WIM System Field Calibration and Validation Summary Report

Ohio SPS-2
SHRP ID – 390200

Validation Date: December 13, 2011
Submitted: January 3, 2012

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1 Executive Summary

A WIM validation was performed on December 13 and 14, 2011 at the Ohio SPS-2 site located on route US-23 at milepost 19.7, 1 mile north of Radnor Road.

This site was installed on March 15, 1996. The in-road sensors are installed in the northbound, righthand driving lane. The site is equipped with load cell WIM sensors and Mettler-Toledo WIM controller. The LTPP lane is identified as lane 1 and DSP-0 in the WIM controller. From a comparison between the report of the most recent validation of this equipment on September 30, 2010 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 the WIM components determined that the the equipment is operating within the manufacturer's tolerances. Further equipment discussion is provided in Section 3.

During the on-site pavement evaluation, There were no pavement distresses noted that may affect the accuracies of the WIM system. A visual observation of the trucks as they approach, traverse, and leave the sensor area indicated significant truck bouncing at a location approximately 500 feet prior to the WIM scales. The adverse truck dynamics appear to diminish prior to the trucks crossing over the scales and do not appear to affect the accuracy of the WIM system. The trucks appear to track down the center of the lane. 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; however, the quality of steering axle weight measurement is marginal due to excessive negative bias (-5.0%). The summary results of the validation are provided in Table 1-1 below.

Table 1-1 – Post-Validation Results – 13-Dec-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-5.0 ± 6.9%	Pass
Tandem Axles	±15 percent	-0.2 ± 4.3%	Pass
GVW	±10 percent	-0.7 ± 2.6%	Pass
Vehicle Length	±3.0 percent (2.0 ft)	-11.3 ± 1.5 ft	FAIL
Axle Length	± 0.5 ft [150mm]	-0.1 ± 0.2 ft	Pass

As shown in the table, this site is not providing research quality data for Vehicle Length. The WIM equipment does not provide the capability of independently calibrating for errors in steering axle weight or overall vehicle length measurement, and so these errors could not be mitigated during the validation.

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 0.4 ± 2.6 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 and that the speeds being reported by the WIM equipment are within acceptable ranges.

This site is not providing research quality vehicle classification data for heavy trucks (Class 6 – 13). The heavy truck misclassification rate of 4.3% is not within the 2.0% acceptability criterion for LTPP SPS WIM sites. The overall misclassification rate of 7.0% from the 100 truck sample (Class 4 – 13) was due to the misclassifications of three Class 9 trucks, one Class 8 truck and three Class 5 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 forklifts and crane weights.

- The Secondary truck was a Class 9 vehicle with air suspension on the tractor tandem, air suspension on the trailer tandem, standard tandem spacing on the tractor and standard tandem on the trailer. The Secondary truck was loaded with forklifts.

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. Axle spacings were measured from the center hub of the each axle to the center hub of the subsequent 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	77.3	11.0	16.6	16.6	16.6	16.6	13.6	4.3	37.4	4.1	59.4	70.6
2	64.6	9.8	11.8	11.8	15.6	15.6	12.8	4.3	31.7	4.0	52.8	63.1

The posted speed limit at the site is 55 mph. During the testing, the speed of the test trucks ranged from to 42 to 57 mph, a difference of 15 mph.

During test truck runs, pavement temperature was collected using a hand-held infrared temperature device. The post-validation pavement surface temperatures varied from 25.7 to 39.5

degrees Fahrenheit, a range of 13.8 degrees Fahrenheit. The mostly cloudy weather conditions prevented the desired 30 degree range in temperatures during testing.

A review of the LTPP Standard Release Database 25 shows that there are 2 years 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 traffic data, a pre-visit analysis was conducted by comparing a two-week data sample from November 15, 2011 (Data) to the most recent Comparison Data Set (CDS) from September 24, 2010. 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 2 years of level "E" WIM data for this site. Table 2-1 provides a breakdown of the available data for years 2004 to 2011.

Table 2-1 – LTPP Data Availability

Year	Total Number of Days in Year	Number of Months
2004	144	9
2005	180	8
2006	37	2
2009	233	9
2010	296	11
2011	114	4

As shown in the table, this site requires 3 additional years of data to meet the minimum of five years of research quality data. The data for years 2004 through 2006 and 2011 does not meet the 210-day minimum requirement for a calendar year.

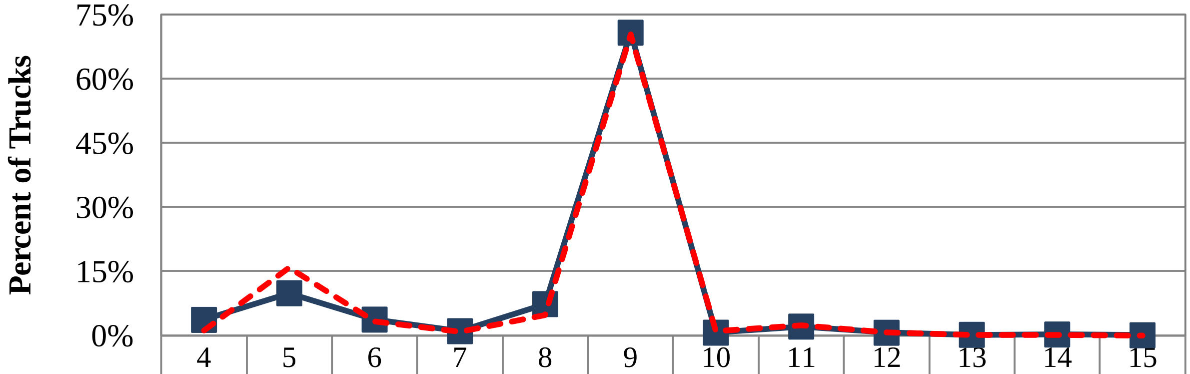
Table 2-2 provides a monthly breakdown of the available data for years 2004 through 2011.

Table 2-2 – LTPP Data Availability by Month

Year	Month												No. of Months
	1	2	3	4	5	6	7	8	9	10	11	12	
2004	16	27	5				14	15	12	20	15	20	9
2005					14	22	22	27	26	27	17	25	8
2006	25	12											2
2009				30	25	21	11	30	30	25	30	31	9
2010	30	28	29	29	30	20		16	29	30	24	31	11
2011	29	26	31			28							4

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.



	4	5	6	7	8	9	10	11	12	13	14	15
Data	3.6%	9.9%	3.7%	1.0%	7.3%	70.8%	0.6%	2.1%	0.6%	0.1%	0.2%	0.0%
CDS	1.1%	15.8%	3.3%	0.8%	4.7%	70.4%	0.9%	2.3%	0.6%	0.1%	0.0%	0.0%

Figure 2-1 – Comparison of Truck Distribution

Table 2-3 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 (70.8%) and Class 5 (9.9%). Table 2-3 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. The table indicates that zero percent of the vehicles at this site are unclassified.

Table 2-3 – Truck Distribution from W-Card

Vehicle Classification	CDS		Data		Change
	Date				
	9/24/2010		11/15/2011		
4	588	1.1%	853	3.6%	2.5%
5	8443	15.8%	2316	9.9%	-5.9%
6	1744	3.3%	868	3.7%	0.4%
7	420	0.8%	232	1.0%	0.2%
8	2516	4.7%	1720	7.3%	2.6%
9	37595	70.4%	16631	70.8%	0.4%
10	498	0.9%	150	0.6%	-0.3%
11	1237	2.3%	485	2.1%	-0.3%
12	330	0.6%	146	0.6%	0.0%
13	27	0.1%	32	0.1%	0.1%
14	15	0.0%	50	0.2%	0.2%
15	0	0.0%	8	0.0%	0.0%

From the table it can be seen that the percentage of Class 9 vehicles has increased by 0.4 percent from September 2010 and November 2011. Changes in the percentage of heavier trucks may be attributed to seasonal variations in truck distributions. During the same time period, the percentage of Class 5 trucks decreased by 5.9 percent. These differences may be attributed to changes in the 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 Agency was analyzed to determine the expected truck speed distributions. This will provide a basis for determining the speed of the test trucks during validation testing. The CDS distribution of speeds is shown in Figure 2-2.

