WIM System Field Calibration and Validation Summary Report

Pennsylvania SPS-6
SHRP ID – 420600

Validation Date: November 24, 2010

Submitted: December 9, 2010

Table of Contents

List of Figures

List of Tables

1 Executive Summary

A WIM validation was performed on November 23 and 24, 2010 at the Pennsylvania SPS-6 site located on route I-80 at milepost 158.2, .54 miles east of exit 158.

This site was installed on May 02, 2007. The in-road sensors are installed in the westbound lane. The site is equipped with quartz WIM sensors and IRD iSINC WIM controller. The LTPP lane is identified as lane 4 in the WIM controller. From a comparison between the report of the most recent validation of this equipment on November 05, 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, no distresses that would affect the performance of the WIM scales were noted. 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.

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 – 24-Nov-10

Parameter	**95% Confidence Limit of Error**	**Site Values**	**Pass/Fail**
Steering Axles	±20 percent	2.2 ± 9.4%	Pass
Tandem Axles	±15 percent	0.5 ± 7.8%	Pass
GVW	±10 percent	0.8 ± 6.1%	Pass
Vehicle Length	±3 percent (1.8 ft)	3.5 ± 1.6 ft	FAIL
Axle Length	± 0.5 ft [150mm]	0.1 ± 0.4 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 0.2 ± 1.8 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 not providing research quality vehicle classification data for heavy trucks (Class 6 – 13). The heavy truck misclassification rate of 3.2% is greater than the 2.0% acceptability criterion for LTPP SPS WIM sites. The overall misclassification rate of 3.0% from the 100 truck sample (Class 4 – 13) was due to the 3 mis-classifications of Class 10 vehicles.

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 crane counter weights loaded on the trailer.

- 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 crane counter weights loaded on 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	75.9	11.0	16.5	16.5	16.0	16.0	11.8	4.3	34.6	4.1	54.8	61.2
2	66.5	9.0	16.6	16.6	12.2	12.2	11.6	4.3	31.9	4.1	51.9	59.5

The posted speed limit at the site is 65 mph. During the testing, the speed of the test trucks ranged from to 54 to 66 mph, a variance of 12 mph.

During test truck runs, pavement temperature was collected using a hand-held infrared temperature device. The post-validation pavement surface temperatures varied from 34.1 to 61.1 degrees Fahrenheit, a range of 27.0 degrees Fahrenheit. The cloudy weather conditions prevented the desired 30 degree range in temperatures.

A review of the LTPP Standard Release Database 24 shows that there are 26 consecutive 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 October 25, 2010 (Data) to the most recent Comparison Data Set (CDS) from November 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 26 consecutive months of level "E" WIM data for this site. This site requires 3 additional years 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 2007 and 2009 calendar years, however, the continuous data for the last 7 months of 2007 and the first 7 months of 2009 provide more than 210 days data for each of the two 12-month periods, and therefore provide for two periods in which 210 days of WIM data has been collected. Table 2-1 provides a breakdown of the available data for years 2007 through 2009.

Table 2-1 – LTPP Data Availability

Year	Total Number of Days in Year	Number of Months
2007	203	7
2008	351	12
2009	191	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. As shown in the figure, the plots for the two data sets are nearly identical.

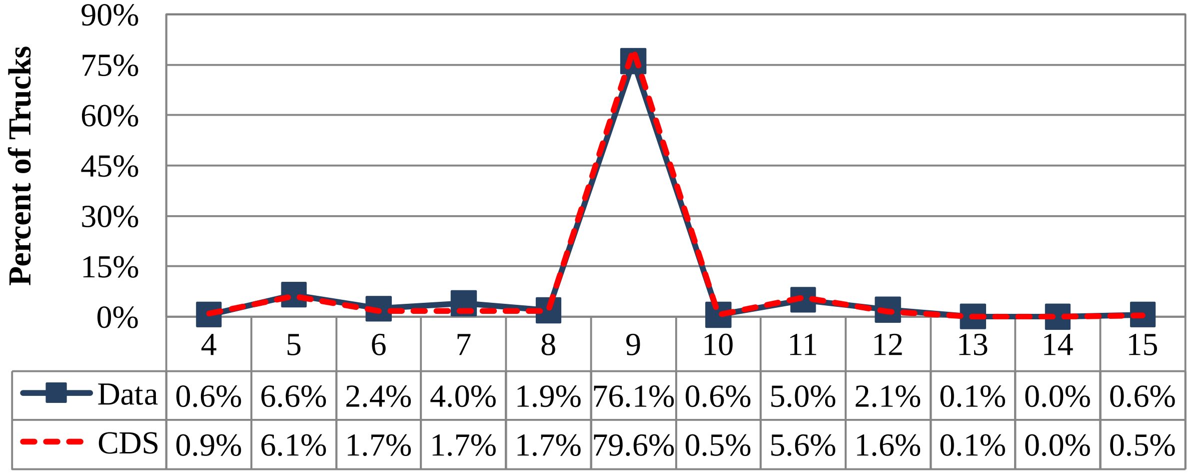


Figure 2-1 – Comparison of Truck Distribution

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 (76.1%) and Class 5 (6.6%). It also indicates that 0.6 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				
	11/10/2008		10/25/2010		
4	312	0.9%	420	0.6%	-0.3%
5	2146	6.1%	4380	6.6%	0.5%
6	607	1.7%	1605	2.4%	0.7%
7	618	1.7%	2669	4.0%	2.3%
8	600	1.7%	1243	1.9%	0.2%
9	28221	79.6%	50771	76.1%	-3.5%
10	189	0.5%	367	0.6%	0.0%
11	1999	5.6%	3357	5.0%	-0.6%
12	570	1.6%	1404	2.1%	0.5%
13	24	0.1%	54	0.1%	0.0%
14	0	0.0%	0	0.0%	0.0%
15	167	0.5%	422	0.6%	0.2%

From the table it can be seen that the number of Class 9 vehicles has decreased by 3.5 percent from November 2008 and October 2010. Small increases 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 0.5 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.

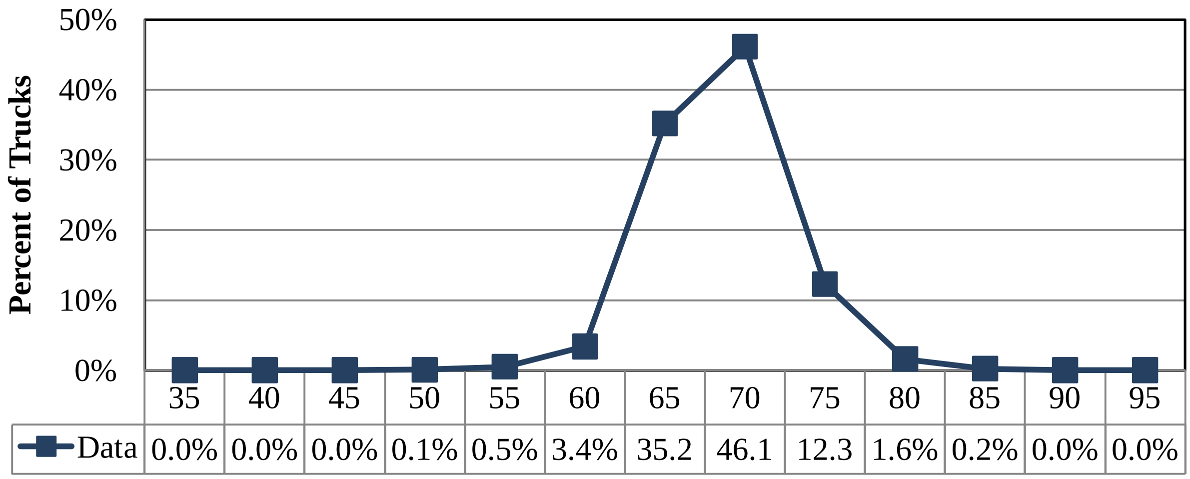


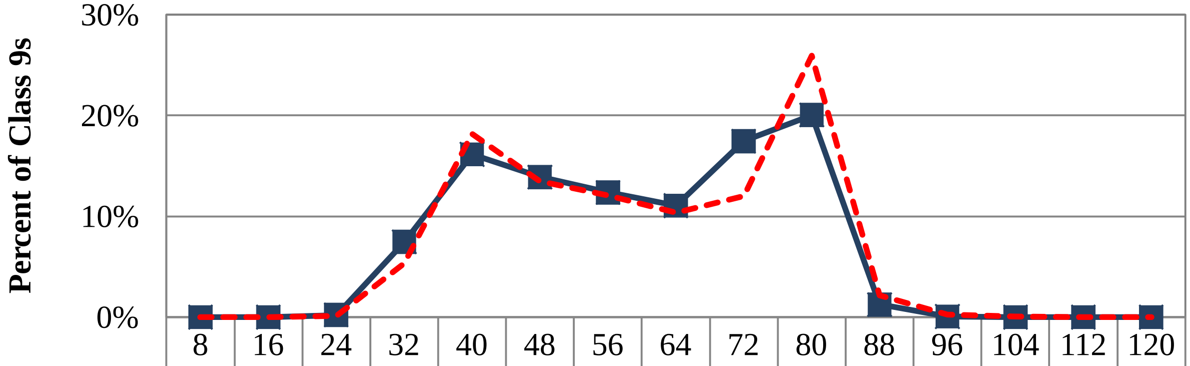
Figure 2-2 – Truck Speed Distribution – 05-Nov-10

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 70 mph. The coverage of truck speeds for the validation will be from 55 to 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 65 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 October 2010 and the Comparison Data Set from November 2008.

