WIM System Field Calibration and Validation Summary Report

Ohio SPS-1
SHRP ID – 390100

Validation Date: December 13, 2011
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1 Executive Summary

A WIM validation was performed on December 13, 2011 at the Ohio SPS-1 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 southbound, righthand driving lane. The site is equipped with load cell WIM sensors and Mettler 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 May 12, 2005 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, a pavement transition was noted approximately 170 feet prior to the WIM scales. The adverse truck dynamics created by the transition appeared to diminish prior to the trucks crossing over the WIM scales and therefore 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 affected by excessive negative bias (-4.7%). The summary results of the validation are provided in Table 1-1 below. As shown in the table, this site is not providing research quality data for vehicle length which could lead to misclassification and atypical weights reported for some vehicle classes.

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

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-4.7 ± 4.7%	Pass
Tandem Axles	±15 percent	-0.5 ± 5.2%	Pass
GVW	±10 percent	-1.3 ± 3.6%	Pass
Vehicle Length	±3.0 percent (2.0 ft)	-11.4 ± 1.1 ft	FAIL
Axle Length	± 0.5 ft [150mm]	-0.2 ± 0.2 ft	Pass

Truck speeds were manually collected for each test run by a radar gun and compared with the speed reported by the WIM equipment. For this site, the error in speed measurement was 0.3 ± 2.3 mph, which is greater than the ±1.0 mph tolerance established by the LTPP Field Operations Guide for SPS WIM Sites. However, since the site is measuring axle spacing length with a mean error of -0.2 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.

Based on a sample of classification data collected, this site is providing research quality vehicle classification data for heavy trucks (Class 6 – 13). The heavy truck misclassification rate of 1.2% is within the 2.0% acceptability criterion for LTPP SPS WIM sites. The overall misclassification rate of 4.9% from the 100 truck sample (Class 4 – 13) was primarily due to the cross-classifications of Class 2, 3, 5, and 8 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 43 to 56 mph, a difference of 13 mph.

During test truck runs, pavement temperature was collected using a hand-held infrared temperature device. The post-validation pavement surface temperatures varied from 26.6 to 39.5 degrees Fahrenheit, a range of 12.9 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 4 years of level “E” WIM data for this site. This site requires at least 1 additional year 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 4 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	282	12
2005	202	8
2006	245	11
2007	59	3
2009	235	9
2010	338	12
2011	92	4

As shown in the table, this site requires 1 additional year of data to meet the minimum of five years of research quality data. The data does not meet the 210-day minimum requirement for a calendar year for years 2005, 2007 and 2011.

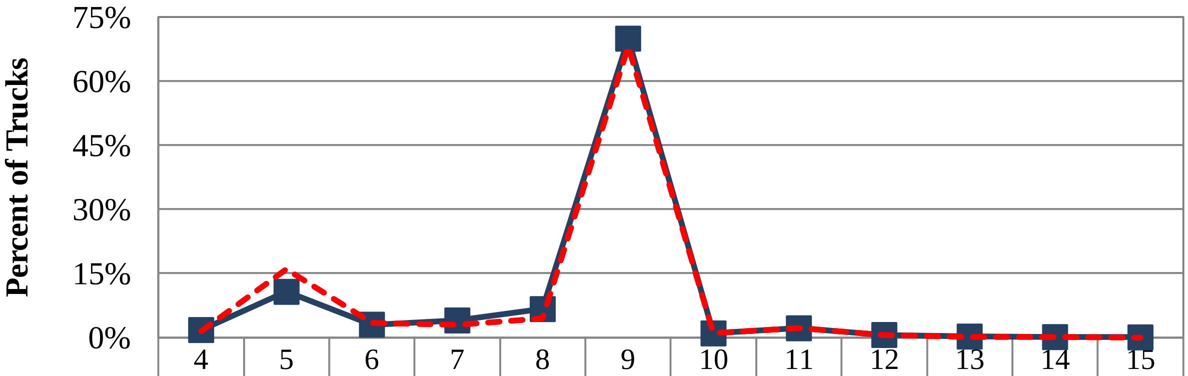
Table 2-2 provides a monthly breakdown of the available data for years 2004 through 2011.