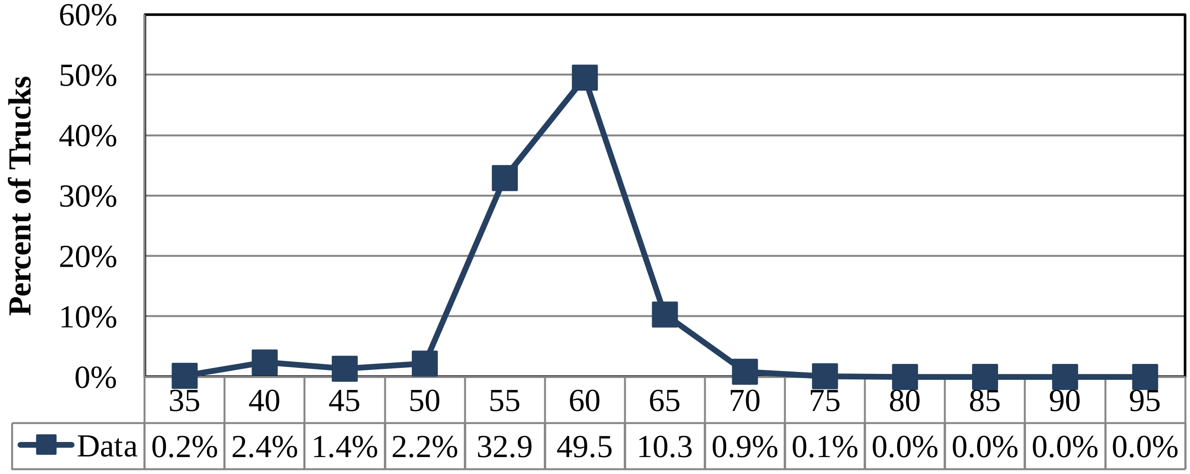


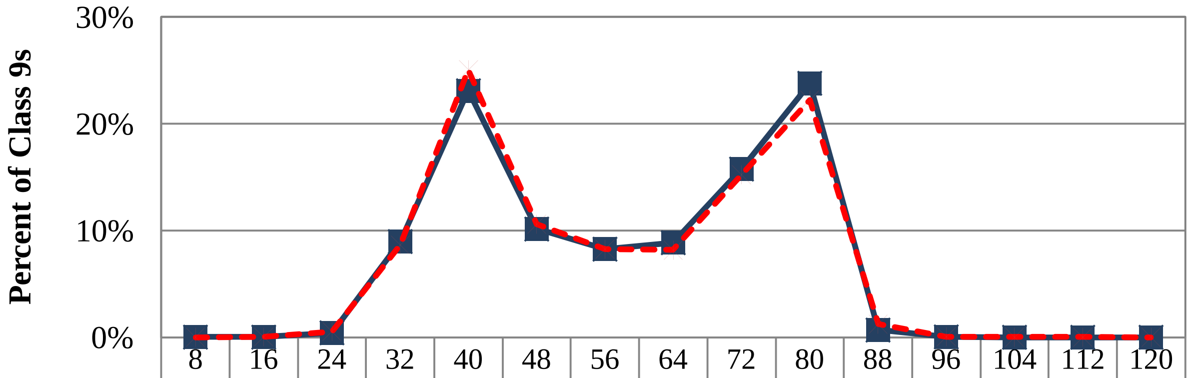
Figure 2-2 – Truck Speed Distribution

As shown in Figure 2-2, the majority of the trucks at this site are traveling between 55 and 65 mph. The posted speed limit at this site is 55 and the 85th percentile speed for trucks at this site is 60 mph. The range of truck speeds for the validation will be 45 to 55 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 2011 and the Comparison Data Set from September 2010.

As shown in Figure 2-3, there is a slightly higher number of unloaded trucks and slightly lower number of loaded trucks between the September 2010 Comparison Data Set (CDS) and the November 2011 two-week sample W-card dataset (Data). However, there is no evidence in the shifts of loaded and unloaded peaks to the left or the right along the x-axis, indicating no systematic drift in the system calibration.



	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
Data	0.0%	0.0%	0.4%	9.0%	23.1	10.1	8.3%	8.9%	15.8	23.8	0.7%	0.0%	0.0%	0.0%	0.0%
CDS	0.0%	0.0%	0.5%	8.6%	25.1	10.6	8.2%	8.2%	15.2	22.2	1.2%	0.0%	0.0%	0.0%	0.0%

Figure 2-3 – Comparison of Class 9 GVW Distribution

Table 2-4 is provided to show the statistical comparison for Class 9 GVW between the Comparison Data Set and the current dataset.

Table 2-4 – Class 9 GVW Distribution from W-Card

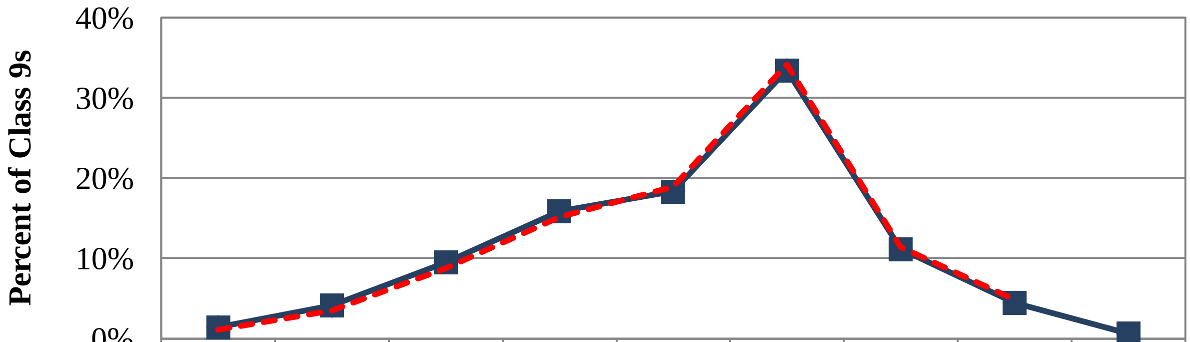
GVW weight bins (kips)	CDS		Data		Change
	Date				
	9/24/2010		11/15/2011		
8	0	0.0%	2	0.0%	0.0%
16	10	0.0%	1	0.0%	0.0%
24	162	0.5%	69	0.4%	-0.1%
32	2626	8.6%	1476	9.0%	0.3%
40	7609	25.1%	3801	23.1%	-2.0%
48	3215	10.6%	1668	10.1%	-0.5%
56	2504	8.2%	1358	8.3%	0.0%
64	2477	8.2%	1458	8.9%	0.7%
72	4624	15.2%	2593	15.8%	0.5%
80	6754	22.2%	3916	23.8%	1.6%
88	369	1.2%	111	0.7%	-0.5%
96	15	0.0%	6	0.0%	0.0%
104	3	0.0%	0	0.0%	0.0%
112	2	0.0%	0	0.0%	0.0%
120	0	0.0%	0	0.0%	0.0%
Average =	53.6 kips		54.1 kips		0.5 kips

As shown in the table, the percentage of unloaded class 9 trucks in the 32 to 40 kips range decreased by 2.0 percent while the percentage of loaded class 9 trucks in the 72 to 80 kips range increased by 1.6 percent. During this time period the percentage of overweight trucks decreased by 0.5 percent. Based on the average Class 9 GVW values from the per vehicle records, the GVW average for this site increased by 0.9 percent, from 53.6 kips to 54.1 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 average front axle weight from the current data sample set with the expected average front axle weight average from the Data Comparison Set.

Figure 2-4 shows a comparison between Class 9 front axle weight plots generated by using the two week W-card sample from November 2011 and the Comparison Data Set from September 2010. The percentages of light axles (9.5 to 10.0 kips) increased by approximately 0.7% and the percentages of heavy axles (11.0 to 11.5 kips) decreased by approximately 0.2%. These small changes do not indicate significant changes in front axle measurement.



	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0
Data	1.4%	4.1%	9.5%	15.9%	18.3%	33.4%	11.1%	4.5%	0.6%
CDS	1.1%	3.5%	8.8%	15.1%	18.9%	34.2%	11.4%	4.8%	

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

It can be seen in the figure that the greatest percentage of trucks have front axle weights measuring between 10.0 and 10.5 kips. The percentage of trucks in this range has remained almost the same between the September 2010 Comparison Data Set (CDS) and the November 2011 dataset (Data).

Table 2-5 provides the Class 9 front axle weight distribution data for the September 2010 Comparison Data Set (CDS) and the November 2011 dataset (Data).

Table 2-5 – Class 9 Front Axle Weight Distribution from W-Card

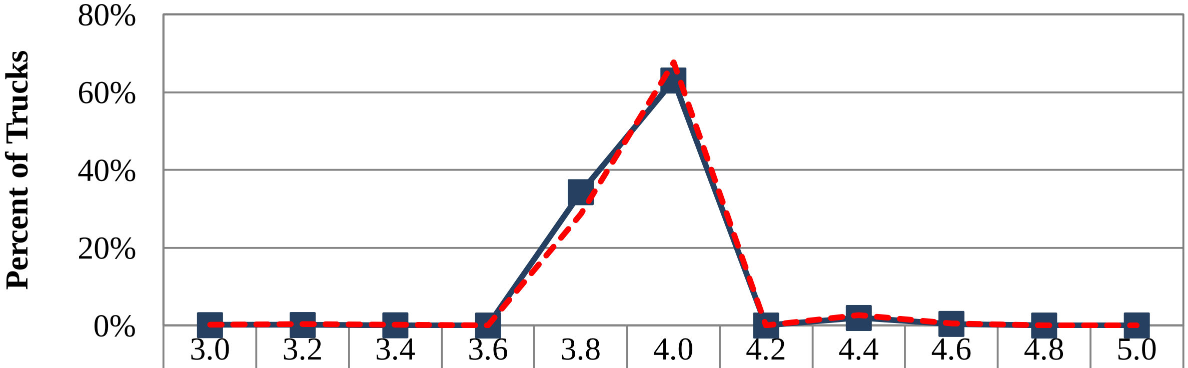
F/A weight bins (kips)	CDS		Data		Change
	Date				
	9/24/2010		11/15/2011		
8.0	463	1.5%	190	1.2%	-0.4%
8.5	320	1.1%	230	1.4%	0.3%
9.0	1051	3.5%	674	4.1%	0.6%
9.5	2653	8.8%	1560	9.5%	0.7%
10.0	4584	15.1%	2605	15.9%	0.7%
10.5	5732	18.9%	3005	18.3%	-0.6%
11.0	10354	34.2%	5487	33.4%	-0.8%
11.5	3444	11.4%	1830	11.1%	-0.2%
12.0	1467	4.8%	731	4.5%	-0.4%
12.5	217	0.7%	102	0.6%	-0.1%
Average =	10.4 kips		10.3 kips		-0.1 kips

The table shows that the average front axle weight for Class 9 trucks has decreased by 0.1 kips, or 1.0 percent. According to the values from the per vehicle records, the average front axle weight for Class 9 trucks is 10.3 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 from the sample data (Data) with the expected average tractor tandem spacing from the comparison data set (CDS).

