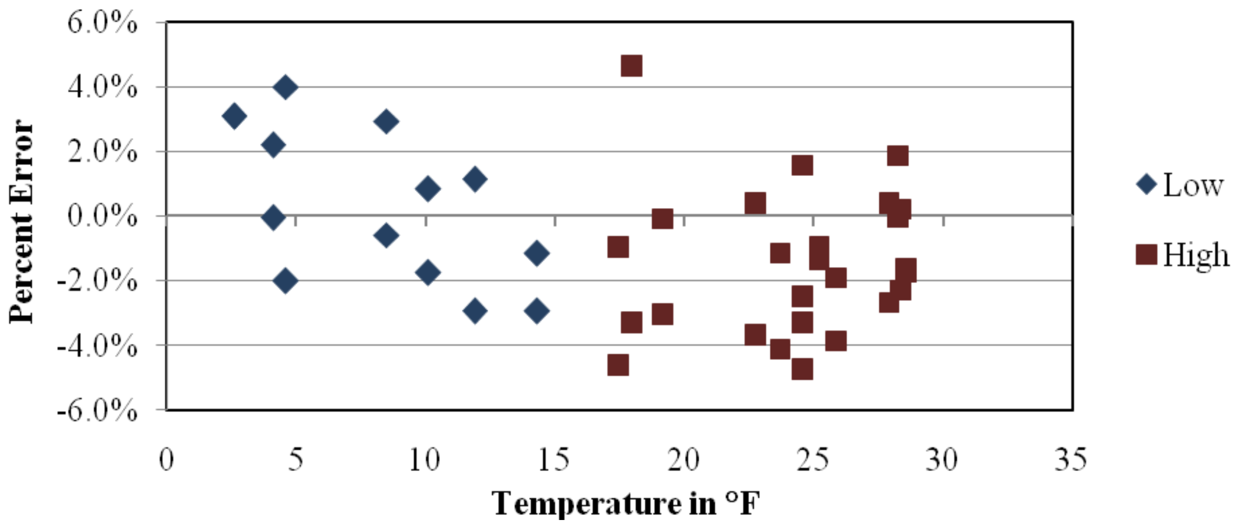


Figure 5-18 – Post-Validation GVW Errors by Temperature – 08-Dec-10

5.3.2.2 Steering Axle Weight Errors by Temperature

Figure 5-19 demonstrates that for steering axle weights, the WIM equipment appears to exhibit the same trend as that observed for GVW, where weight estimates decrease as temperature rises. The range in error is similar for different temperature groups.

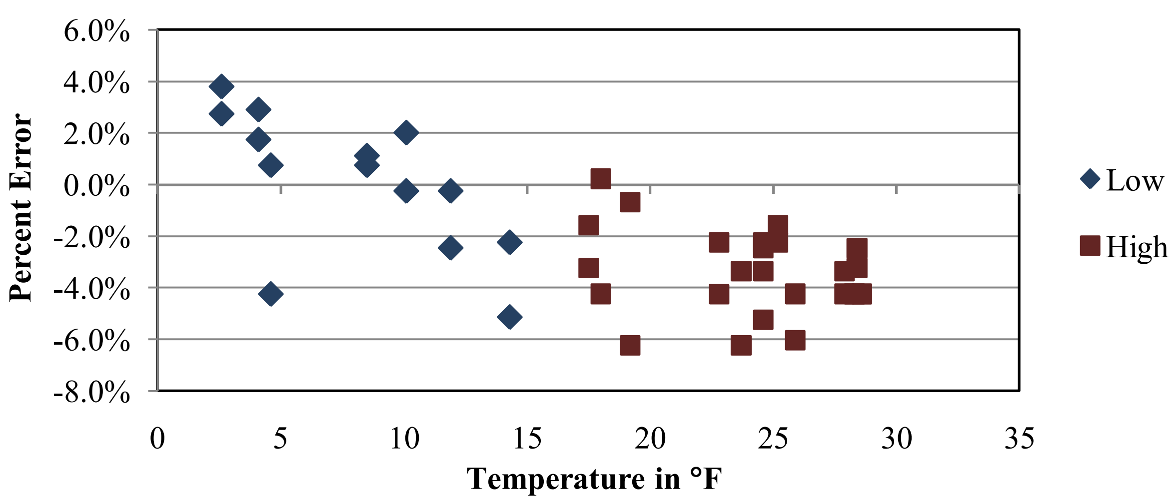


Figure 5-19 – Post-Validation Steering Axle Weight Errors by Temperature – 08-Dec-10

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 tandem axle measurement and temperature, where the weight of tandem axles decreases as temperature increases. The range in tandem axle errors is consistent for the two temperature groups.