As shown in Figure 2-3, there is no change in the number of unloaded trucks between the November 2008 Comparison Data Set (CDS) and the October 2010 two-week sample W-card dataset (Data), and a change in the GVW distribution of loaded trucks. The results indicate that, in addition to actual changes in GVW, there may have been a change in the pavement condition or sensor deterioration.



	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
Data	0.0%	0.0%	0.2%	7.5%	16.2	13.9	12.4	11.1	17.5	20.1	1.2%	0.1%	0.0%	0.0%	0.0%
CDS	0.0%	0.0%	0.1%	5.3%	18.2	13.5	12.1	10.4	12.0	25.9	2.2%	0.3%	0.1%	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

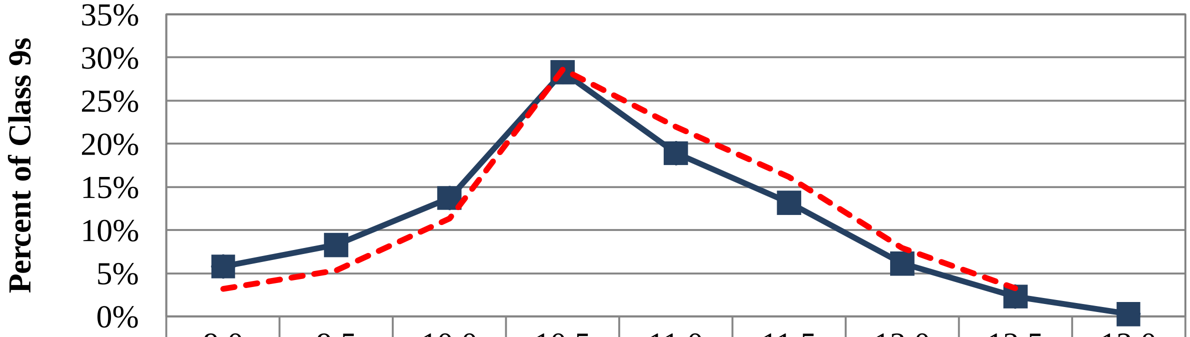
GVW weight bins (kips)	CDS		Data		Change
	Date				
	11/10/2008		10/25/2010		
8	0	0.0%	0	0.0%	0.0%
16	0	0.0%	0	0.0%	0.0%
24	39	0.1%	112	0.2%	0.1%
32	1496	5.3%	3779	7.5%	2.1%
40	5124	18.2%	8190	16.2%	-2.0%
48	3789	13.5%	7044	13.9%	0.4%
56	3401	12.1%	6267	12.4%	0.3%
64	2922	10.4%	5604	11.1%	0.7%
72	3379	12.0%	8849	17.5%	5.5%
80	7302	25.9%	10162	20.1%	-5.9%
88	615	2.2%	628	1.2%	-0.9%
96	72	0.3%	32	0.1%	-0.2%
104	22	0.1%	7	0.0%	-0.1%
112	3	0.0%	0	0.0%	0.0%
120	2	0.0%	0	0.0%	0.0%
Average =	56.4		55.3		-1.1

As shown in the table, the number of unloaded class 9 trucks in the 32 to 40 kips range decreased by 2.0 percent and the number of loaded class 9 trucks in the 72 to 80 kips range decreased by 5.9 percent. The number of overweight trucks decreased during this time period by 1.2 percent and the overall GVW average for this site decreased from 56.4 kips to 55.3 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 October 2010 and the Comparison Data Set from November 2008.



	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0
Data	5.8%	8.3%	13.7%	28.3%	18.9%	13.2%	6.1%	2.3%	0.3%
CDS	3.2%	5.4%	11.3%	28.7%	22.0%	16.2%	8.0%	3.3%	

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

It can be seen in the figure that although the greatest percentage of trucks has remained at 10.5 kips between the November 2008 Comparison Data Set (CDS) and the October 2010 dataset (Data), the number of trucks with front axle weights greater than 10.5 kips has decreased and the number of trucks with front axle weights less than 10.5 kips has increased during this time.

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

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

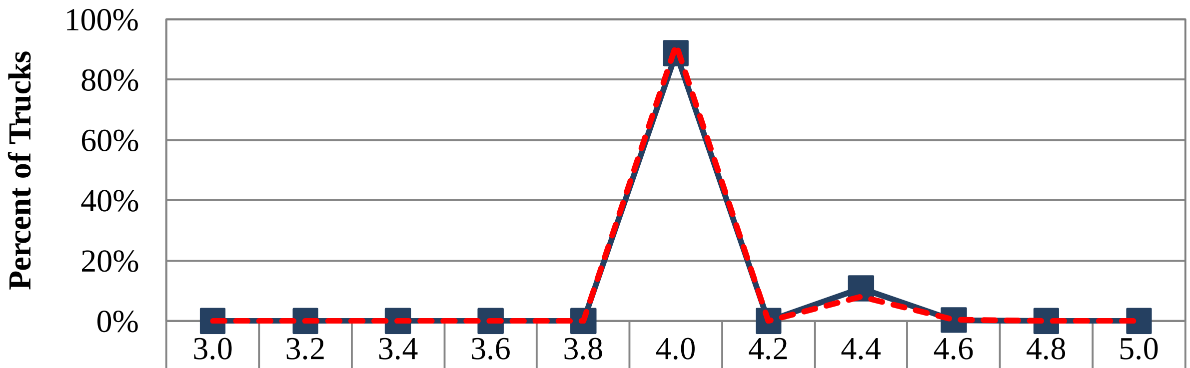
F/A weight bins (kips)	CDS		Data		Change
	Date				
	11/10/2008		10/25/2010		
9.0	460	1.6%	1582	3.1%	1.5%
9.5	895	3.2%	2928	5.8%	2.6%
10.0	1509	5.4%	4191	8.3%	2.9%
10.5	3187	11.3%	6935	13.7%	2.4%
11.0	8048	28.7%	14318	28.3%	-0.4%
11.5	6166	22.0%	9575	18.9%	-3.0%
12.0	4548	16.2%	6665	13.2%	-3.0%
12.5	2236	8.0%	3102	6.1%	-1.8%
13.0	922	3.3%	1154	2.3%	-1.0%
13.5	112	0.4%	133	0.3%	-0.1%
Average =	11.1		10.8		-0.2

The table shows that the average front axle weight for Class 9 trucks has decreased by 0.2 kips, or -2.0 percent. According to the current 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 10.8 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%	0.0%	88.8%	0.0%	10.8%	0.3%	0.0%	0.0%
CDS	0.0%	0.0%	0.0%	0.0%	0.0%	91.5%	0.0%	8.1%	0.4%	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 November 2008 Comparison Data Set and the October 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				
	11/10/2008		10/25/2010		
3.0	0	0.0%	0	0.0%	0.0%
3.2	1	0.0%	0	0.0%	0.0%
3.4	1	0.0%	0	0.0%	0.0%
3.6	0	0.0%	0	0.0%	0.0%
3.8	9	0.0%	19	0.0%	0.0%
4.0	25775	91.5%	45011	88.8%	-2.7%
4.2	0	0.0%	0	0.0%	0.0%
4.4	2272	8.1%	5484	10.8%	2.8%
4.6	105	0.4%	137	0.3%	-0.1%
4.8	0	0.0%	0	0.0%	0.0%
5.0	5	0.0%	23	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 4.2 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 (November 2008) based on the last calibration with the most recent two-week WIM data sample from the site (October 2010). Comparison of vehicle class distribution data indicates a 3.5 percent decrease in the number of Class 9 vehicles. Analysis of Class 9 weight data indicates that front axle weights have decreased by 0.2 percent and average Class 9 GVW has decreased by 2.0 percent for the October 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 November 05, 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 May 02, 2007 by International Road Dynamics. It is instrumented with quartz 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. The cellular modem and associated connectors are beginning to corrode as shown in Photo 3-1.