The Class 9 tractor tandem spacing plot in Figure 2-5 is 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	0.1%	0.1%	0.1%	0.0%	34.3%	63.0%	0.0%	1.9%	0.4%	0.0%	0.0%
CDS	0.2%	0.3%	0.1%	0.0%	28.6%	67.7%	0.0%	2.6%	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 spacings for the September 2010 Comparison Data Set and the November 2011 Data have similar distributions with small change in percent trucks that have tandem axle spacing between 3.8 and 4.0 feet.

Table 2-6 shows the Class 9 axle spacings between the second and third axles.

Table 2-6 – Class 9 Axle 2 to 3 Spacing from W-Card

Tandem 1 spacing bins (feet)	CDS		Data		Change
	Date				
	9/24/20010		11/15/2011		
3.0	70	0.2%	16	0.1%	-0.1%
3.2	87	0.3%	22	0.1%	-0.2%
3.4	31	0.1%	10	0.1%	0.0%
3.6	0	0.0%	0	0.0%	0.0%
3.8	8700	28.6%	5645	34.3%	5.7%
4.0	20553	67.7%	10373	63.0%	-4.7%
4.2	0	0.0%	0	0.0%	0.0%
4.4	780	2.6%	320	1.9%	-0.6%
4.6	136	0.4%	69	0.4%	0.0%
4.8	0	0.0%	0	0.0%	0.0%
5.0	13	0.0%	4	0.0%	0.0%
Average =	3.9 feet		3.9 feet		0.0 feet

From the table it can be seen that the majority of drive tandem spacings for Class 9 trucks at this site is between 3.8 and 4.0 feet. Based on the average Class 9 drive tandem spacing values from the per vehicle records, the average tractor tandem spacing is 3.9 feet, which is identical to the expected average of 3.9 feet from the CDS per vehicle records. Further axle spacing analyses are performed during the validation analysis.

2.7 Data Analysis Summary

Historical data analysis involved the comparison of the most recent Comparison Data Set (September 2010) based on the last calibration with the most recent two-week WIM data sample from the site (November 2011). Comparison of vehicle class distribution data indicates a 0.4 percent increase in the percentage of Class 9 vehicles. Analysis of Class 9 weight data indicates that front axle weights have decreased by 0.1 kips and average Class 9 GVW has increased by 0.9 percent for the November 2011 data. The data indicates an average truck tandem spacing of 3.9 feet, which is identical to the expected average of 3.9 feet.

3 WIM Equipment Discussion

From a comparison between the report of the most recent validation of this equipment on September 29, 2010 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 March 15, 1996 by the Ohio DOT. It is instrumented with load cell weighing sensors and a Mettler WIM Controller. As the installation contractor, Agency 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 after 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 unscheduled 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 14, 2011 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, beginning 900 feet prior to WIM scales and ending 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 139 in/mi and is located approximately 526 feet prior to the WIM scale. The highest IRI value within the 400 foot approach section was 146 in/mi and is located approximately 155 feet prior to the WIM scale. These areas of the pavement were closely investigated during the validation visit, and truck dynamics in this area were closely observed. Although significant truck bouncing was noted at a location approximately 500 feet prior to the WIM scales, no distresses were noted at these locations and the truck dynamics appeared to diminish prior to the trucks crossing over 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**	**Pass 5**	**Avg**
Left	LWP	LRI (m/km)	1.273	1.246	1.201			1.240
		SRI (m/km)	1.257	1.254	1.081			1.197
		Peak LRI (m/km)	1.274	1.269	1.213			1.252
		Peak SRI (m/km)	**2.325**	**1.860**	**2.008**			**2.064**
	RWP	LRI (m/km)	0.971	0.897	0.957			0.942
		SRI (m/km)	0.971	0.746	0.911			0.876
		Peak LRI (m/km)	1.184	1.078	1.219			1.160
		Peak SRI (m/km)	1.168	0.964	1.090			1.074
Center	LWP	LRI (m/km)	1.207	1.411	1.329	1.393	1.404	1.335
		SRI (m/km)	0.729	0.965	0.963	1.090	1.264	0.937
		Peak LRI (m/km)	1.223	1.426	1.329	1.393	1.404	1.343
		Peak SRI (m/km)	1.352	1.903	1.808	1.757	1.612	1.705
	RWP	LRI (m/km)	1.043	1.054	1.017	1.043	0.951	0.805
		SRI (m/km)	1.234	1.268	1.324	1.381	1.278	1.302
		Peak LRI (m/km)	1.049	1.057	1.020	1.046	0.953	1.043
		Peak SRI (m/km)	1.556	1.625	1.664	1.660	1.585	1.626
Right	LWP	LRI (m/km)	1.492	1.576	1.547			1.538
		SRI (m/km)	1.361	1.285	1.459			1.368
		Peak LRI (m/km)	1.492	1.576	1.547			1.538
		Peak SRI (m/km)	1.752	1.734	1.935			1.807
	RWP	LRI (m/km)	1.038	1.030	0.994			1.021
		SRI (m/km)	1.271	1.556	1.301			1.376
		Peak LRI (m/km)	1.038	1.030	0.995			1.021
		Peak SRI (m/km)	1.881	2.074	1.851			1.935

From Table 4-2 it can be seen that all of the indices computed from the profiles are between the upper and lower threshold values. The highest values, on average, are the Peak SRI values in the left wheel path of the left shift passes (shown in bold).

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 validation 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 Validation

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

The 40 validation test truck runs were conducted on December 13, 2011, beginning at approximately 9:09 AM and continuing until 3:21 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with forklifts and crane weights, and equipped with air suspension on truck and trailer tandems and with standard tandem spacings on both the tractor and trailer.
- A Class 9 truck, loaded with forklifts, 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 validation and were re-weighed at the conclusion of the validation. The average test truck weights and measurements are provided in Table 5-1.

Table 5-1 - 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	77.3	11.0	16.6	16.6	16.6	16.6	13.6	4.3	37.4	4.1	59.4	70.6
2	64.6	9.8	11.8	11.8	15.6	15.6	12.8	4.3	31.7	4.0	52.8	63.1

Test truck speeds varied by 15 mph, from 42 to 57 mph. The measured validation pavement temperatures varied 13.8 degrees Fahrenheit, from 25.7 to 39.5. The mostly cloudy weather conditions prevented the desired 30 degree temperature range during testing. Table 5-2 provides a summary of the validation results.

As shown in Table 5-2, the site did not meet the LTPP requirements for Vehicle Length measurement as a result of the validation test truck runs.

Table 5-2 – Validation Overall Results – 13-Dec-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-5.0 ± 6.9%	Pass
Tandem Axles	±15 percent	-0.2 ± 4.3%	Pass
GVW	±10 percent	-0.7 ± 2.6%	Pass
Vehicle Length	±3.0 percent (2.0 ft)	-11.3 ± 1.5 ft	FAIL
Axle Length	± 0.5 ft [150mm]	-0.1 ± 0.2 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 0.4 ± 2.6 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 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 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 55 mph. The test runs were divided into three speed groups - low, medium and high speeds, as shown in Table 5-3.

Table 5-3 – Validation Results by Speed – 13-Dec-11

Parameter	95% Confidence Limit of Error	Low	Medium	High
		42.0 to 47.0 mph	47.1 to 52.1 mph	52.2 to 57.0 mph
Steering Axles	±20 percent	-2.7 ± 6.8%	-6.1 ± 5.4%	-6.8 ± 6.9%
Tandem Axles	±15 percent	-0.5 ± 5.0%	-0.4 ± 3.6%	0.6 ± 4.3%
GVW	±10 percent	-0.4 ± 2.5%	-1.3 ± 2.2%	-0.5 ± 3.6%
Vehicle Length	±3.0 percent (2.0 ft)	-11.4 ± 2.0 ft	-11.1 ± 1.3 ft	-11.5 ± 1.5 ft
Vehicle Speed	± 1.0 mph	0.0 ± 2.4 mph	-0.1 ± 2.6 mph	1.3 ± 2.4 mph
Axle Length	± 0.5 ft [150mm]	-0.1 ± 0.3 ft	-0.1 ± 0.2 ft	-0.2 ± 0.2 ft

From the table, it can be seen that, on average, the WIM equipment underestimates all weights at low and medium speeds. At high speeds, the equipment underestimates steering axle weights and GVW. The range in error appears to be greater at the lower and upper ends of the speed range. Underestimation of steering axle weights is consistently higher compared to tandem axles and GVW.

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 estimated GVW with similar bias at all speeds. The range in error was similar throughout the entire speed range. There does not appear to be a correlation between speed and weight estimates at this site.