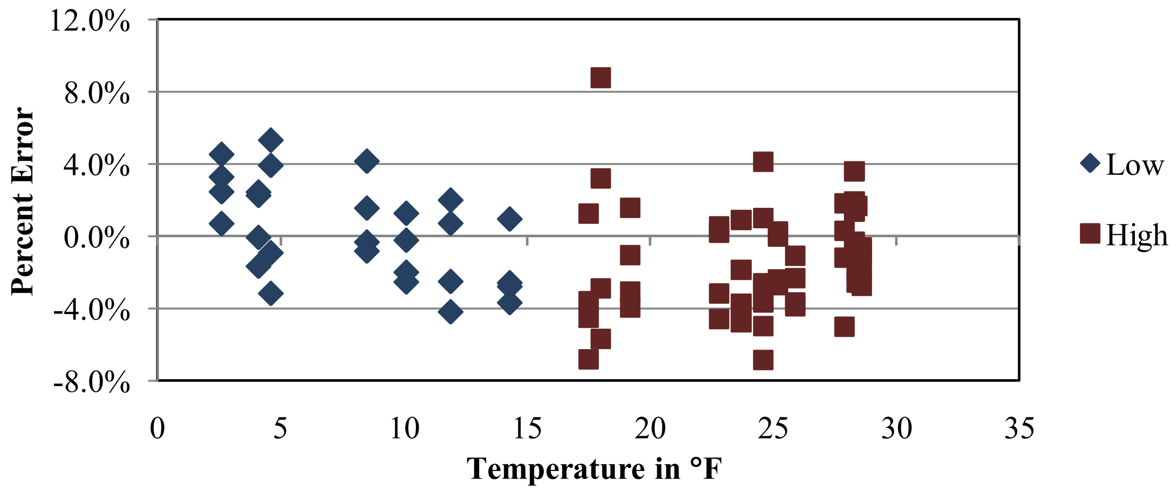


Figure 5-20 – Post-Validation Tandem Axle Weight Errors by Temperature – 08-Dec-10

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 decreases 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 the following figure.

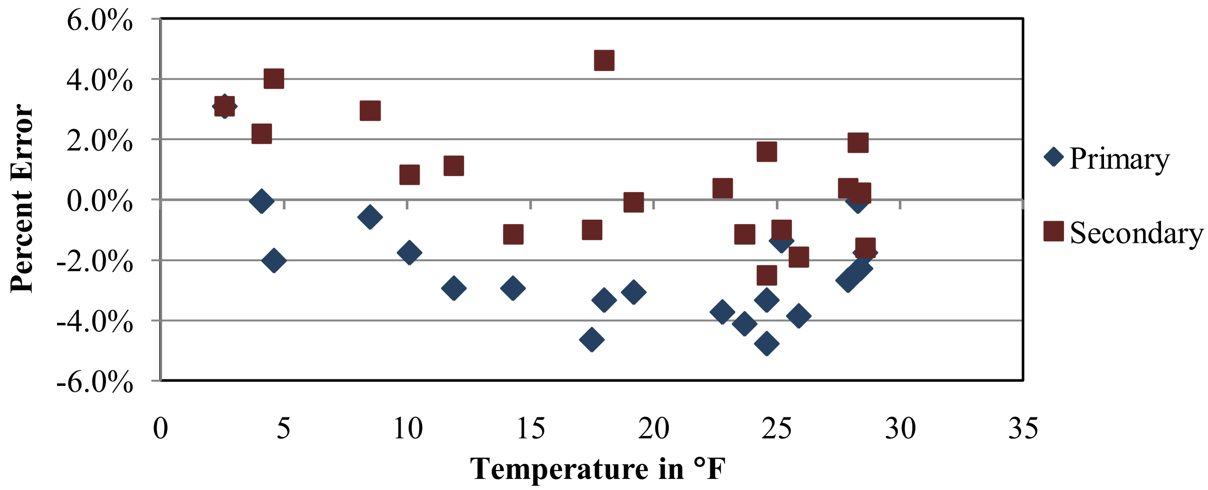


Figure 5-21 – Post-Validation GVW Error by Truck and Temperature – 08-Dec-10

5.3.3 Multivariable Analysis

This section provides additional analysis of post-validation results using a multivariable statistical technique of multiple linear regression. 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 axle on the secondary trailer had a different suspension system compared to all other tandem axles.

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 65 mph.
- Pavement temperature. Pavement temperature ranged from 2.6 to 28.6 degrees Fahrenheit.

- Interaction between the factors such as the interaction between speed and pavement temperature.

5.3.3.2 Results

For analysis of GVW weights, the value of regression coefficients and their statistical properties are summarized in Table 5-15. 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 5-15 table are for the null hypothesis that assumes that the coefficients are equal to zero. The effects of temperature and truck type were found to be statistically significant. The probabilities that the effects of truck type and temperature on the observed GVW errors occurred by chance alone are less than 1 percent.

Table 5-15 – Table of Regression Coefficients for Measurement Error of GVW

Parameter	Regression coefficients	Standard error	Value of t-distribution	Probability value
Intercept	-6.898	5.94648	-1.1600	0.25370
Speed	0.1475	0.10012	1.47356	0.1493
Temp	-0.0951	0.04348	-2.1874	0.03529
Truck	-3.1047	0.75074	-4.1355	0.00023

The relationship between temperature and measurement errors 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 -0.0951 (in Table 5-15). This means, for example, that for a 20-degree increase in temperature, the % error is decreased by about 1.9 % (0.0951 x 20). The statistical assessment of the relationship is provided by the probability value of the regression coefficient.