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	29	28	17	24	24	13	27	24	23	25	28	20	12
2005					16	28	24	26	28	28	27	25	8
2006	25	26	17	12	26	11	22	30		24	25	27	11
2007	26	15	18										3
2009				30	25	21	11	31	30	26	30	31	9
2010	30	28	29	30	30	29	30	16	29	30	26	31	12
2011	29	27	8			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	1.7%	10.7%	3.0%	4.0%	6.6%	70.0%	0.9%	2.2%	0.6%	0.2%	0.1%	0.0%
CDS	1.4%	16.0%	3.4%	2.9%	4.4%	68.1%	1.0%	2.2%	0.5%	0.0%	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 (70.0%) and Class 5 (10.7%). 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	726	1.4%	405	1.7%	0.4%
5	8550	16.0%	2489	10.7%	-5.3%
6	1835	3.4%	697	3.0%	-0.4%
7	1530	2.9%	928	4.0%	1.1%
8	2353	4.4%	1547	6.6%	2.2%
9	36384	68.1%	16300	70.0%	1.9%
10	536	1.0%	221	0.9%	-0.1%
11	1177	2.2%	501	2.2%	-0.1%
12	284	0.5%	135	0.6%	0.0%
13	26	0.0%	49	0.2%	0.2%
14	12	0.0%	20	0.1%	0.1%
15	0	0.0%	4	0.0%	0.0%

From the table it can be seen that the number of Class 9 vehicles has increased by 1.9 percent from September 2010 and November 2011. Changes in the number of heavier trucks may be attributed to seasonal variations in truck distributions or natural variations in truck volumes. During the same time period, the number of Class 5 trucks decreased by 5.3 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 Phase II Contractor 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.

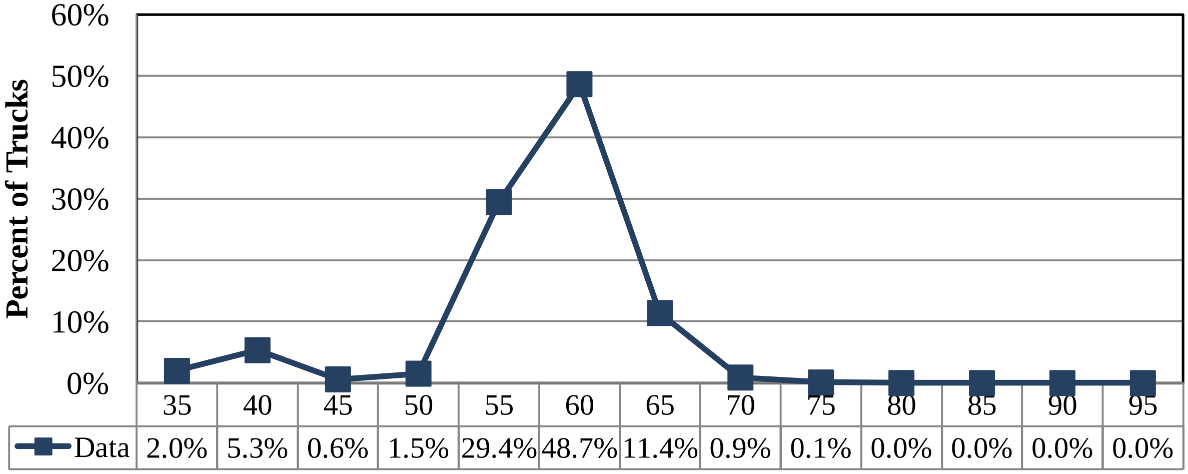


Figure 2-2 – Truck Speed Distribution

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 55 to 65 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 slight increase for the unloaded peak between the September 2010 Comparison Data Set (CDS) and the November 2011 two-week sample W-card dataset (Data).