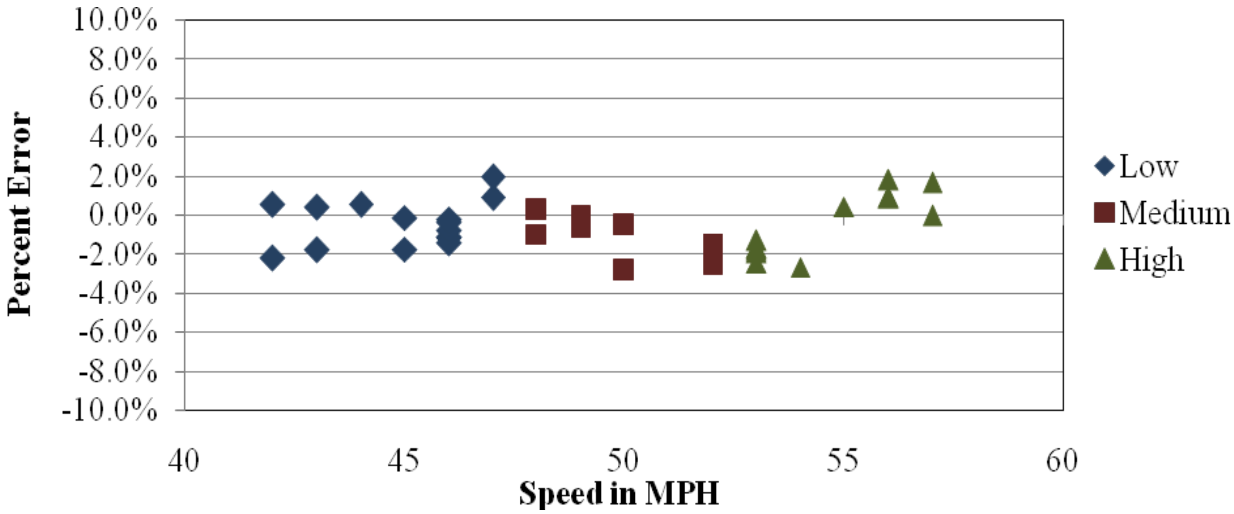


Figure 5-1 – Validation GVW Error by Speed – 13-Dec-11

5.1.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-2, the equipment generally underestimated steering axle weights at all speeds. The range in error and bias were similar at all speeds.

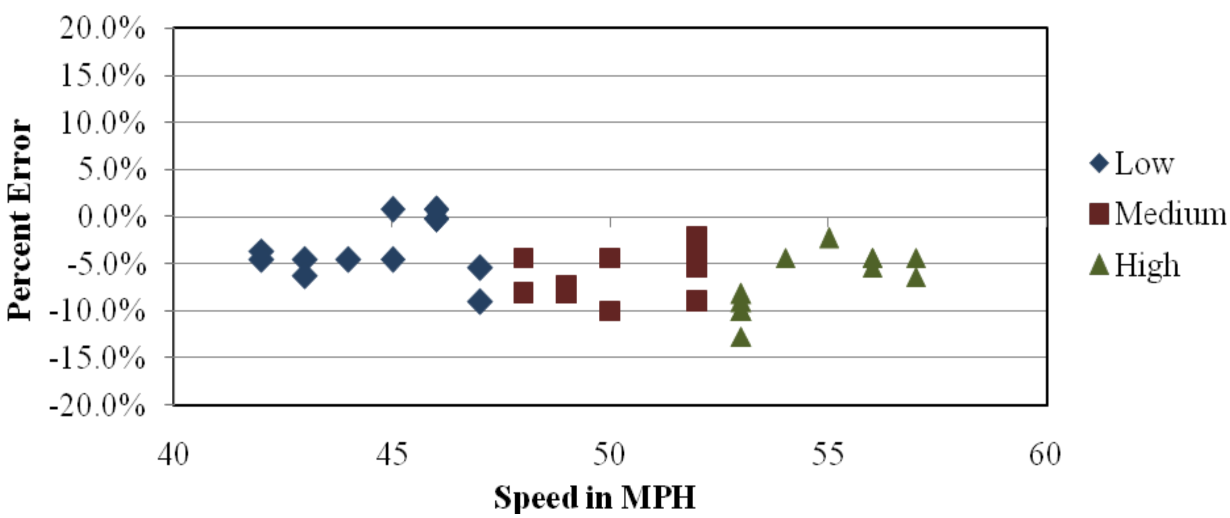


Figure 5-2 – Validation Steering Axle Weight Errors by Speed – 13-Dec-11

5.1.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 5-3, the equipment estimates tandem axle weights with similar accuracy at all speeds. The range in error and bias are similar throughout the entire speed range.

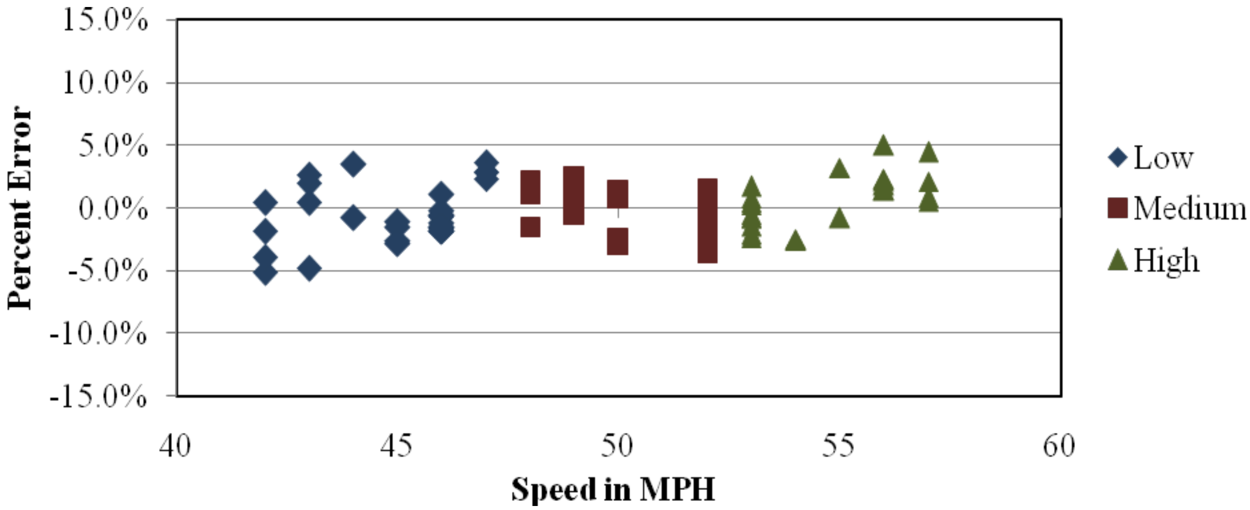


Figure 5-3 – Validation Tandem Axle Weight Errors by Speed – 13-Dec-11

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 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 Figure 5-4.

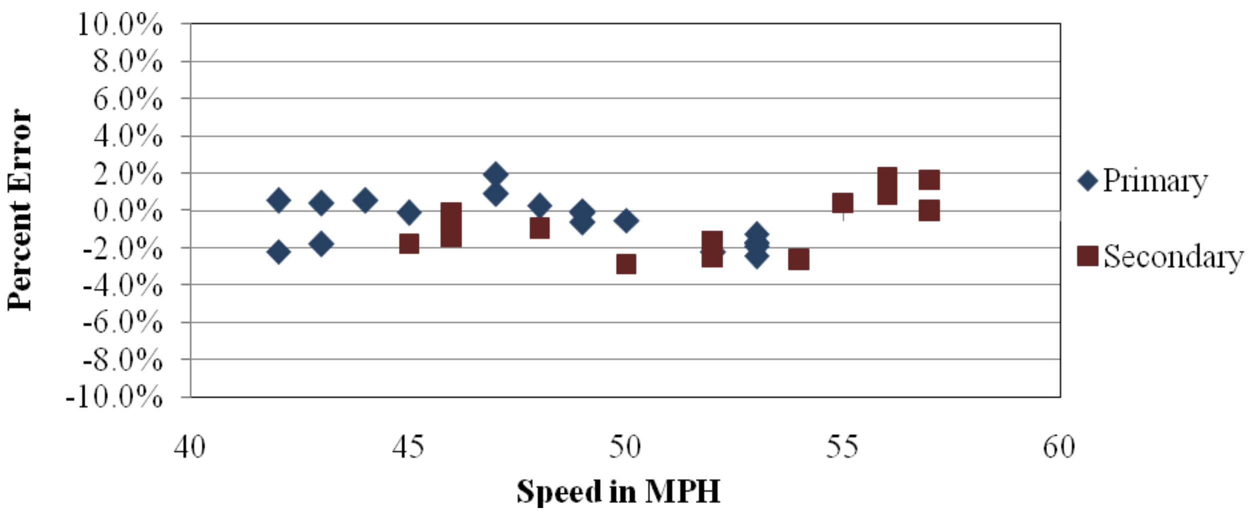


Figure 5-4 – Validation GVW Errors by Truck and Speed – 13-Dec-11

5.1.1.5 Axle Length Errors by Speed

For this site, the equipment generally underestimated axle length at all speeds. The error in axle length measurement error ranged from 0.1 feet to -0.5 feet. Distribution of errors is shown graphically in Figure 5-5.