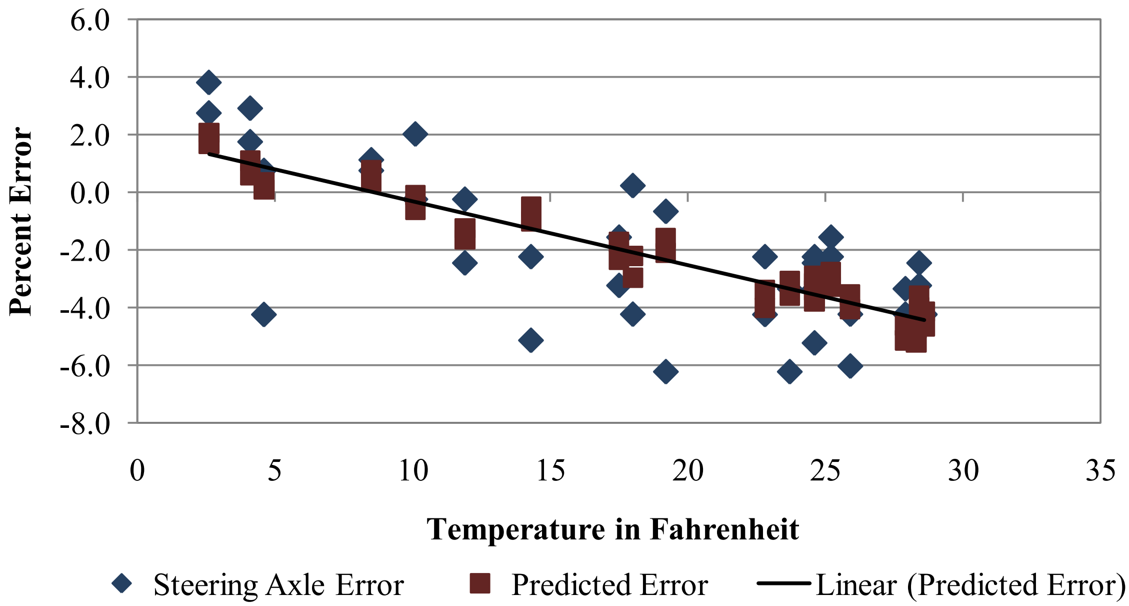


Figure 5-22 – Influence of Temperature on the Measurement Error of Steering Axles

The effect speed on GWV was not statistically significant. The probability that the regression coefficient for speed (0.1475 in Table 5-15) is not different from zero was 0.1493. In other words, there is about 15 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 5-16 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 5-16 indicates that the relationship was not statistically significant (the probability that the relationship can occur by chance alone was greater than 20 percent).

Table 5-16 – Summary of Regression Analysis

Parameter	Factor					
	Speed		**Temperature**		**Truck type**	
	Regression coefficient	Probability value	Regression coefficient	Probability value	Regression coefficient	Probability value
GVW	-	-	-0.1193	0.0004	-2.9662	0.0000
Steering axle	-0.1261	0.1068	-0.2189	0.0000	-	-
Tandem axle tractor	0.1475	0.1493	-0.0951	0.0353	-3.1047	0.0002
Tandem axle trailer	-	-	-0.1133	0.0051	-3.7254	0.0000

5.3.3.4 Conclusions

1. Pavement temperature had statistically significant effect on the weight measurement errors of all weight parameters.

2. Speed had marginally statistically significant effect on the measurement errors of steering axles (P=0.1068).

3. Truck type had statistically significant effect on the measurement errors of GVW and tandem axle weights. The regression coefficient for truck type in Table 5-16, 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 3% lower 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 5-17 illustrates the breakdown of vehicles observed and identified by the WIM equipment for the manual classification study.

Table 5-17 – Post-Validation Classification Study Results – 08-Dec-10

Class	4	5	6	7	8	9	10	11	12	13
Observed Count	0	7	3	0	1	84	0	3	1	1
WIM Count	0	7	3	0	1	84	0	3	1	0
Observed Percentage	0	7	3	0	1	84	0	3	1	1
WIM Percentage	0	7	3	0	1	84	0	3	1	0
Misclassified Count	0	0	0	0	0	0	0	0	0	0
Misclassified Percentage	N/A	0	0	N/A	0	0	N/A	0	0	0
Unclassified Count	0	0	0	0	0	0	0	0	0	1
Unclassified Percentage	N/A	0	0	N/A	0	0	N/A	0	0	N/A

As shown in the table above, 1 Class 13 vehicle was misclassified. The equipment was unable to classify the vehicle due to a non-typical axle spacing arrangement and so it was identified as a Class 15 vehicle by the equipment. Because it was not identified as another type of valid vehicle type, it was not considered a misclassification, but an unclassification by the study.

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 5-18.