Photo 3-1 – Corrosion of Connectors to Cellular Modem

No other 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

The corrosion on the cellular modem connections should be removed. No other 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. The pavement condition upstream and downstream from the site is shown in Photos 4-1 and 4-2, respectively.

Photo 4-1 - Upstream

Photo 4-2 - Downstream

4.2 Profile and Vehicle Interaction

Profile data was collected on November 01, 2010 by the North Atlantic 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 is 140 in/mi and is located approximately 568 feet prior to the WIM scale. The highest IRI value within the 400 foot approach section was none in/mi and is located approximately 0 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. There were no distresses observed that would 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)	*0.391*	*0.362*	*0.357*			*0.370*
		SRI (m/km)	*0.226*	*0.270*	*0.275*			*0.257*
		Peak LRI (m/km)	0.538	0.514	0.559			0.537
		Peak SRI (m/km)	*0.359*	*0.406*	*0.302*			*0.356*
	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)	0.516	0.516	0.543	*0.382*	0.500	*0.489*
		SRI (m/km)	0.543	0.538	*0.433*	*0.265*	*0.487*	*0.445*
		Peak LRI (m/km)	0.553	0.549	0.613	0.507	0.534	0.556
		Peak SRI (m/km)	*0.675*	*0.622*	*0.620*	*0.403*	*0.613*	*0.580*
	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)	0.525	*0.433*	*0.452*			*0.470*
		SRI (m/km)	*0.470*	*0.313*	*0.336*			*0.373*
		Peak LRI (m/km)	0.601	*0.466*	*0.498*			0.522
		Peak SRI (m/km)	*0.597*	*0.370*	*0.554*			*0.507*
	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.

The zero values are due to a reconfiguration of the profiler profiling sensors. It was reported by the RSC that since the right sensor malfunctioned, the center sensor was relocated to the right position. This configuration change cannot be accounted for by the WIM Smoothness Index software, and consequently resulted in the zero values for the right wheel path for each run.

4.4 Recommended Pavement Remediation

No pavement remediation is recommended.

5 Statistical Reliability of the WIM Equipment

5.1 Pre-Validation

The 44 pre-validation test truck runs were conducted from 9:10 AM to 1:10 PM on November 23, 2010 and 7:31 AM to 9:02 AM on November 24, 2010.

The two test trucks consisted of:

- A Class 9 truck, loaded with crane counter weights on 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 crane counter weights on the trailer, 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 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 Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	75.9	11.0	16.5	16.5	16.0	16.0	11.8	4.3	34.6	4.1	54.8	61.2
2	66.5	9.0	16.6	16.6	12.2	12.2	11.6	4.3	31.9	4.1	51.9	59.5

Test truck speeds varied by 12 mph, from 54 to 66 mph. The measured pre-validation pavement temperatures varied 27.0 degrees Fahrenheit, from 34.1 to 61.1. The cloudy weather conditions prevented for reaching the desired 30 degree temperature range. Table 5-2 is a summary of post validation results.

Table 5-2 – Pre-Validation Overall Results – 24-Nov-10

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	2.2 ± 9.4%	Pass
Tandem Axles	±15 percent	0.5 ± 7.8%	Pass
GVW	±10 percent	0.8 ± 6.1%	Pass
Vehicle Length	±3 percent (1.8 ft)	3.5 ± 1.6 ft	FAIL
Axle Length	± 0.5 ft [150mm]	0.1 ± 0.4 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 0.2 ± 1.8 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.

5.1.1 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 5-3 below.

Table 5-3 – Pre-Validation Results by Speed – 24-Nov-10

Parameter	95% Confidence Limit of Error	Low	Medium	High
		54.0 to 58.0 mph	58.1 to 62.1 mph	62.2 to 66.0 mph
Steering Axles	±20 percent	3.9 ± 12.5%	2.4 ± 6.8%	-0.1 ± 8.9%
Tandem Axles	±15 percent	-0.3 ± 9.1%	0.9 ± 8.3%	0.9 ± 7.6%
GVW	±10 percent	0.4 ± 8.2%	1.1 ± 5.9%	0.9 ± 5.2%
Vehicle Length	±3 percent (1.8 ft)	3.4 ± 1.5 ft	3.5 ± 1.7 ft	3.4 ± 2.1 ft
Vehicle Speed	± 1.0 mph	0.2 ± 0.9 mph	0.1 ± 2.3 mph	0.3 ± 2.2 mph
Axle Length	± 0.5 ft [150mm]	0.1 ± 0.5 ft	0.1 ± 0.3 ft	0.2 ± 0.2 ft

From the table, it can be seen that the WIM equipment estimates all weights with reasonable accuracy at all speeds. The range in weight estimate errors appears to be greater at the lower speeds when compared with the medium and high 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.

5.1.1.1 GVW Errors by Speed

As shown in Figure 5-1, the equipment estimated GVW with reasonable accuracy at all speeds. The range in error appears to decrease as speed increases. Distribution of errors is shown graphically in the figure.

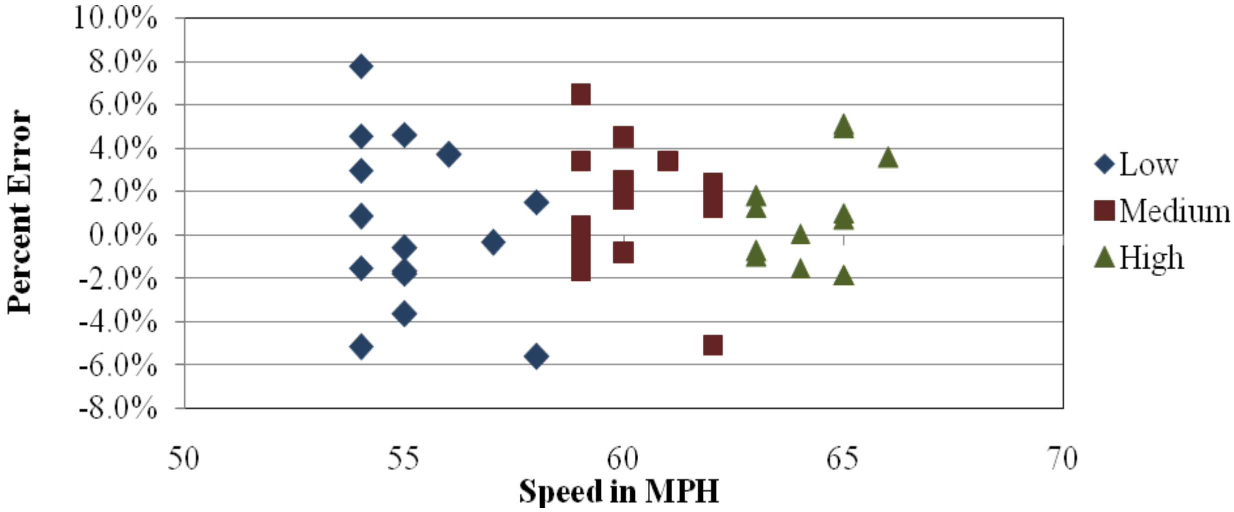


Figure 5-1 – Pre-Validation GVW Errors by Speed – 24-Nov-10

5.1.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-2, the equipment estimated steering axle weights with reasonable accuracy at all speeds. The range in errors is similar throughout the entire speed range. There appears to be a slight trend of decreasing errors with increasing speed. Distribution of errors is shown graphically in the figure.

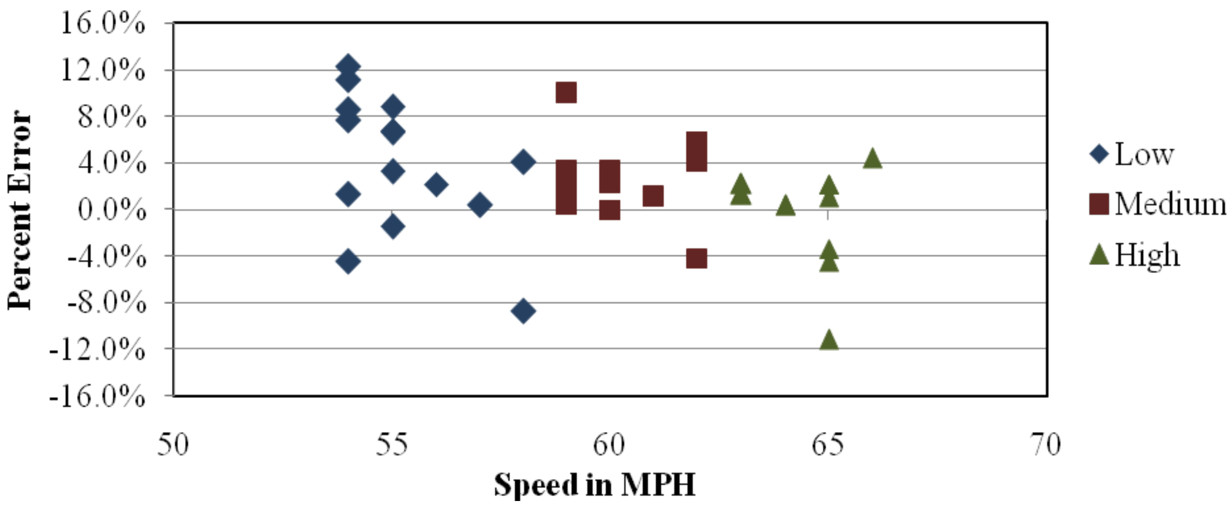


Figure 5-2 – Pre-Validation Steering Axle Weight Errors by Speed – 24-Nov-10

5.1.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 5-3, 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.