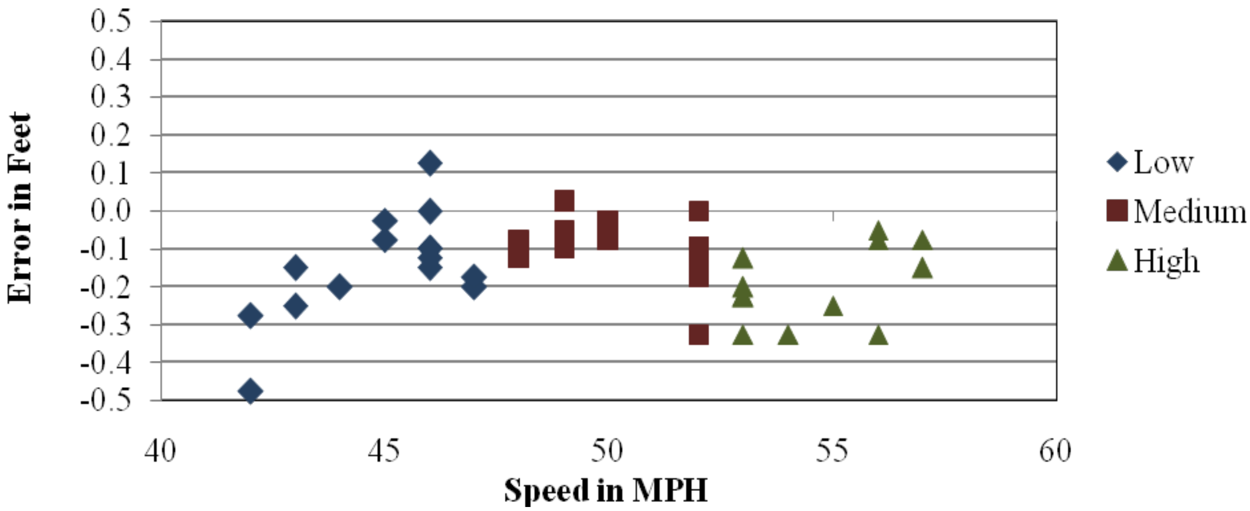


Figure 5-5 – Validation Axle Length Errors by Speed – 13-Dec-11

5.1.1.6 Overall Length Errors by Speed

For this system, the WIM equipment reports axle length as overall vehicle length, and so thereby underestimated overall vehicle length consistently over the entire range of speeds, with an error range of -9.8 feet to -13.1 feet. Distribution of errors is shown graphically in Figure 5-6.

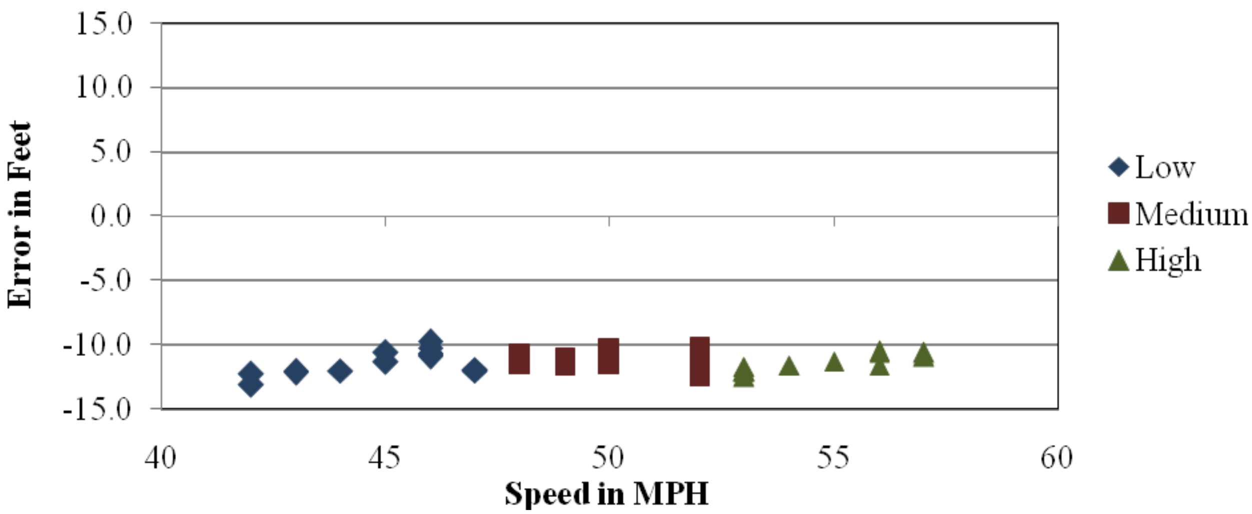


Figure 5-6 – Validation Overall Length Error by Speed – 13-Dec-11

5.1.2 Statistical Temperature Analysis

Statistical analysis was performed for the test truck run data to investigate whether a relationship exists between pavement temperature and WIM equipment weight and distance measurement accuracy. The range of pavement temperatures varied 13.8 degrees, from 25.7 to 39.5 degrees Fahrenheit. Since the desired 30 degree temperature range was not met, the validation test runs are being reported under one temperature groups, as shown in Table 5-4.

Table 5-4 – Validation Results by Temperature – 13-Dec-11

Parameter	95% Confidence Limit of Error	Medium
		25.7 to 39.5 degF
Steering Axles	±20 percent	-5.0 ± 6.9%
Tandem Axles	±15 percent	-0.2 ± 4.3%
GVW	±10 percent	-0.7 ± 2.6%
Vehicle Length	±3.0 percent (2.0 ft)	-11.3 ± 1.5 ft
Vehicle Speed	± 1.0 mph	0.4 ± 2.6 mph
Axle Length	± 0.5 ft [150mm]	-0.1 ± 0.2 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 generally estimates GVW with similar accuracy across the range of temperatures observed in the field.

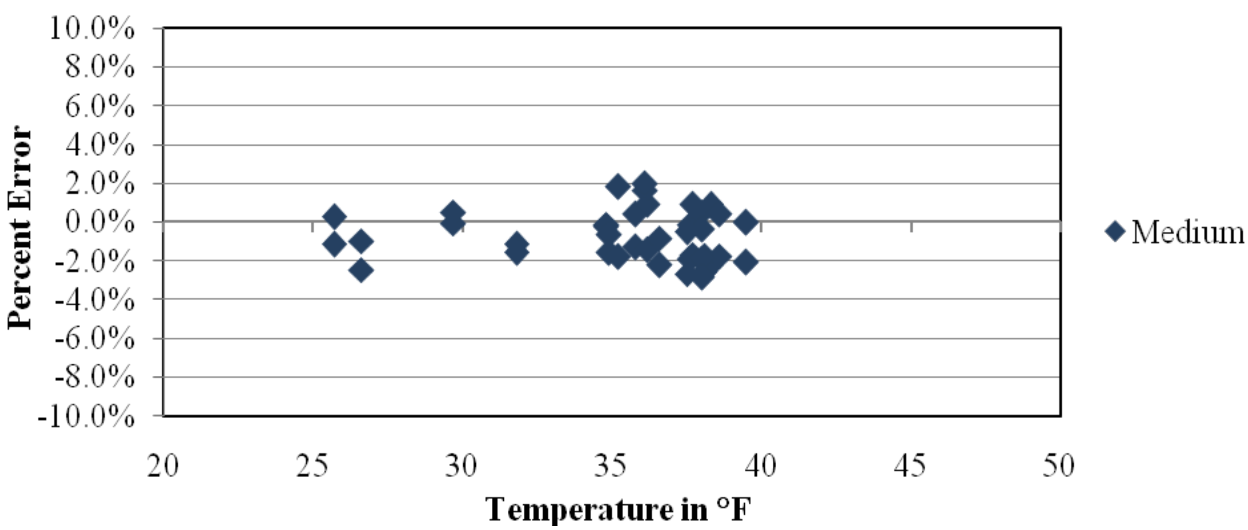


Figure 5-7 – Validation GVW Errors by Temperature – 13-Dec-11

5.1.2.2 Steering Axle Weight Errors by Temperature

Figure 5-8 illustrates that the WIM equipment generally underestimates steering axles weights at all temperatures.

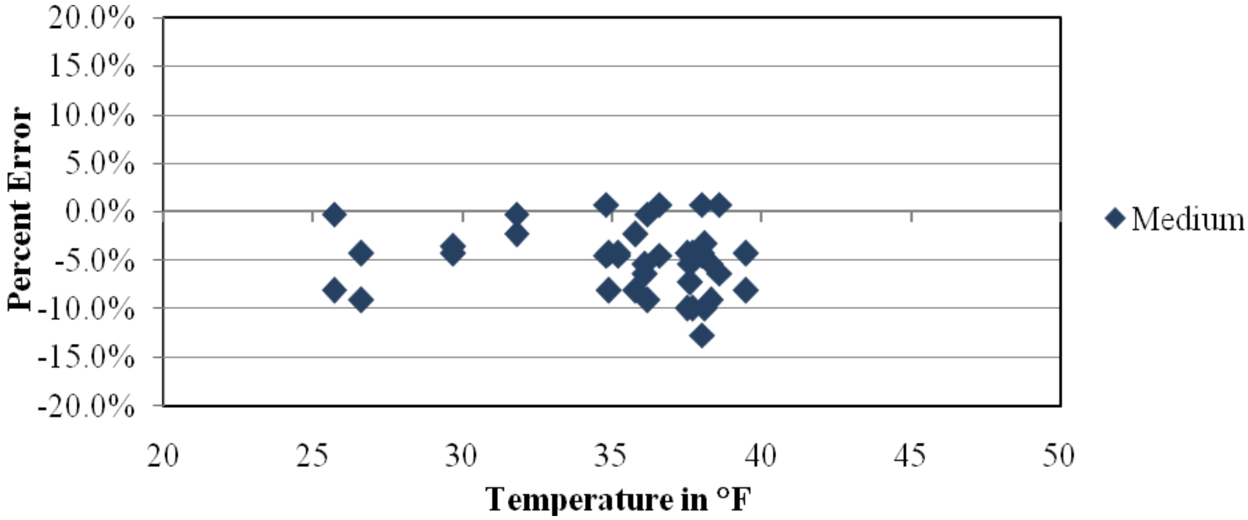


Figure 5-8 – Validation Steering Axle Weight Errors by Temperature – 13-Dec-11

5.1.2.3 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-9, the WIM equipment generally estimates tandem axle weights with similar accuracy across the range of temperatures observed in the field.