Table 5-18 – Post-Validation Misclassifications by Pair – 08-Dec-10

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

Based on the vehicles observed during the post-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 0.0%.

As shown in the table, a total of 0 vehicles, including 0 heavy trucks (6 – 13) were misclassified by the equipment. The majority (12) of the misclassifications were Class 5s identified by the WIM equipment as Class 3. For trucks, four of the eight Class 13 trucks were identified as Class 10s by the controller. A review of the system algorithm indicates that there is not a Class 10 classification for single trailer trucks with more than six axles.

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 5-19.

Table 5-19 – Post-Validation Unclassified Trucks by Pair – 08-Dec-10

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

Based on the manually collected sample of the 100 trucks, 1.0% 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 vehicle was a single Class 13 which could not be identified by the WIM equipment. The cause of the unclassification was a non-typical axle spacing arrangement on a very large, overloaded truck.

For speed, the mean error for WIM equipment speed measurement was 0.4 mph; the range of errors was 0.9 mph.

5.4 Post Visit Applied Calibration

The 85th percentile speed for trucks, based on the CDS data, is 69 mph, 4 mph above the posted speed limit of 65 mph. Consequently, applied calibration will be utilized and recommendations for changes to the 65 and 70 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.

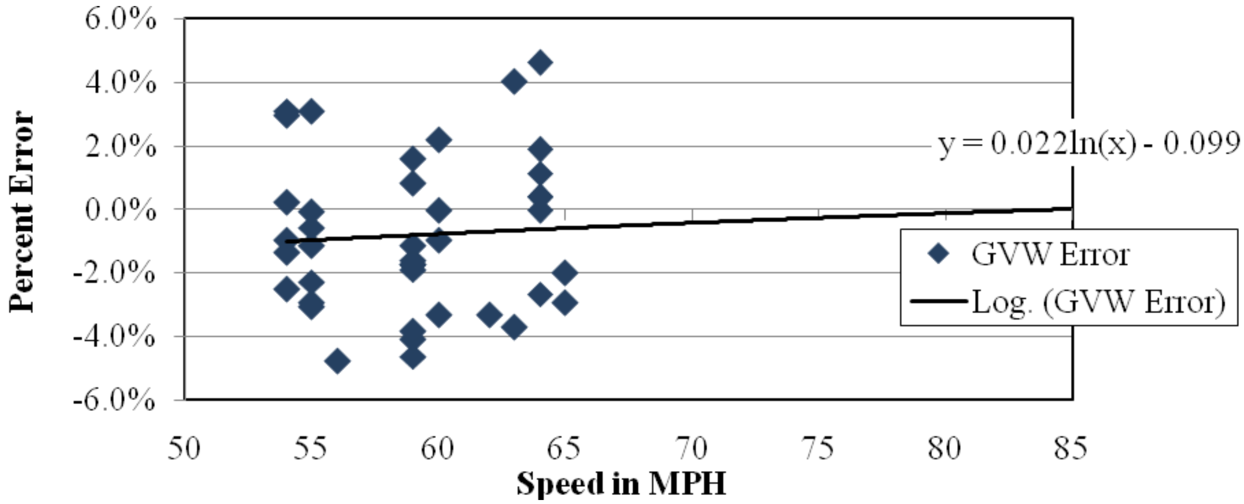


Figure 5-23 – GVW Error Trend

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.