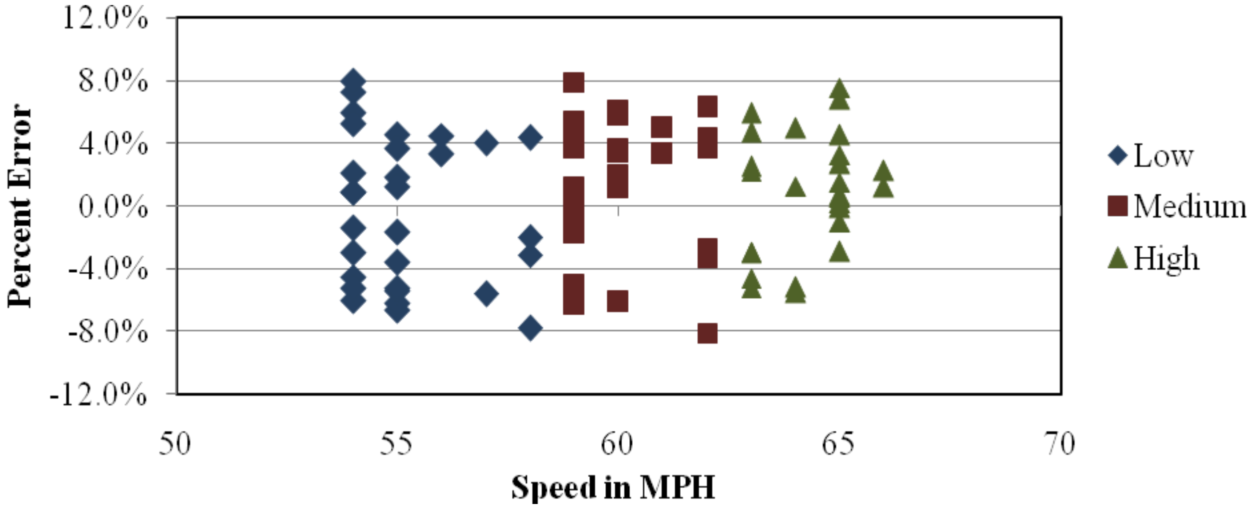


Figure 5-3 – Pre-Validation Tandem Axle Weight Errors by Speed – 24-Nov-10

5.1.1.4 GVW Errors by Speed and Truck Type

It can be seen in Figure 5-4 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.

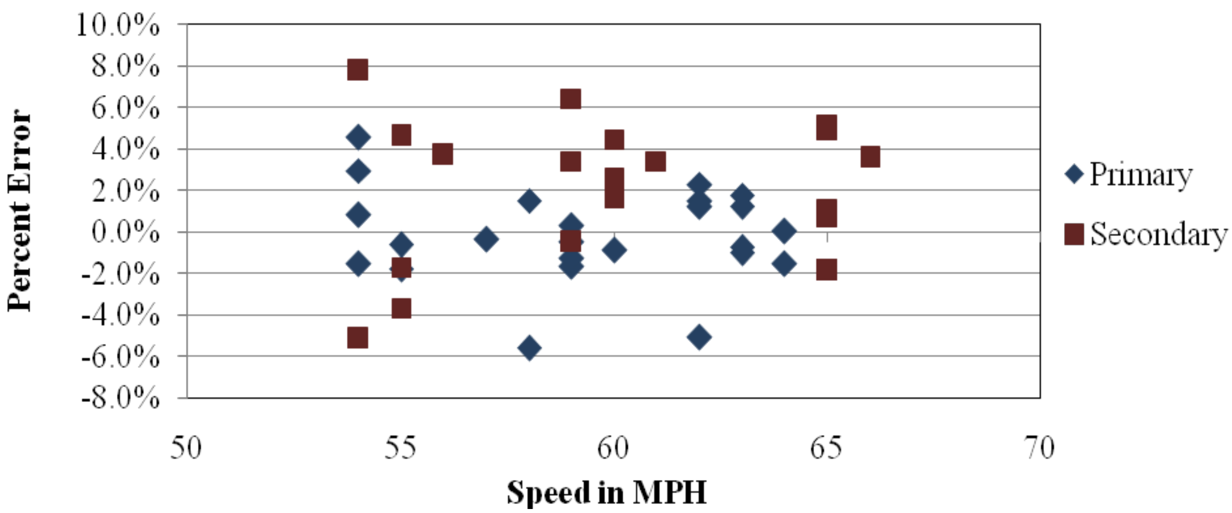


Figure 5-4 – Pre-Validation GVW Error by Truck and Speed – 24-Nov-10

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 -0.3 feet to 0.6 feet. Distribution of errors is shown graphically in Figure 5-5.

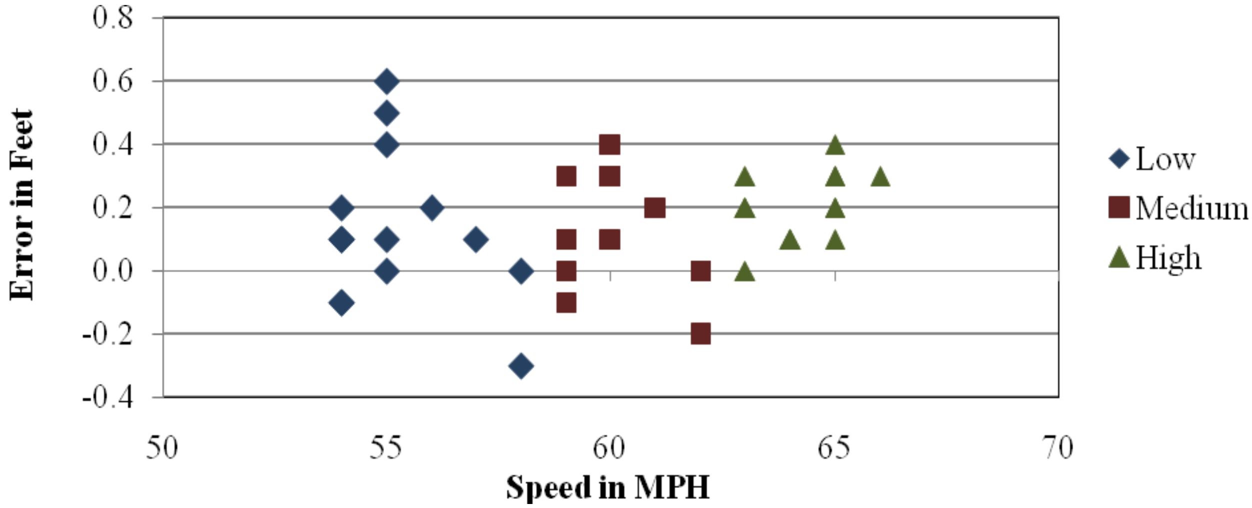


Figure 5-5 – Pre-Validation Axle Length Error by Speed – 24-Nov-10

5.1.1.6 Overall Length Errors by Speed

For this system, the WIM equipment overestimates overall length consistently over the entire range of speeds, with errors ranging from 2.5 to 4.8 feet. Distribution of errors is shown graphically in Figure 5-6.