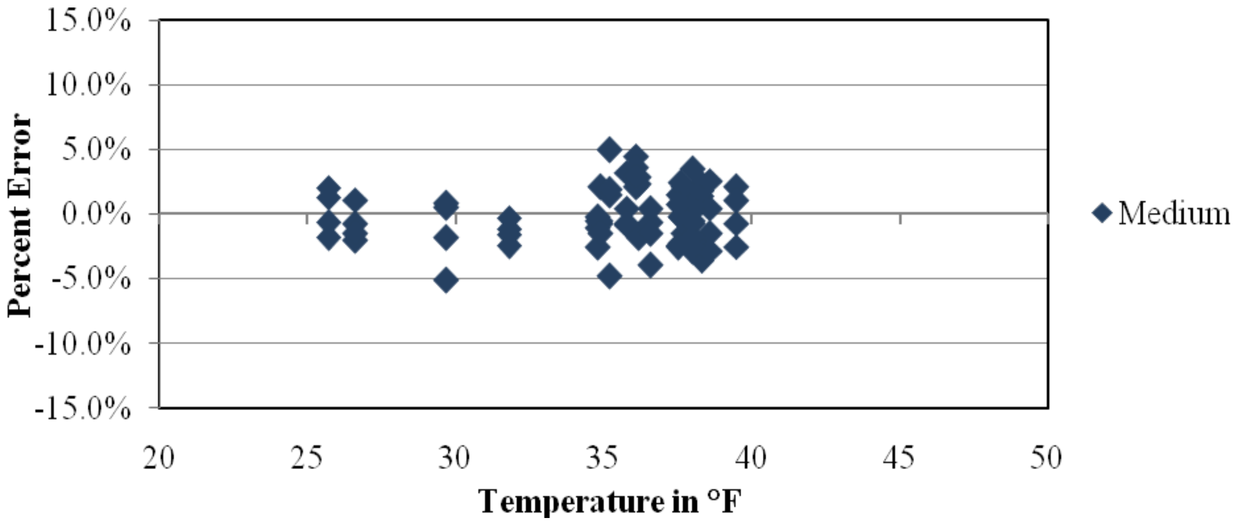


Figure 5-9 – Validation Tandem Axle Weight Errors by Temperature – 13-Dec-11

5.1.2.4 GVW Errors by Temperature and Truck Type

When analyzed for each test truck, it can be seen that the WIM equipment precision and bias is similar for both the heavily loaded (Primary) truck and the partially loaded (Secondary) truck. For both trucks, the range of errors and bias are consistent over the range of temperatures. Distribution of errors is shown graphically in Figure 5-10.

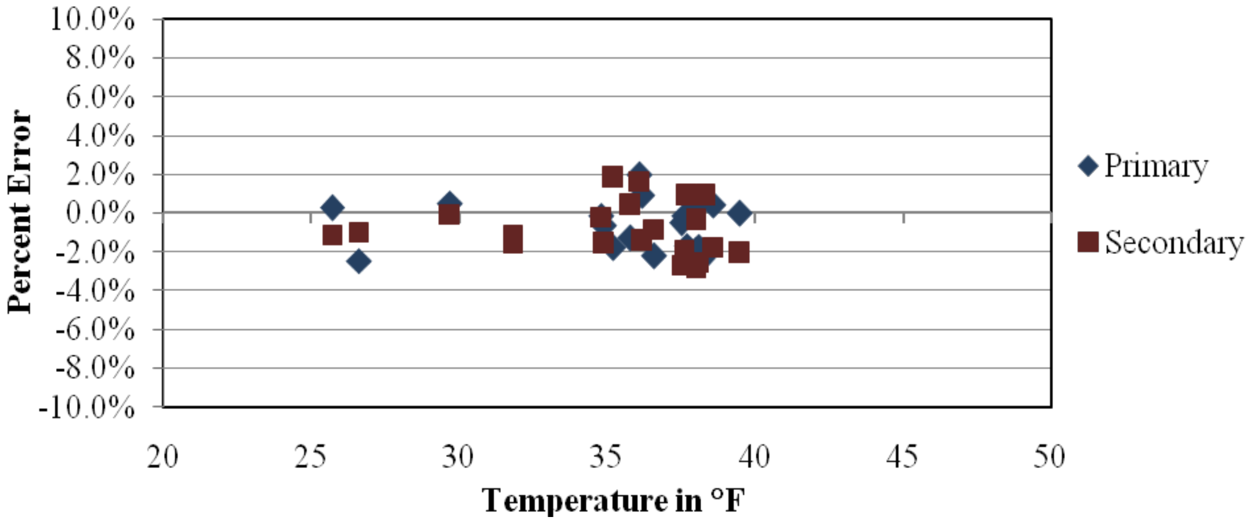


Figure 5-10 – Validation GVW Error by Truck and Temperature – 13-Dec-11

5.1.3 GVW and Steering Axle Trends

Figure 5-11 is provided to illustrate the predicted GVW error with respect to the post-validation errors by speed.

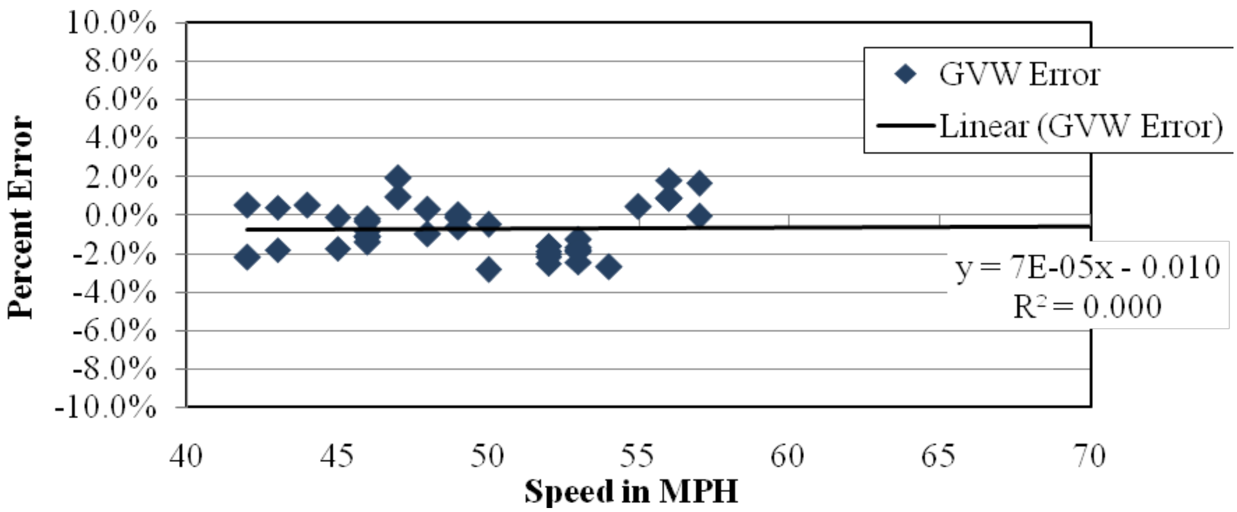


Figure 5-11 – GVW Error Trend by Speed

Figure 5-12 is provided to illustrate the predicted Steering Axle error with respect to the post-validation errors by speed.

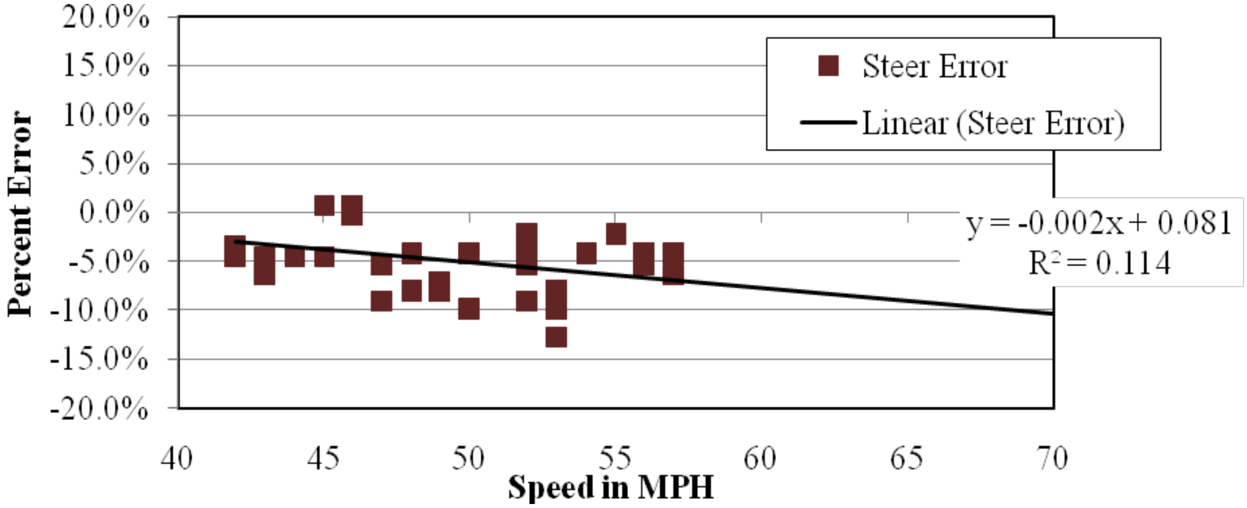


Figure 5-12 – Steering Axle Trend by Speed

5.1.4 Multivariable Analysis

This section provides additional results for the analysis carried out to determine the influence of truck type, speed and pavement temperature on WIM measurement errors. Multivariable linear regression analysis was applied to WIM data collected during calibration procedures. The same calibration data analyzed and discussed previously was used for this analysis; however a more comprehensive statistical methodology was applied. 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 analysis provides additional insight on how factors like speed, temperature, and truck type may affect weight measurement errors for a specific WIM site. It is expected that multivariable analysis done systematically for many sites may reveal overall trends.