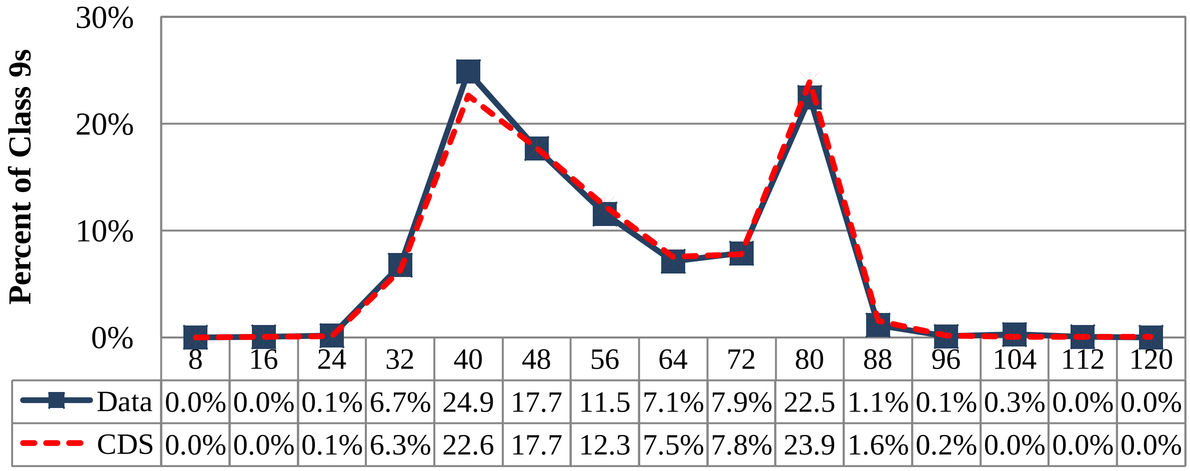


Figure 2-3 – Comparison of Class 9 GVW Distribution

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

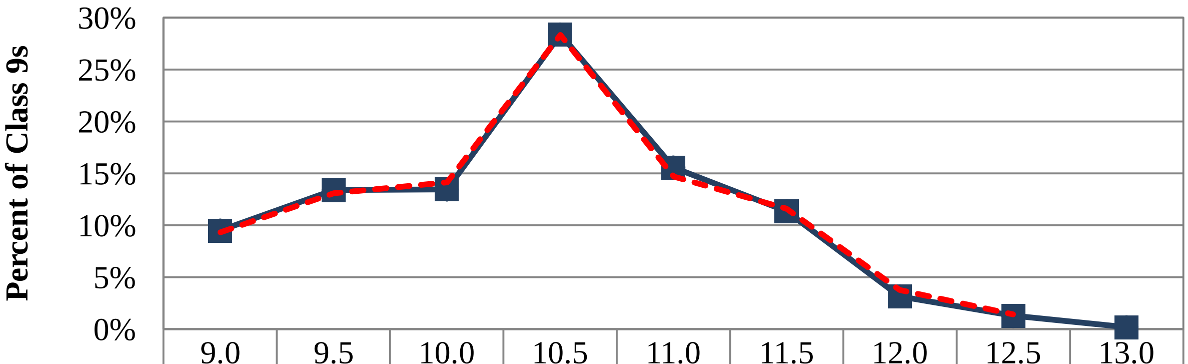
GVW weight bins (kips)	CDS		Data		Change
	Date				
	9/24/2010		11/15/2011		
8	0	0.0%	0	0.0%	0.0%
16	5	0.0%	6	0.0%	0.0%
24	29	0.1%	24	0.1%	0.0%
32	1648	6.3%	1094	6.7%	0.5%
40	5954	22.6%	4033	24.9%	2.3%
48	4671	17.7%	2867	17.7%	-0.1%
56	3231	12.3%	1871	11.5%	-0.7%
64	1977	7.5%	1154	7.1%	-0.4%
72	2044	7.8%	1276	7.9%	0.1%
80	6302	23.9%	3643	22.5%	-1.5%
88	409	1.6%	184	1.1%	-0.4%
96	41	0.2%	11	0.1%	-0.1%
104	8	0.0%	41	0.3%	0.2%
112	5	0.0%	8	0.0%	0.0%
120	4	0.0%	0	0.0%	0.0%
Average =	53.6 kips		52.6 kips		-1.0 kips