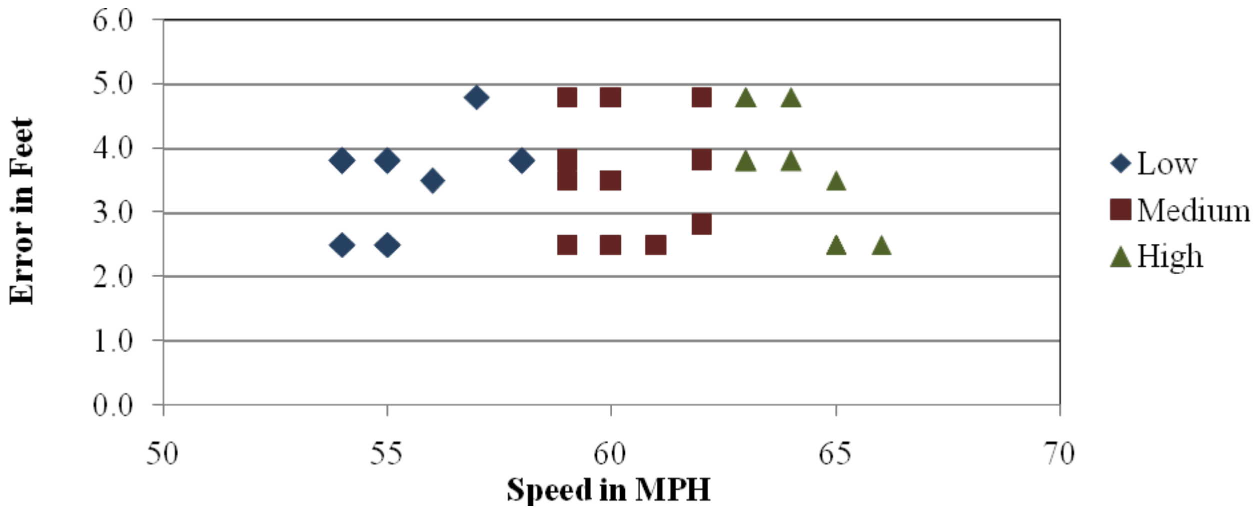


Figure 5-6 – Pre-Validation Overall Length Error by Speed – 24-Nov-10

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 34.1 to 61.1 degrees Fahrenheit. Although the preferred 30 degree temperature range was not reached, the pre-validation test runs are being reported under three temperature groups to demonstrate the temperature affects on weight measurement as shown in Table 5-4 below.

Table 5-4 – Post-Validation Results by Temperature – 24-Nov-10

Parameter	95% Confidence Limit of Error	Low 34.1 to 43.1 degF	Medium 43.2 to 52.2 degF	High 52.3 to 61.1 degF
Steering Axles	±20 percent	4.1 ± 11.7%	1.5 ± 5.5%	-0.6 ± 11.6%
Tandem Axles	±15 percent	2.4 ± 7.3%	-1.3 ± 6.5%	0.1 ± 10.3%
GVW	±10 percent	2.7 ± 5.7%	-0.8 ± 3.9%	0.1 ± 8.5%
Vehicle Length	±3 percent (1.8 ft)	3.3 ± 1.7 ft	3.6 ± 1.9 ft	3.5 ± 1.8 ft
Vehicle Speed	± 1.0 mph	0.0 ± 2.6 mph	0.4 ± 1.1 mph	0.1 ± 0.8 mph
Axle Length	± 0.5 ft [150mm]	0.2 ± 0.3 ft	0.2 ± 0.4 ft	0.1 ± 0.5 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.

5.1.2.1 GVW Errors by Temperature

From Figure 5-7, 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 an increase in temperature causes weight estimates to decrease.

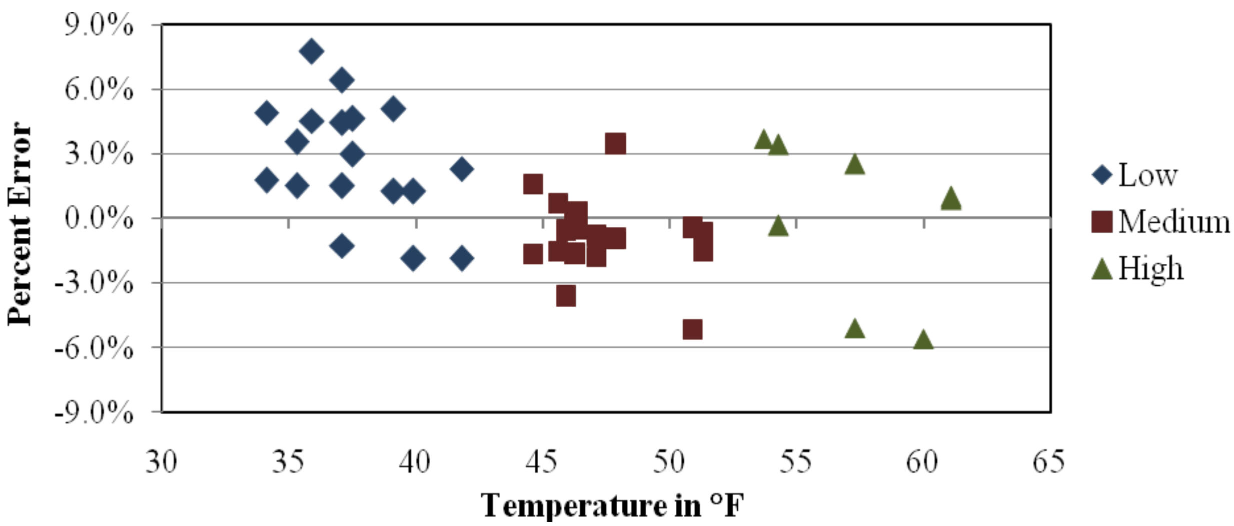


Figure 5-7 – Pre-Validation GVW Errors by Temperature – 24-Nov-10

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 estimation of steering axle weight decreases. The range in error is greater at the lower temperatures. Distribution of errors is shown graphically in the following figure.

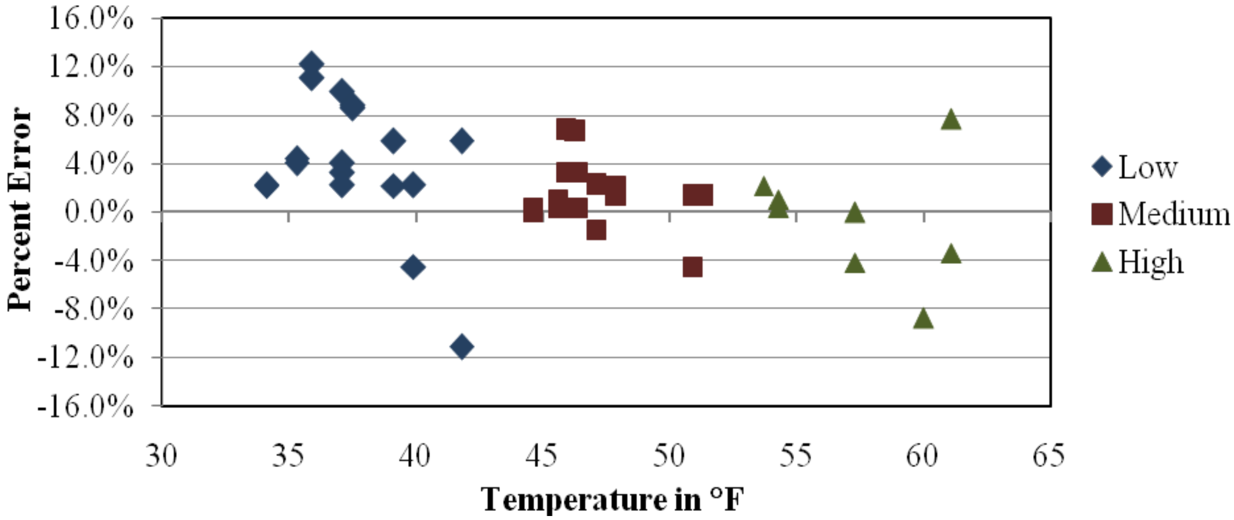


Figure 5-8 – Pre-Validation Steering Axle Weight Errors by Temperature – 24-Nov-10

5.1.2.3 Tandem Axle Weight Errors by Temperature

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

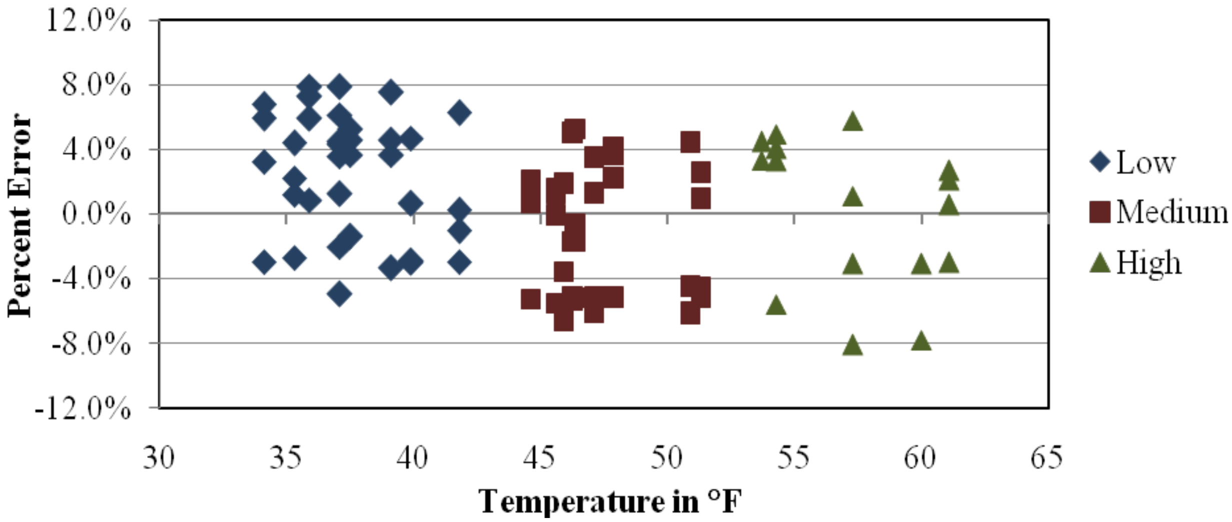


Figure 5-9 – Pre-Validation Tandem Axle Weight Errors by Temperature – 24-Nov-10

5.1.2.4 GVW Errors by Temperature and Truck Type

As shown in Figure 5-10, 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.