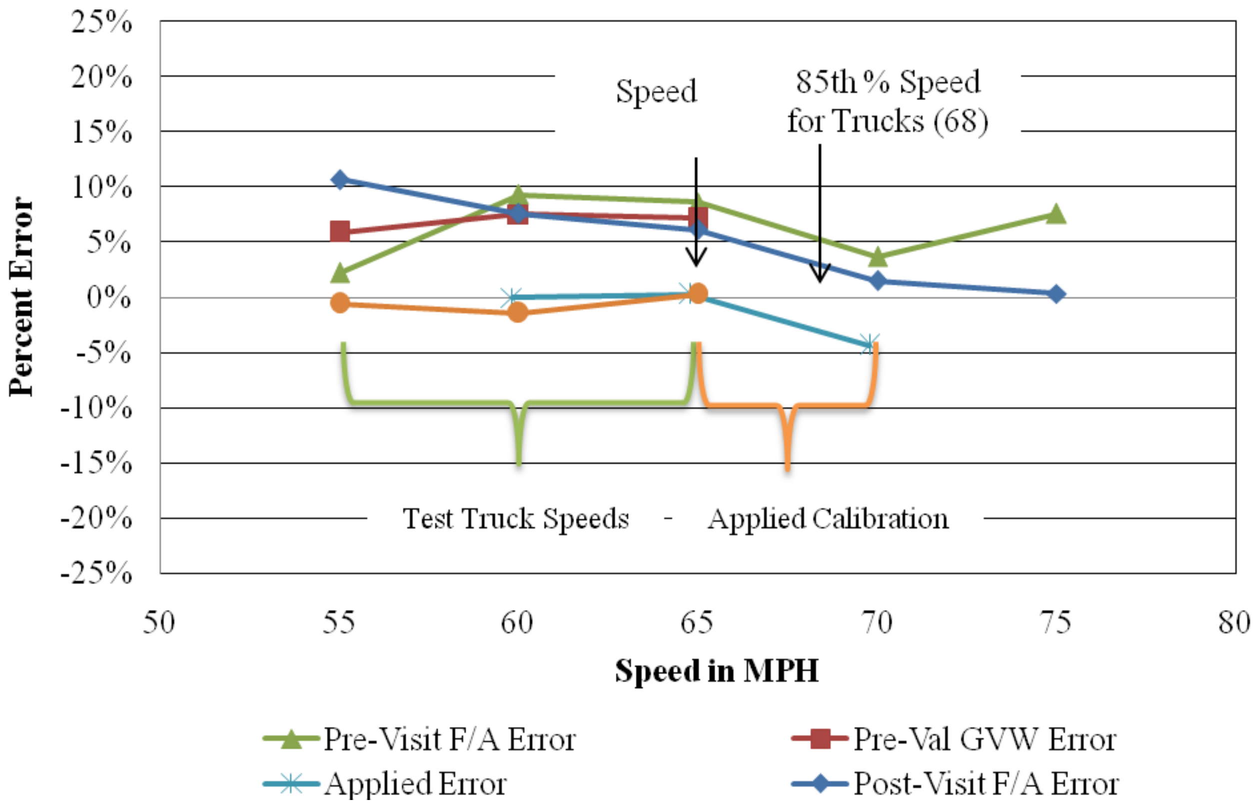


Figure 5-24 – Applied Calibration

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 5-20.

Table 5-20 – Recommended Factor Changes from Applied Error

Speed Point	Speed	Old Factors		Applied Error	New Factors	
		Right	Left		Right	Left
104	65	3172	3567	0.3%	3162	3556
112	70	3004	3377	-4.4%	3142	3532

Considering the parameters left in place at the conclusion of the post-validation on December 08, 2010, along with the post-visit applied calibration recommendations shown above, the final factor recommendations are provided in Table 5-21.

Table 5-21 – Recommended Final Speed Factors

Speed Point	Speed	Old Factors		Applied Error	New Factors	
		Right	Left		Right	Left
80	50	3092	3478	0.0%	3275	3684
88	55	3269	3678	0.0%	3462	3895
96	60	3180	3578	0.0%	3420	3848
104	65	3172	3567	0.3%	3389	3811
112	70	3004	3377	-4.4%	3366	3784

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 four 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	
7-Sep-05	75	67	0	N/A	0	0	0	0	0	N/A	0
8-Sep-05	67	25	25	N/A	0	0	N/A	N/A	N/A	N/A	0
20-Sep-06	67	20	0	N/A	0	0	0	0	0	N/A	0
21-Sep-06	50	44	0	N/A	0	0	0	N/A	0	0	0
28-Mar-07	N/A	0	0	0	0	0	0	0	0	0	0
29-Mar-07	N/A	0	0	N/A	N/A	0	N/A	N/A	N/A	N/A	0
9-Jul-08	N/A	13	N/A	N/A	33	0	0	N/A	N/A	N/A	0
10-Jul-08	100	13	0	N/A	0	1	100	0	0	100	2
7-Dec-10	N/A	0	0	N/A	0	0	100	0	0	0	0
8-Dec-10	N/A	0	0	N/A	0	0	N/A	0	0	0	1

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
7-Sep-05	1.6 (2.6)	-3.5 (5.2)	2.6 (3.6)
8-Sep-05	1.5 (2.9)	-3.0 (6.5)	2.4 (3.5)
20-Sep-06	-0.4 (2.5)	-3.4 (4.4)	0.1 (3.7)
21-Sep-06	-0.7 (2.5)	-4.8 (5.1)	0.0 (3.5)
28-Mar-07	1.6 (2.8)	-6.6 (6.3)	-0.3 (3.9)
29-Mar-07	0.2 (2.4)	-3.1 (5.6)	1.0 (3.6)
9-Jul-08	-0.8 (2.0)	-2.7 (1.8)	-0.5 (2.8)
10-Jul-08	-0.5 (1.6)	-2.0 (2.5)	0.9 (2.2)
7-Dec-10	6.2 (5.3)	1.8 (5.4)	7.2 (6.2)
8-Dec-10	-0.8 (4.9)	-2.2 (5.4)	-0.8 (5.9)

The variability (standard deviation) of the weight errors appears to have increased since the visit in July, 2008. The table also demonstrates the effectiveness of the validations in maintaining the weight estimations within LTPP SPS WIM equipment tolerances.