5.1.4.1 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 on 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 42 to 57 mph.

- Pavement temperature. Pavement temperature ranged from 25.7 to 39.5 degrees Fahrenheit.

5.1.4.2 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 (speed, temperature, and truck type). The values of the t-distribution (for the regression coefficients) given in Table 5-5 are for the null hypothesis that assumes that the regression coefficients are equal to zero. The p-value reported in Table 5-5 is for the probability that the regression coefficient, given in Table 5-5, is equal to zero.

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

Parameter	Regression coefficients	Standard error	Value of t-distribution	Probability value (p-value)
Intercept	-0.7650	3.0426	-0.2514	0.8029
Speed	0.0179	0.0526	0.3407	0.7353
Temp	-0.0208	0.0564	-0.3681	0.7150
Truck Type	-0.2444	0.4531	-0.5394	0.5929

The lowest probability value in Table 5-5 was 0.5929 for Truck Type. This means that there is about a 59 percent chance that the value of regression coefficient for truck type (-0.2444) can occur by chance alone. Consequently, speed, temperature, and truck type did not have a statistically significant effect on the GVW measurement error.

The relationship between speed and GVW measurement errors is shown in Figure 5-13. The figure includes a trend line for the predicted percent error. Besides the visual assessment of the relationship, Figure 5-13 provides quantification and statistical assessment of the relationship.

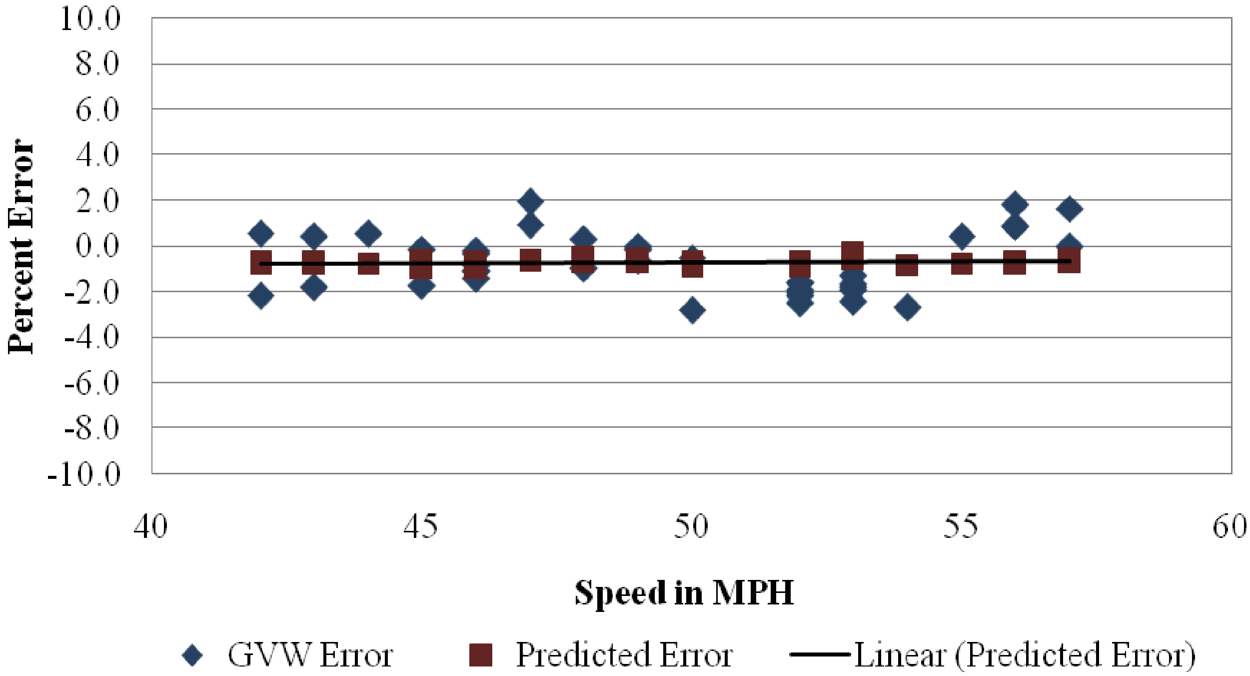


Figure 5-13 – Influence of Speed on the Measurement Error of GVW

The quantification is provided by the value of the regression coefficient, in this case 0.0179 (in Table 5-5). This means, for example, that for a 10 MPH increase in speed, the % error is increased by about 0.2 % (0.0179 x 10). The statistical assessment of the relationship is provided by the probability value of the regression coefficient and is not statistically significant.

5.1.4.3 Summary Results

Table 5-6 lists regression coefficients and their probability values for all combinations of factors and % errors evaluated. 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 (p-value)	Regression coefficient	Probability value (p-value)	Regression coefficient	Probability value (p-value)
GVW	-	-	-	-	-	-
Steering axle	-0.4923	$1.83\ 10^{-11}$	-	-	6.1616	$4.45\ 10^{-16}$
Tandem axle tractor	0.3043	0.0004	-	-	-0.9179	0.1773
Tandem axle trailer	-	-	-	-	-1.1564	0.0839

5.1.4.4 Conclusions

1. Speed had statistically significant effect on the measurement errors of steering axles and tandem axles on the tractors. The effect was positive for the steering axles, and negative for the tandem axles. Consequently, the effect of speed on the GVW measurement errors was not significant.

2. Temperature had no statistically significant effect on measurement errors. However, the range of pavement temperatures was limited to 13.8 °F.

3. Truck type had a statistically significant effect on the measurement errors of steering axles, and marginally statistically significant effect on the measurement error of tandem axles. 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.). For example, the difference in the mean error for steering axle weights for the Primary truck the corresponding error for the Secondary truck. was about 6.2 %.

4. Even though speed and truck type had statistically significant effect on measurement errors, the practical significance of these factors on WIM system calibration tolerances was small and does not affect the validity of the calibration.

5.1.5 Classification and Speed Evaluation

The 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 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.

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 misclassifications by pair are provided in Table 5-7. As shown in the table, a total of 7 vehicles, including 4 heavy trucks (6 – 13) were misclassified by the equipment. Based on the vehicles observed during the validation study, the misclassification percentage is 4.3% for heavy trucks (6 – 13), which is not within the 2.0% acceptability criteria for LTPP SPS WIM sites. The overall misclassification rate for all vehicles (3 – 15) is 7.0%.

Table 5-7 – Validation Misclassifications by Pair – 13-Dec-11

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

As shown in Table 5-7, one Class 5 vehicle was misclassified as a Class 2 vehicle, one Class 5 was misclassified as a Class 7, and another Class 5 vehicle was misclassified as a Class 8 vehicle by the equipment. For heavy trucks, one Class 8 vehicle was misclassified as a Class 4 vehicle, two Class 9 vehicles were misclassified as Class 6 vehicles and one Class 9 was misclassified as a Class 8 by the equipment. The cause of the misclassifications was not investigated in the field. A number of these misclassifications may be attributed to the fact that for this site, vehicle weight is not used in the classification process. The results of misclassification observed at this site raise concerns with the quality of data collected for this site.

Table 5-8 illustrates the breakdown of vehicles observed and identified by the WIM equipment for the manual classification study. The misclassified percentage represents the percentage of the misclassified vehicles in the manual sample. As shown in the table, the combined results produced an undercount of three Class 5 vehicles and three Class 9 vehicles, and an overcount of one Class 4 vehicle, two Class 6 vehicles, and one vehicle each of Classes 7 and 8. The Class 5 vehicle that was misclassified as a Class 2 is not listed as Class 2 vehicle in Table 5-8.

Table 5-8 – Validation Classification Study Results – 13-Dec-11

Class	3	4	5	6	7	8	9	10	11	12	13
Observed Count	0	0	8	2	0	8	80	1	1	0	0
WIM Count	0	1	5	4	1	9	77	1	1	0	0
Observed Percent	0.0	0.0	8.0	2.0	0.0	8.0	80.0	1.0	1.0	0.0	0.0
WIM Percent	0.0	1.0	5.0	4.0	1.0	9.0	77.0	1.0	1.0	0.0	0.0
Misclassified Count	0	0	3	0	0	1	3	0	0	0	0
Misclassified Percent	0.0	0.0	37.5	0.0	0.0	12.5	3.8	0.0	0.0	0.0	0.0
Unclassified Count	0	0	0	0	0	0	0	0	0	0	0
Unclassified Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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 – Validation Unclassified Trucks by Pair – 13-Dec-11

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 -0.5 mph; the range of errors was 3.2 mph.

5.2 Calibration

The validation study demonstrated that the site is currently providing high-quality research type traffic loading data. The mean measurement error for GVW of the two test trucks was -0.7 %. Consequently, no calibration of the equipment compensation factors was required. The WIM equipment does not provide the capability of independently calibrating for errors in steering axle weight or overall vehicle length measurement.