As shown in the table, the number of unloaded class 9 trucks in the 32 to 40 kips range increased by 2.3 percent while the number of loaded class 9 trucks in the 72 to 80 kips range decreased by 1.5 percent. During this time period the number of overweight trucks decreased by 0.3 percent. Based on the average Class 9 GVW values from the per vehicle records, the GVW average for this site decreased by 1.9 percent, from 53.6 kips to 52.6 kips 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 0.3% and the percentages of heavy axles (11.0 to 11.5 kips) increased by approximately 0.9%.



	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0
Data	9.5%	13.4%	13.5%	28.4%	15.6%	11.4%	3.2%	1.3%	0.2%
CDS	9.3%	13.1%	14.1%	28.3%	14.7%	11.6%	3.8%	1.4%	

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 10.5 and 11.0 kips. The percentage of trucks in this range has increased 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

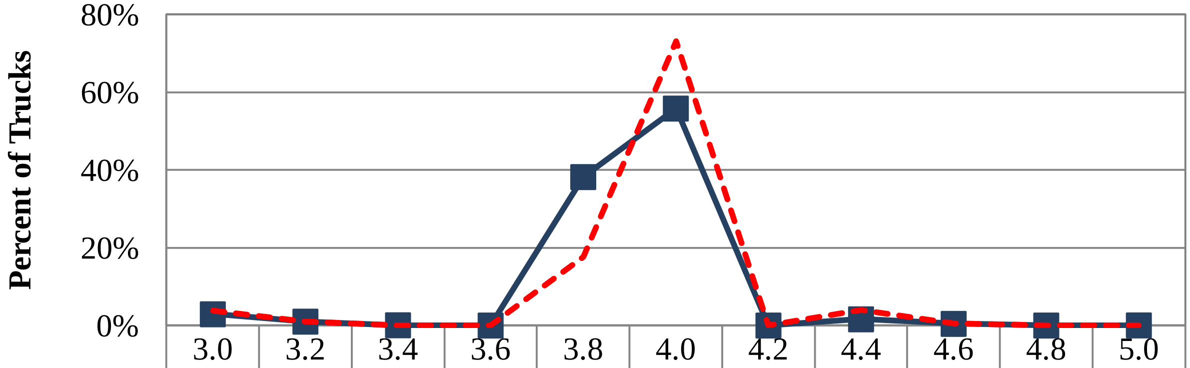
F/A weight bins (kips)	CDS		Data		Change
	Date				
	9/24/2010		11/15/2011		
9.0	898	3.4%	588	3.6%	0.2%
9.5	2443	9.3%	1538	9.5%	0.2%
10.0	3440	13.1%	2170	13.4%	0.3%
10.5	3713	14.1%	2178	13.5%	-0.7%
11.0	7436	28.3%	4594	28.4%	0.1%
11.5	3859	14.7%	2521	15.6%	0.9%
12.0	3055	11.6%	1842	11.4%	-0.2%
12.5	995	3.8%	513	3.2%	-0.6%
13.0	366	1.4%	206	1.3%	-0.1%
13.5	62	0.2%	31	0.2%	0.0%
Average =	10.6 kips		10.6 kips		0.0 kips

The table shows that the average front axle weight for Class 9 trucks has not changed. According to the values from the per vehicle records, the average front axle weight for Class 9 trucks is 10.6 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	2.9%	1.0%	0.1%	0.0%	38.2%	55.8%	0.0%	1.6%	0.4%	0.0%	0.0%
CDS	3.8%	1.0%	0.0%	0.0%	17.6%	73.1%	0.0%	3.9%	0.5%	0.0%	0.1%

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 shifted to the left, indicating a possible shift in the distance measurement calibration for the system.