6.2 Comparison of Past Validation Results

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

Table 6-3 – Comparison of Post-Validation Results

Parameter	95 %Confidence Limit of Error	Site Values (Mean and Standard Deviation)				
		8-Sep-05	20-Sep-06	29-Mar-07	10-Jul-08	8-Dec-10
Single Axles	±20 percent	-3.0 ± 6.5	-3.4 ± 4.4	-3.1 ± 5.6	-2.0 ± 2.5	-2.2 ± 5.4
Tandem Axles	±15 percent	2.4 ± 3.5	0.1 ± 3.7	1.0 ± 3.6	0.9 ± 2.2	-0.8 ± 5.9
GVW	±10 percent	1.5 ± 2.9	-0.4 ± 2.5	0.2 ± 2.4	-0.5 ± 1.6	-0.8 ± 4.9

Based on Table 6-3, it appears that the standard deviation of the measurement error has been relatively stable for all weight parameters since the equipment was installed to July 2008. The December 2010 validation indicates that the standard deviation of the measurement error increased for all parameters.

Validation results indicated that the GVW measurement errors marginally exceeded the 95% confidence limit of error by 1.5% (± 10% limit versus the observed range of +0.9% to +11.5%). However, the confidence limits of error for the individual axle groups were not exceeded. Also, following the calibration, the system now provides research quality load data.

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 24A/B – Site Photograph Logs
- Updated Handout Guide

WIM System Field Calibration and Validation - Photos

Illinois, SPS-6
SHRP ID: 170600

Validation Date: December 8, 2010


Photo 1 – Cabinet Exterior

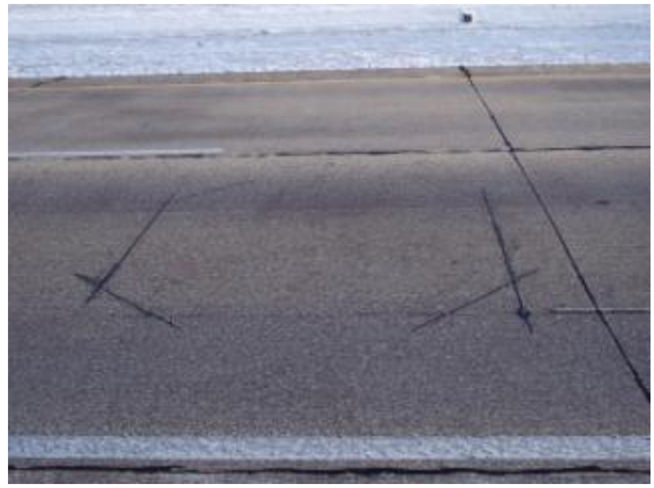


Photo 4 – Leading Loop


Photo 2 – Cabinet Interior (Front)


Photo 5 – Leading WIM Sensor

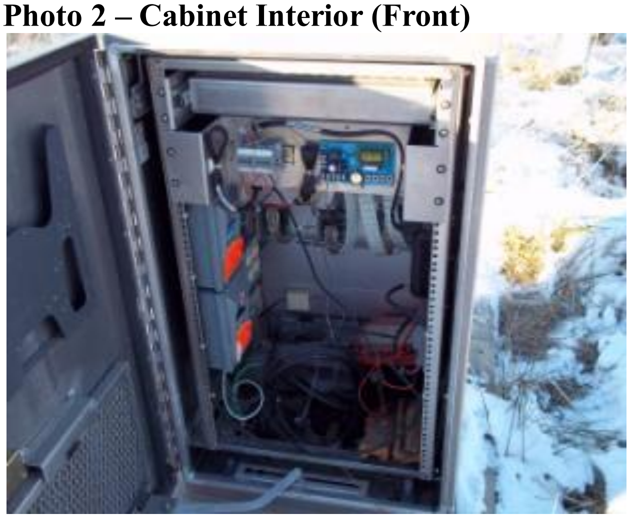


Photo 3 – Cabinet Interior (Back)