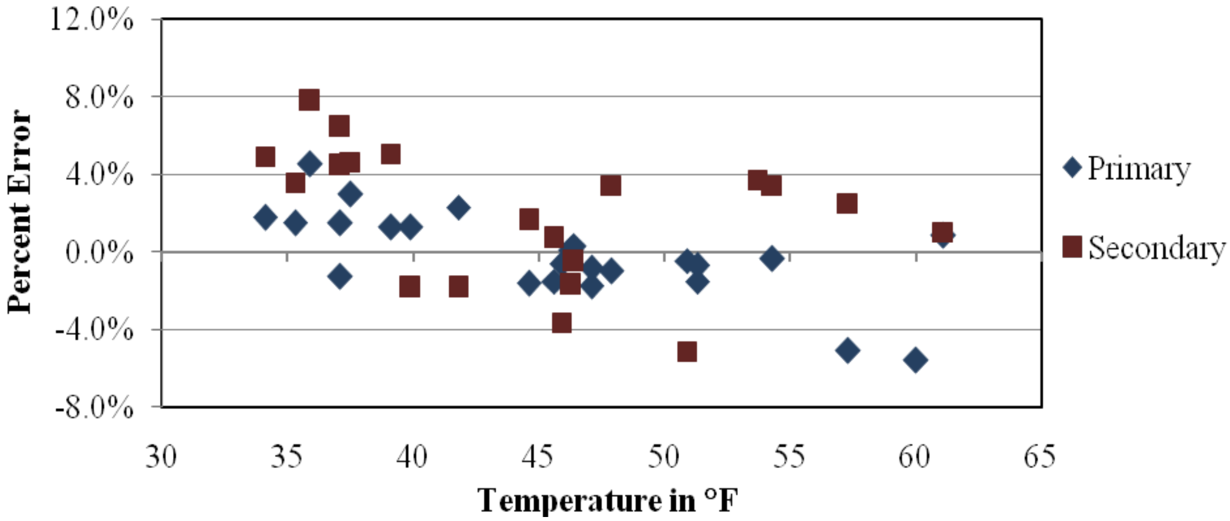


Figure 5-10 – Pre-Validation GVW Error by Truck and Temperature – 24-Nov-10

5.1.3 Multivariable Analysis

This section provides additional analysis of pre-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.

5.1.3.1 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 66 mph.
- Pavement temperature. Pavement temperature ranged from 34.1 to 61.1 degrees Fahrenheit.
- Interaction between the factors such as the interaction between speed and pavement temperature.

5.1.3.2 Results

For analysis of GVW weights, the value of regression coefficients and their statistical properties are summarized in Table 5-5. 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 5-5 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 5-5 – Table of Regression Coefficients for Measurement Error of GVW

Parameter	Regression coefficients	Standard error	Value of t-distribution	Probability value
Intercept	10.336	6.6909	1.5449	0.1311
Speed	0.0139	0.1023	0.1354	0.8931
Temp	-0.1955	0.0488	-4.0044	0.0003
Truck	-2.4873	0.7731	-3.2172	0.0027

The relationship between temperature and measurement errors is shown in Figure 5-11. The figure includes trend line for the predicted percent error. Besides the visual assessment of the relationship, Figure 5-11 provides quantification and statistical assessment of the relationship.

The quantification is provided by the value of the regression coefficient, in this case *-0.1955* (in Table 5-5). This means, for example, that for a 20 degree increase in temperature, the % error is decreased by about 3.9 % (-0.1955 x 20). The statistical assessment of the relationship is provided by the probability value of the regression coefficient.

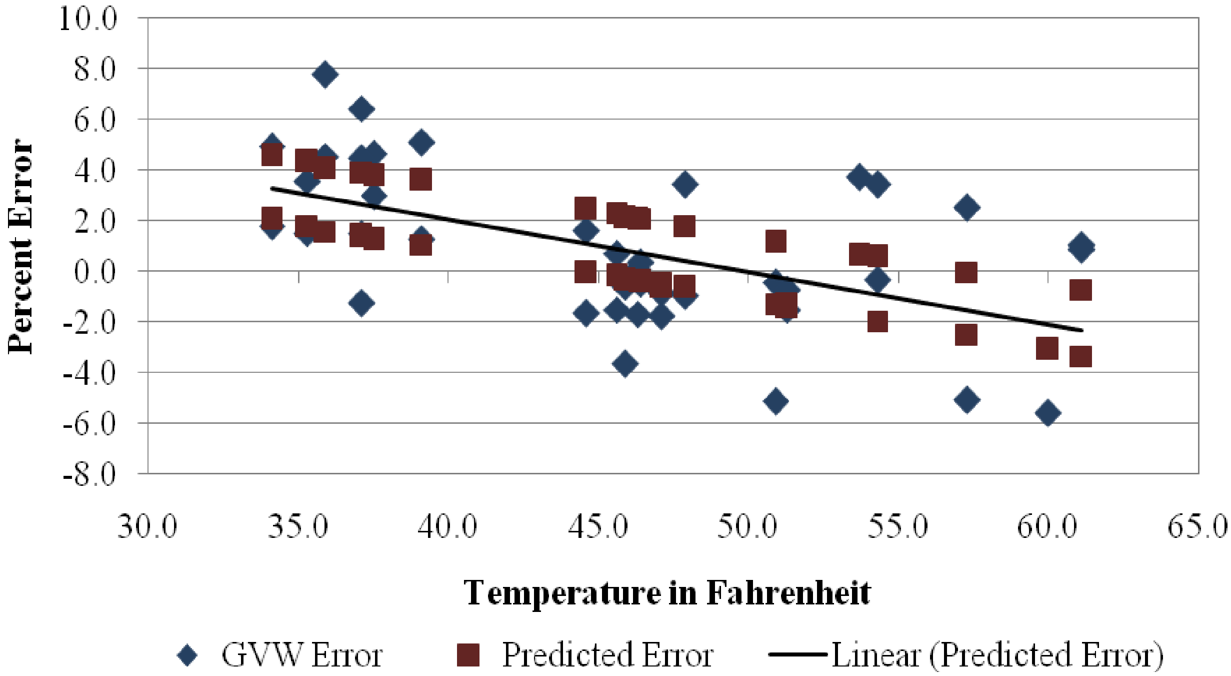


Figure 5-11 – Influence of Temperature on the Measurement Error of GVW

The effect of speed on GWV was not statistically significant. The probability that the regression coefficient for speed (-0.0139 in Table 5-5) is not different from zero was 0.0.893.1 In other words, there is about 89 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.

5.1.3.3 Summary Results

Table 5-6 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 5-6 indicates that the relationship was not statistically significant (the probability that the relationship can occur by chance alone was greater than 20 percent).

Table 5-6 – Summary of Regression Analysis

	Factor					
	Speed		Temperature		Truck type	
Weight, % error	Regression coefficient	Probability value	Regression coefficient	Probability value	Regression coefficient	Probability value
GVW	0.0139	-	-0.1955	0.0003	-2.4873	0.0027
Steering axle	-0.4574	0.0011	-0.3316	0.00001	-0.6643	-
Tandem axle tractor	0.0662	-	-0.1950	0.0007	1.0920	0.1963
Tandem axle trailer	0.0801	-	-0.1480	0.0262	-6.9895	0.00001

5.1.3.4 Conclusions

1. With the exception of steering axle weights, speed had *no statistically significant effect on measurement errors.*

2. Temperature had statistically significant effect on the measurement error of all axle groups and thus also the measurement error of the GVW. The regression coefficients ranged from -0.3316 for the steering axle to -0.1480 for the tandem axel on trailer.

3. Truck type affected the GVW and the tandem axle weight errors. The regression coefficient for truck type in Table 5-6, 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.). The mean error in GVW for the Secondary truck was about 2.5 % 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.