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 five previous visits as well as the current one as summarized in the tables below and provided on the Traffic Sheet 16. Table 6-1 data was extracted from the most recent previous validation and was updated to include the results of this validation. The high frequency of misclassification observed at this site raise concerns with the quality of collected data.

Table 6-1 – Classification Validation History

Date	Misclassification Percentage by Class										Pct Unclass
	4	5	6	7	8	9	10	11	12	13	
14-Apr-04	25	17	67	67	33	6	100	0	0	100	0
15-Apr-04	-	33	20	100	17	5	0	0	-	100	0
11-May-05	100	50	0	0	0	0	0	-	-	-	0
12-May-05	75	54	100	-	0	3	0	0	-	-	0
28-Sep-10	-	22	0	-	0	0	0	0	-	-	0
29-Sep-10	-	-	-	-	-	-	-	-	-	-	0
13-Dec-11	0	38	0	0	13	4	0	0	0	0	0

Table 6-2 data was extracted from the previous validation and was updated to include the results of this validation. The table provides the mean error and standard deviation for GVW, single axles and tandems for prior pre- and post-validations as reported on the LTPP Traffic Sheet 16s. As evidenced from the historical data, this site has a problem with consistent negative bias in steering axle weight measurements, evidenced throughout the years.

Table 6-2 – Weight Validation History

Date	Mean Error and SD		
	GVW	Single Axles	Tandem
14-Apr-04	-2.7 ± 3.6	-6.6 ± 3.7	0.0 ± 5.4
15-Apr-04	-0.8 ± 3.6	-4.6 ± 4.1	-1.5 ± 5.0
11-May-05	2.9 ± 6.2	-1.6 ± 4.9	3.8 ± 7.5
12-May-05	0.3 ± 3.1	-5.1 ± 3.6	1.5 ± 4.6
28-Sep-10	-0.2 ± 1.5	-5.7 ± 2.8	0.8 ± 2.3
29-Sep-10	-0.9 ± 1.9	-5.6 ± 3.4	-0.1 ± 2.8
13-Dec-11	-0.7 ± 1.3	-5.0 ± 3.4	-0.2 ± 2.1

The variability of the weight errors appears to have decreased since the site was first validated. From this information, it appears that the system demonstrates an ability to maintain its calibration over time.

6.2 Comparison of Past Validation Results

A comparison of the post-validation results from previous visits is provided in Table 6-3. The table provides the historical performance of the WIM system with regard to the 95% confidence interval tolerances.

Table 6-3 – Comparison of Post-Validation Results

Parameter	95 %Confidence Limit of Error	Site Values (Mean Error and 95% Confidence Interval)			
		15-Apr-04	12-May-05	29-Sep-10	13-Dec-11
Steering Axles	±20 percent	-4.6 ± 8.4	-5.1 ± 7.3	-5.6 ± 7.0	-5.0 ± 6.9
Tandem Axles	±15 percent	-1.5 ± 10.2	1.5 ± 9.4	-0.1 ± 5.7	-0.2 ± 4.3
GVW	±10 percent	-0.8 ± 7.3	0.3 ± 6.3	-0.9 ± 3.9	-0.7 ± 2.6

From Table 6-3, it appears that the mean error has remained reasonably consistent and the 95% confidence interval has decreased for all weights since the equipment was first validated.

The final factors left in place at the conclusion of the validation are provided in Table 6-4.

Table 6-4 – Final Factors

Parameter	Factor
Heavy -	1.175300
Medium -	1.242105

A review of the LTPP Standard Release Database 24 shows that there are 2 years 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
- Validation Sheet 16 – Site Calibration Summary
- 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 – Validation 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

Ohio, SPS-2
SHRP ID: 390200

Validation Date: December 13, 2011

Photo 1 – Cabinet Exterior

Photo 2 – Cabinet Interior (Top)

Photo 3 – Cabinet Interior (Bottom)

Photo 4 – Leading Loop

Photo 5 – Leading WIM Sensor

Photo 6 – Trailing WIM Sensor

Photo 7 – Telephone Pedestal

Photo 8 – Downstream

Photo 9 – Upstream

Photo 10 – Truck 1

Photo 11 – Truck 1 Tractor

Photo 12 – Truck 1 Trailer and Load

Photo 13 – Truck 1 Suspension 1

Photo 14 – Truck 1 Suspension 2

Photo 15 – Truck 1 Suspension 3

Photo 16 – Truck 1 Suspension 4

Photo 17 – Truck 1 Suspension 5

Photo 18 – Truck 2

Photo 19 – Truck 2 Tractor

Photo 20 – Truck 2 Trailer and Load

Photo 21 – Truck 2 Suspension 1

Photo 22 – Truck 2 Suspension 2

Photo 23 – Truck 2 Suspension 3

Photo 24 – Truck 2 Suspension 4

Photo 25 – Truck 2 Suspension 5

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 39 SPS WIM ID: 390200 DATE (mm/dd/yyyy) 12/13/2011

SITE CALIBRATION INFORMATION

1. **DATE OF CALIBRATION** {mm/dd/yy} 12/13/11

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. Load Cells d.

5. **EQUIPMENT MANUFACTURER:** Mettler

WIM SYSTEM CALIBRATION SPECIFICS

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

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

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

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

Mean Difference Between -

Dynamic and Static GVW:	-0.7%	Standard Deviation:	1.3%
Dynamic and Static Single Axle:	-5.0%	Standard Deviation:	3.4%
Dynamic and Static Double Axles:	-0.2%	Standard Deviation:	2.1%

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

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

			Low		High	Runs
a.	Low	-	42.0	to	47.0	15
b.	Medium	-	47.1	to	52.1	13
c.	High	-	52.2	to	57.0	12
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: SPS WIM ID: DATE (mm/dd/yyyy)	39 390200 12/13/2011

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 1.1753

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

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

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:	-4.0	FHWA Class		-	
FHWA Class 8:		FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 0.0%

Validation Test Truck Run Set - Pre

Person Leading Calibration Effort:

Contact Information: Phone:

E-mail:

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 39 SPS WIM ID: 390200 DATE (mm/dd/yyyy) 12/13/2011

Count - 100 Time = 1:09:07 Trucks (4-15) - 100 Class 3s - 0

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
59	9	6033	60	9	56	9	6493	59	9
57	9	6112	58	9	53	5	6525	52	5
63	9	6146	62	9	55	9	6532	55	9
55	9	6159	55	9	58	9	6541	58	9
56	9	6169	53	9	47	9	6549	48	9
56	9	6199	58	9	54	5	6553	55	5
61	9	6213	60	9	53	9	6594	54	9
57	9	6219	56	9	55	9	6598	55	9
55	9	6237	53	9	55	9	6602	55	9
55	9	6252	55	9	56	9	6618	58	9
56	11	6256	54	11	57	9	6626	56	9
37	9	6295	37	9	55	9	6639	54	9
36	**6**	**6311**	**53**	**9**	53	9	6641	54	9
57	9	6331	56	9	54	9	6650	53	9
57	6	6350	55	6	59	9	6658	60	9
57	9	6359	58	9	57	9	6666	59	9
56	9	6370	55	9	55	9	6678	55	9
59	8	6376	60	8	59	8	6684	59	8
57	9	6414	56	9	56	9	6701	55	9
58	9	6417	58	9	55	9	6705	57	9
54	9	6441	55	9	56	9	6719	56	9
56	5	6443	56	5	**59**	**8**	**6738**	**58**	**9**
55	8	6468	53	8	60	9	6743	60	9
53	9	6473	54	9	58	9	6745	57	9
55	9	6490	54	9	59	9	6760	59	9

Sheet 1 - 0 to 50 Start: 9:23:09 Stop: 9:59:48

Recorded By: djw Verified By: ar

Validation Test Truck Run Set - Pre

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 39 SPS WIM ID: 390200 DATE (mm/dd/yyyy) 12/13/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
64	9	6778	62	9	57	9	7074	56	9
59	9	6791	59	9	58	9	7105	56	9
57	9	6792	59	9	48	9	7110	48	9
60	9	6814	61	9	55	9	7125	56	9
57	8	6820	55	8	59	9	7135	60	9
57	9	6827	59	9	48	8	7162	50	8
57	9	6846	56	9	55	9	7189	54	9
55	9	6848	54	9	55	8	7191	56	8
37	**6**	**6854**	**54**	**9**	57	10	7217	58	10
57	9	6877	56	9	57	9	7224	56	9
60	9	6914	60	9	61	9	7228	61	9
58	5	6921	60	5	59	9	7240	59	9
56	9	6925	57	9	58	9	7250	60	9
57	9	6929	58	9	52	9	7257	51	9
58	9	6939	59	9	58	5	7271	57	5
55	9	6949	54	9	50	6	7293	50	6
56	9	6956	54	9	**56**	**2**	**7304**	**55**	**5**
40	**4**	**6974**	**54**	**8**	56	9	7322	56	9
55	9	6976	55	9	57	9	7338	55	9
54	9	6980	54	9	56	9	7346	55	9
55	**8**	**6986**	**53**	**5**	59	9	7377	59	9
56	8	7006	56	8	54	9	7415	53	9
59	9	7011	58	9	55	9	7420	54	9
42	**7**	**7018**	**54**	**5**	54	9	7448	54	9
54	9	7049	53	9	52	9	7453	53	9

Sheet 2 - 51 to 100 Start: 10:00:40 Stop: 10:32:16

Recorded By: djw Verified By: ar

Validation Test Truck Run Set - Pre