Photo 6 – Trailing WIM Sensor

Photo 7 – Trailing Loop Sensor

Photo 8 – Power Meter

Photo 9 – Telephone Pedestal

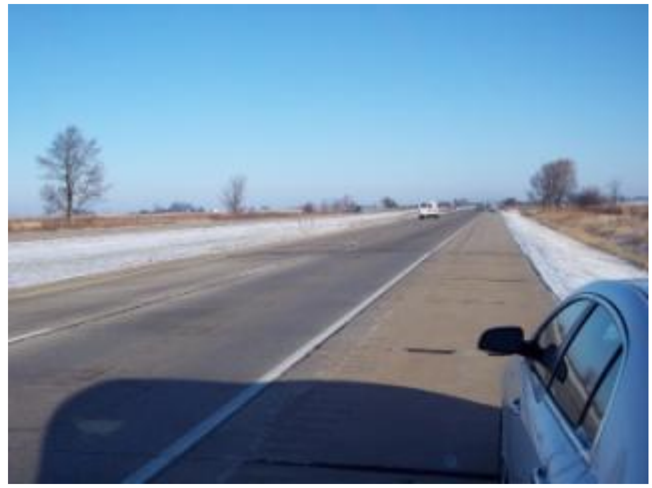


Photo 10 – Downstream

Photo 11 – Upstream

Photo 12 – Transition

Photo 13 – Faulting

Photo 14 – Transverse Crack

Photo 15 – Truck 2 Tractor

Photo 16 – Truck 2 Trailer and Load

Photo 17 – Truck 2 Suspension 1

Photo 18 – Truck 2 Suspension 2


Photo 19 – Truck 2 Suspension 3


Photo 20 – Truck 2 Suspension 4


Photo 21 – Truck 2 Suspension 5


Photo 22 – Truck 1 Tractor


Photo 23 – Truck 1 Trailer and Load


Photo 24 – Truck 1 Suspension 1


Photo 25 – Truck 1 Suspension 2


Photo 26 – Truck 1 Suspension 3


Photo 27 – Truck 1 Suspension 4


Photo 28 – Truck 1 Suspension 5

Traffic Sheet 16	STATE CODE:	17
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	170600
SITE CALIBRATION SUMMARY	DATE (mm/dd/yyyy)	12/7/2010

SITE CALIBRATION INFORMATION

1. **DATE OF CALIBRATION** {mm/dd/yy} 12/7/10

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. Inductance Loops
   b. Bending Plates
   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: 21

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

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

Mean Difference Between -

Dynamic and Static GVW:	6.2%	Standard Deviation:	2.6%
Dynamic and Static Single Axle:	1.8%	Standard Deviation:	2.7%
Dynamic and Static Double Axles:	7.2%	Standard Deviation:	3.1%

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

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

			Low		High	Runs
a.	Low	-	52.0	to	56.3	13
b.	Medium	-	56.4	to	60.8	13
c.	High	-	60.9	to	65.0	15
d.		-		to		
e.		-		to		

Traffic Sheet 16		
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	170600
SITE CALIBRATION SUMMARY	DATE (mm/dd/yyyy)	12/7/2010
	STATE CODE:	17

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3004 | 3377

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:	0.0	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: 717-975-3550

E-mail: dwolf@ara.com

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 17 SPS WIM ID: 170600 DATE (mm/dd/yyyy) 12/8/2010

SITE CALIBRATION INFORMATION

1. DATE OF CALIBRATION {mm/dd/yy} 12/8/10

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. Inductance Loops c. ______
b. Bending Plates 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	steel spring
Truck 3:	0	0	0

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

Mean Difference Between -

Dynamic and Static GVW:	-0.8%	Standard Deviation:	2.4%
Dynamic and Static Single Axle:	-2.2%	Standard Deviation:	2.7%
Dynamic and Static Double Axles:	-0.8%	Standard Deviation:	2.9%

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

9. DEFINE SPEED RANGES IN MPH:

			Low		High	Runs
a.	Low	-	54.0	to	57.7	14
b.	Medium	-	57.8	to	61.4	14
c.	High	-	61.5	to	65.0	12
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 17 SPS WIM ID: 170600 DATE (mm/dd/yyyy) 12/8/2010

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 2995 | 3368

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:	0.0	FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 1.0%

Validation Test Truck Run Set - Post

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

Contact Information: Phone: 717-975-3550

E-mail: dwolf@ara.com

Traffic Sheet 20	STATE CODE:	17
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	170600
SPEED AND CLASSIFICATION STUDIES	DATE (mm/dd/yyyy)	12/7/2010

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
64	9	41772	62	9	61	9	41821	61	9
67	9	41773	67	9	60	9	41822	60	9
67	9	41774	67	9	65	9	41824	65	9
63	11	41776	63	11	65	12	41827	64	12
55	9	41785	57	9	62	9	41828	62	9
63	9	41789	63	9	67	9	41835	65	9
64	9	41790	64	9	72	9	41838	69	9
48	9	41792	48	9	64	9	41841	63	9
65	9	41794	63	9	60	9	41842	61	9
66	9	41795	66	9	51	6	41843	51	6
66	5	41798	65	5	61	11	41845	61	11
60	9	41799	60	9	61	9	41854	61	9
63	9	41801	62	9	64	9	41857	64	9
61	9	41802	62	9	64	9	41858	63	9
60	9	41803	61	9	64	9	41861	64	9
62	9	41805	60	9	52	9	41862	53	9
67	9	41807	67	9	55	9	41864	55	9
59	9	41808	59	9	57	9	41871	57	9
60	9	41809	60	9	63	9	41874	62	9
62	9	41810	65	9	69	5	41875	70	5
54	9	41811	53	9	62	9	41881	62	9
64	9	41812	62	9	65	9	41883	64	9
62	9	41816	62	9	61	5	41884	62	5
64	9	41817	67	9	65	5	41889	67	5
60	9	41820	61	9	62	9	48980	61	9

Sheet 1 - 0 to 50 Start: 8:52:00 Stop: 9:50:14

Recorded By: djw Verified By: kt

Validation Test Truck Run Set - Pre

Traffic Sheet 20	STATE CODE:	17
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	170600
SPEED AND CLASSIFICATION STUDIES	DATE (mm/dd/yyyy)	12/7/2010