5.1.4 Classification 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 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 5-7 illustrates the breakdown of vehicles observed and identified by the WIM equipment for the manual classification study.

Table 5-7 – Pre-Validation Classification Study Results – 24-Nov-10

Class	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Observed Count	0	5	4	8	2	60	4	13	4	0
WIM Count	0	5	4	8	2	60	1	13	3	3
Observed Percent	0	5	4	8	2	60	4	13	4	0
WIM Percent	0	5	4	8	2	60	1	13	3	3
Misclassified Count	0	0	0	0	0	0	3	0	0	0
Misclassified Percent	N/A	0	0	0	0	0	75	0	0	N/A
Unclassified Count	0	0	0	0	0	0	0	0	1	0
Unclassified Percent	N/A	0	0	0	0	0	0	0	33	0

As shown in the above table, there were 3 Class 10 vehicles that were not identified correctly by the WIM equipment. These vehicles were all identified as Class 13 vehicles. Consequently, the WIM equipment over-counted 3 Class 13 vehicles.

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 5-8.

Table 5-8 – Pre-Validation Misclassifications by Pair – 24-Nov-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	3
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 3.2% for heavy trucks (6 – 13), which is greater than 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, a total of 3 vehicles, including 3 heavy trucks (6 – 13) were misclassified by the equipment. All of the misclassifications were Class 10s identified by the WIM equipment as Class 13s. 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 5-9.

Table 5-9 – Pre-Validation Unclassified Trucks by Pair – 24-Nov-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	1
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, 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 12 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 0.7 mph; the range of errors was 1.5 mph.

5.2 Calibration

The pre-validation study demonstrated that the site is currently providing high-quality research-type traffic loading data. In addition, the average weight measurement errors are close to zero. For example, the average measurement error was -0.2 percent for the primary truck and +1.9 percent and for the secondary truck. Consequently, considering the uncertainty that can be introduced by even marginal changes to the calibration factors, no calibration changes are recommended and none were made. Since no changes were made to any of the speed or distance compensation factors, a post-validation classification and speed study was not carried out.

5.3 Post Visit Applied Calibration

The 85th percentile speed for trucks, based on the CDS data, is 70 mph, 5 mph above the posted speed limit of 65 mph. Consequently, the use of applied calibration was utilized to determine if recommendations for changes to the 65 and 70 mph speed point compensation factors will be made.

Figure 5-12 is provided to illustrate the predicted GVW error with respect to the pre-validation errors by speed. This provides a reasonable expectation for the applied errors.

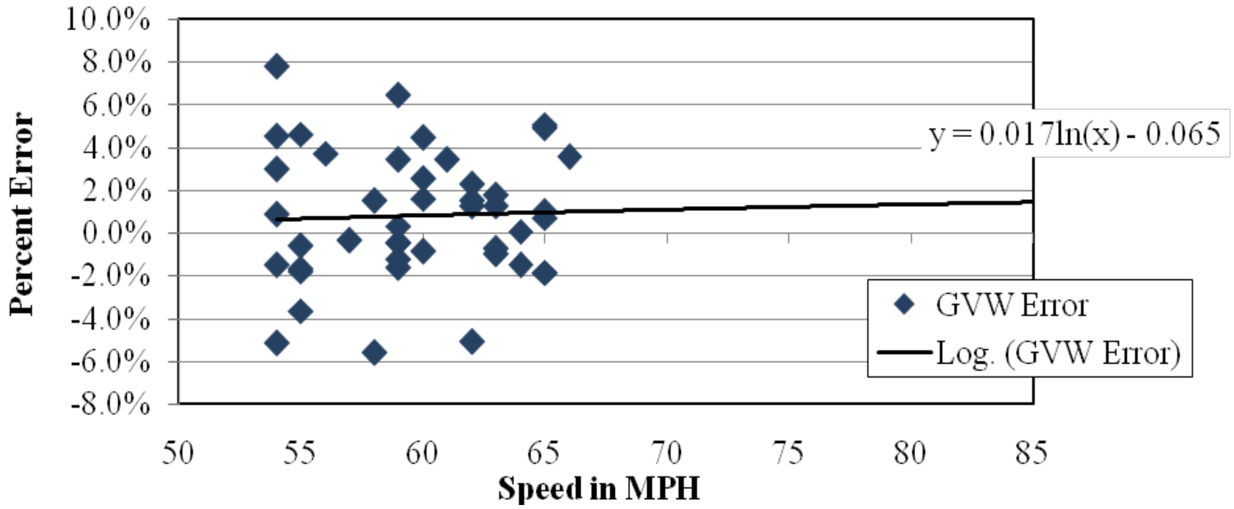


Figure 5-12 – GVW Error Trend

Pre-validation and pre- 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 5-13.

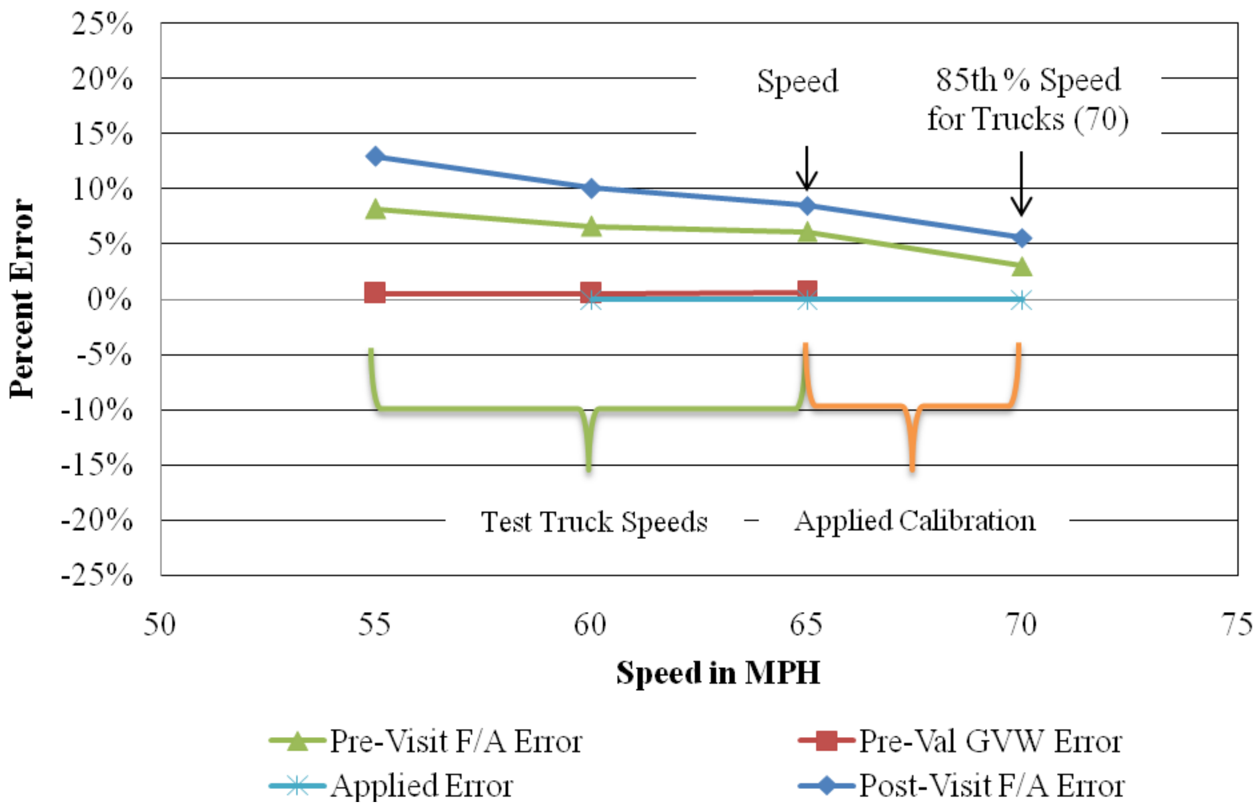


Figure 5-13 – Applied Calibration

Based on these errors and the GVW error trend developed from the pre-validation test truck runs and shown in Figure 5-13, applied errors were calculated and are given in Table 5-10.

Table 5-10 – Recommended Factor Changes from Applied Error

Speed Point	Speed	Old Factors				Applied Error	New Factors			
		1	2	3	4		1	2	3	4
96	60	3184	3644	3184	3248	0.0%	3184	3644	3184	3248
104	65	3172	3631	3172	3235	0.0%	3172	3631	3172	3235
112	70	3095	3542	3095	3156	0.0%	3095	3542	3095	3156

Considering the parameters left in place at the conclusion of the pre-validation on November 24, 2010, along with the post-visit applied calibration recommendations shown above, the final factor recommendations are provided in Table 5-11. As shown in the table, applied calibration was not recommended for the 60 to 70 mph speed points. The final factors left in place at the conclusion of the validation are provided in the table.

Table 5-11 – Recommended Final Speed Factors

Speed Point	Speed	Final Factors			
		1	2	3	4
80	50	3239	3717	3239	3312
88	55	3221	3687	3221	3275
96	60	3184	3644	3184	3248
104	65	3172	3631	3172	3235
112	70	3095	3542	3095	3156

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 pre-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	
29-May-07	100	50	50	0	0	0	N/A	N/A	N/A	0	0
30-May-07	100	17	40	0	0	0	0	0	0	N/A	0
4-Nov-08	N/A	0	0	0	N/A	0	0	0	0	0	0
5-Nov-08	N/A	0	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	0
24-Nov-10	N/A	0	0	0	0	0	75	0	0	N/A	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
29-May-07	-2.3 (2.6)	-2.7 (4.5)	-2.6 (3.7)
30-May-07	-0.1 (2.0)	-1.3 (5.7)	0.2 (3.4)
4-Nov-08	-2.6 (1.9)	-2.1 (7.4)	-3.7 (2.4)
5-Nov-08	-1.7 (2.0)	-0.2 (7.5)	-3.4 (2.4)
24-Nov-10	0.8 (3.0)	2.2 (4.7)	0.5 (3.9)

The variability of the weight errors appears to have remained reasonably consistent since the site was first validated. The table verifies that the weight estimates have remained 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		
		30-May-07	4-Nov-08	24-Nov-10
Single Axles	±20 percent	-1.3 ± 5.7	-2.1 ± 7.4	2.2 ± 4.7
Tandem Axles	±15 percent	0.2 ± 3.4	-3.7 ± 2.4	0.5 ± 3.9
GVW	±10 percent	-0.1 ± 2.0	-2.6 ± 1.9	0.8 ± 3.0

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

A review of the LTPP Standard Release Database 24 shows that there are 26 consecutive months of level "E" WIM data for this site. This site requires 3 additional years of data to meet the minimum of five years of research quality 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
- Pre-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

Pennsylvania, SPS-6
SHRP ID: 420600

Validation Date: November 24, 2010

Photo 1 – Cabinet Exterior

Photo 2 – Cabinet Interior (Front)

Photo 3 – Cabinet Interior (Back)

Photo 4 – Leading Loop

Photo 5 – Leading WIM Sensor

Photo 6 – Trailing WIM Sensor


Photo 7 – Trailing Loop Sensor


Photo 8 – Solar Panel


Photo 9 – Cellular Modem


Photo 10 – Downstream


Photo 11 – Upstream


Photo 12 – Modem Corrosion

Photo 13 – Truck 1

Photo 14 – Truck 1 Tractor

Photo 15 – Truck 1 Trailer and Load

Photo 16 – Truck 1 Suspension 1

Photo 17 – Truck 1 Suspension 2

Photo 18 – Truck 1 Suspension 3


Photo 19 – Truck 1 Suspension 4


Photo 20 – Truck 1 Suspension 5


Photo 21 – Truck 2


Photo 22 – Truck 2 Tractor


Photo 23 – Truck 2 Trailer and Load


Photo 24 – Truck 2 Suspension 1


Photo 25 – Truck 2 Suspension 2

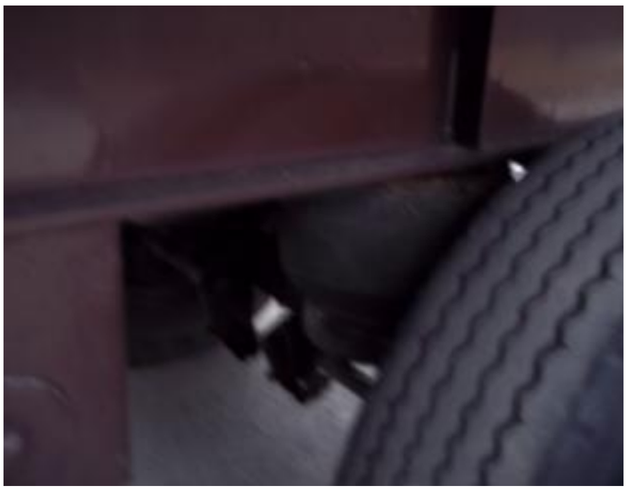


Photo 26 – Truck 2 Suspension 3


Photo 27 – Truck 2 Suspension 4


Photo 28 – Truck 2 Suspension 5

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 42 SPS WIM ID: 420600 DATE (mm/dd/yyyy) 11/23/2010

SITE CALIBRATION INFORMATION

1. DATE OF CALIBRATION {mm/dd/yy} 11/23/10

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. Quartz Piezo 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: 22

	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 -

Dynamic and Static GVW:	0.8%	Standard Deviation:	3.0%
Dynamic and Static Single Axle:	2.2%	Standard Deviation:	4.7%
Dynamic and Static Double Axles:	0.5%	Standard Deviation:	3.9%

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

9. DEFINE SPEED RANGES IN MPH:

			Low		High	Runs
a.	Low	-	54.0	to	58.0	15
b.	Medium	-	58.1	to	62.1	16
c.	High	-	62.2	to	66.0	13
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)	42 420600 11/23/2010

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3074 | 3518

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: ____________

13. METHOD TO DETERMINE LENGTH OF COUNT: ____________

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 - Pre

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

Contact Information: Phone: 717-512-6638

E-mail: dwolf@ara.com

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 42 SPS WIM ID: 420600 DATE (mm/dd/yyyy) 11/23/2010

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
65	9	19765	64	9	67	9	20387	67	9
67	9	19761	66	9	69	9	20436	69	9
68	6	19788	67	6	73	9	20449	73	9
65	5	19809	65	5	68	9	20462	70	9
65	9	19826	65	9	70	9	20465	67	9
66	9	19837	64	9	70	6	20477	68	6
68	7	19845	66	7	67	5	20480	64	5
68	9	19850	66	9	67	9	20486	67	9
67	9	19862	68	9	60	9	20499	60	9
68	11	19870	67	11	62	9	20509	62	9
70	7	19877	68	7	64	5	20522	64	5
62	9	19880	59	9	64	9	20528	65	9
60	9	19886	60	9	67	9	20553	65	9
66	7	19892	63	7	64	9	20562	63	9
65	**13**	**19905**	**64**	**10**	65	5	20564	67	5
65	9	19921	64	9	67	9	20574	66	9
69	9	20128	65	9	65	9	20592	64	9
61	9	20140	58	9	65	9	20599	63	9
66	9	20153	65	9	62	9	20618	60	9
62	11	20208	62	11	69	12	20623	71	12
64	11	20218	64	11	61	7	20743	61	7
62	9	20225	60	9	64	9	20768	65	9
64	9	20232	63	9	64	11	20771	64	11
67	11	20243	65	11	64	11	20781	65	11
68	9	20261	69	9	64	9	20790	65	9

Sheet 1 - 0 to 50 Start: ____________ Stop: ____________

Recorded By: AR Verified By: KT

Validation Test Truck Run Set - Pre

Traffic Sheet 20 **LTPP MONITORED TRAFFIC DATA** **SPEED AND CLASSIFICATION STUDIES**	STATE CODE: 42 SPS WIM ID: 420600 DATE (mm/dd/yyyy) 11/23/2010

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
63	9	20957	63	9	59	12	21321	59	12
69	6	20974	67	6	67	9	21329	67	9
62	5	20981	61	5	59	11	21343	56	11
67	11	20987	66	11	68	6	21347	68	6
62	11	20992	61	11	64	9	21398	65	9
56	9	21001	52	9	69	9	21405	68	9
70	9	21003	69	9	67	9	21420	67	9
64	15	21012	65	12	67	7	21427	66	7
65	11	21056	66	11	64	9	21431	63	9
67	11	21062	67	11	70	7	21459	67	7
67	11	21072	66	11	64	9	21464	63	9
65	9	21147	64	9	68	11	21473	68	11
68	9	21168	66	9	70	13	21476	68	10
67	9	21172	65	9	62	8	21494	62	8
59	9	21177	62	9	66	9	22506	63	9
62	7	21179	62	7	67	9	22511	66	9
70	9	21207	70	9	65	9	22519	68	9
66	9	21223	65	9	64	9	22523	66	9
62	9	21226	60	9	66	12	22529	67	12
65	9	21231	65	9	65	9	22533	64	9
68	9	21236	64	9	67	7	22553	67	7
64	9	21248	62	9	65	8	22575	64	8
66	9	21280	65	9	56	10	22588	55	10
71	9	21284	69	9	60	9	22606	62	9
64	13	21301	64	10	68	9	22631	67	9

Sheet 2 - 51 to 100 Start: ____________ Stop: ____________

Recorded By: AR Verified By: KT

Validation Test Truck Run Set - Pre