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
63	9	41892	62	9	65	9	42041	64	9
57	8	41900	57	8	66	9	42044	67	9
64	5	41902	64	5	64	9	42045	64	9
65	9	41906	65	9	64	9	42051	64	9
50	5	41912	52	5	68	9	42057	68	9
65	9	41915	65	9	67	9	42059	67	9
65	5	41920	66	5	64	9	42061	63	9
68	9	41924	68	9	59	9	42062	59	9
64	5	41928	64	5	65	9	42063	64	9
65	9	41932	65	9	69	9	42065	69	9
68	9	41939	67	9	65	9	42072	65	9
63	9	41942	62	9	64	5	42084	64	5
61	9	41945	61	9	70	5	42086	69	5
61	**9**	**41946**	**62**	**10**	67	9	42092	66	9
60	9	41947	60	9	68	9	42093	67	9
65	9	41955	65	9	61	9	42094	61	9
61	9	41958	60	9	70	9	42105	70	9
56	13	41960	57	13	66	9	42116	66	9
55	13	41963	56	13	67	5	42121	67	5
64	9	41965	64	9	62	9	42124	63	9
59	9	42007	60	9	59	5	42125	60	5
58	9	42008	58	9	64	9	42126	65	9
64	9	41018	64	9	63	9	42127	63	9
65	9	42030	65	9	65	9	42130	65	9
62	9	42031	62	9	67	9	42133	67	9

Sheet 2 - 51 to 100 Start: 9:50:30 Stop: 12:03:40

Recorded By: djw Verified By: kt

Validation Test Truck Run Set - Pre

Traffic Sheet 20	STATE CODE: 17
LTPP MONITORED TRAFFIC DATA	SPS WIM ID: 170600
SPEED AND CLASSIFICATION STUDIES	DATE (mm/dd/yyyy) 12/8/2010

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
61	9	46957	61	9	67	9	47012	67	9
65	9	46958	65	9	72	9	47014	71	9
67	9	46959	67	9	68	6	47017	67	6
64	9	46963	64	9	65	9	47020	64	9
65	9	46967	65	9	65	11	47023	65	11
59	9	46969	58	9	65	9	47025	65	9
61	9	46977	61	9	58	9	47028	59	9
67	5	46979	66	5	65	9	47029	64	9
67	9	46981	66	9	63	9	47031	65	9
65	9	46982	65	9	65	9	47032	65	9
67	9	46983	65	9	**66**	**15**	**47038**	**66**	**13**
62	9	46984	61	9	70	5	47041	70	5
65	9	46985	64	9	61	9	47042	60	9
66	9	46986	65	9	59	9	47048	59	9
65	5	46987	64	5	67	9	47049	65	9
61	9	46988	60	9	66	9	47057	65	9
63	9	46994	63	9	60	9	47058	59	9
67	9	46997	66	9	65	9	47060	64	9
68	9	46998	67	9	66	9	47062	65	9
66	9	47000	66	9	62	9	47063	62	9
61	9	47002	59	9	64	6	47065	63	6
65	11	47003	64	11	62	9	47070	61	9
63	9	47004	65	9	60	9	47071	60	9
64	9	47005	65	9	62	11	47075	62	11
66	9	47010	64	9	60	9	47076	62	9

Sheet 1 - 0 to 50 Start: 12:52:21 Stop: 13:39:52

Recorded By: djw Verified By: kt

Validation Test Truck Run Set - Post

Traffic Sheet 20	STATE CODE:	17
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	170600
SPEED AND CLASSIFICATION STUDIES	DATE (mm/dd/yyyy)	12/8/2010

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
64	9	47081	64	9	67	9	47165	67	9
64	9	47083	65	9	66	9	47170	69	9
67	9	47091	67	9	65	9	47171	65	9
62	9	47092	61	9	66	9	47172	67	9
64	9	47094	63	9	62	5	47176	62	5
64	9	47095	65	9	65	9	47185	65	9
65	5	47104	67	5	65	9	47192	65	9
68	9	47108	68	9	65	9	47194	65	9
64	9	47112	64	9	62	9	47196	62	9
66	9	47113	65	9	62	9	47197	61	9
65	9	47114	65	9	64	9	47200	64	9
64	9	47115	64	9	59	9	47201	59	9
62	9	47117	61	9	60	9	47202	59	9
63	6	47119	62	6	65	9	47203	66	9
61	9	47143	60	9	73	9	47240	72	9
68	9	47145	67	9	62	9	47241	62	9
64	9	47148	65	9	68	9	47243	67	9
59	9	47149	58	9	62	9	47244	62	9
65	9	47150	64	9	59	9	47245	58	9
62	12	47151	61	12	60	9	47246	60	9
70	5	47154	69	5	66	9	47248	65	9
70	9	47155	68	9	65	9	47249	66	9
64	9	47157	63	9	64	9	47251	63	9
66	5	47158	65	5	64	9	47252	63	9
65	8	47159	64	8	65	9	47253	64	9

Sheet 2 - 51 to 100 Start: 13:40:00 Stop: 14:40:45

Recorded By: djw Verified By: kt

Validation Test Truck Run Set - Post