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				
	9/24/2010		11/15/2011		
3.0	998	3.8%	469	2.9%	-0.9%
3.2	275	1.0%	162	1.0%	0.0%
3.4	6	0.0%	11	0.1%	0.0%
3.6	0	0.0%	0	0.0%	0.0%
3.8	4626	17.6%	6190	38.2%	20.6%
4.0	19241	73.1%	9047	55.8%	-17.3%
4.2	0	0.0%	0	0.0%	0.0%
4.4	1027	3.9%	259	1.6%	-2.3%
4.6	135	0.5%	69	0.4%	-0.1%
4.8	0	0.0%	0	0.0%	0.0%
5.0	20	0.1%	5	0.0%	0.0%
Average =	3.9 feet		3.8 feet		-0.1 feet

From the table it can be seen that the highest percentage of drive tandem spacing of 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 3.8 feet, which is below to the expected average of 3.9 feet from the CDS per vehicle records. Further axle spacing 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 (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 1.9 percent increase in the number of Class 9 vehicles. Analysis of Class 9 weight data indicates that front axle weights have not changed, and average Class 9 GVW has decreased by 1.9 percent for the November 2011 data. The data indicates an average truck tandem spacing of 3.8 feet, which is below 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 May 12, 2005 and this validation visit, it appears that no changes have occurred during this time to the basic operating condition of the equipment. On June 17, 2011, Ohio DOT had all fasteners replaced and repaired and replaced three LC bolts for the leading WIM scale in the LTPP lane.

3.1 Description

This site was installed on March 15, 1996 by Ohio DOT. It is instrumented with load cell weighing sensors and a Mettler-Toledo WIM Controller. As the installation contractor, the 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 and the 400 foot approach section is 273 in/mi and is located approximately 171 feet prior to the WIM scale. This area of the pavement was closely investigated during the validation visit, and truck dynamics in this area were closely observed. Asphalt to PCC pavement transition was noted in this area as shown in Photo 1 and Photo 2. Although the distress observed at this location is considered severe by LTPP Pavement Distress standards, the adverse truck dynamics created by the transition appeared to diminish prior to the trucks crossing over the WIM scale area.

Photo 1 – Asphalt to PCC Pavement Transition – Southbound

Photo 2 – Asphalt to PCC Pavement Transition – LTPP Lane

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**	**Pass 5**	**Avg**
Left	LWP	LRI (m/km)	1.119	1.157	1.100			1.125
		SRI (m/km)	0.993	0.999	0.938			0.977
		Peak LRI (m/km)	***2.111***	***2.128***	***2.170***			***2.136***
		Peak SRI (m/km)	1.203	1.212	1.111			1.175
	RWP	LRI (m/km)	1.007	0.994	1.082			1.028
		SRI (m/km)	1.310	1.210	1.404			1.308
		Peak LRI (m/km)	1.203	1.289	1.756			1.416
		Peak SRI (m/km)	1.789	1.655	1.965			1.803
Center	LWP	LRI (m/km)	1.199	1.172	1.306	1.275	1.152	1.238
		SRI (m/km)	1.000	1.007	0.783	0.847	1.020	0.909
		Peak LRI (m/km)	1.830	1.806	1.799	1.873	1.809	1.827
		Peak SRI (m/km)	1.521	1.491	1.424	1.493	1.511	1.482
	RWP	LRI (m/km)	1.355	0.969	0.852	0.838	0.915	1.004
		SRI (m/km)	*2.947*	1.087	0.987	0.982	1.144	1.501
		Peak LRI (m/km)	1.779	1.881	1.813	1.853	1.866	1.832
		Peak SRI (m/km)	*3.204*	1.339	1.383	1.349	1.280	1.819
Right	LWP	LRI (m/km)	1.244	1.177	1.237			1.219
		SRI (m/km)	1.219	1.126	1.247			1.197
		Peak LRI (m/km)	1.468	1.348	1.498			1.438
		Peak SRI (m/km)	1.746	1.754	1.813			1.771
	RWP	LRI (m/km)	0.962	0.926	1.041			0.976
		SRI (m/km)	1.324	1.142	1.430			1.299
		Peak LRI (m/km)	1.831	1.987	1.831			1.883
		Peak SRI (m/km)	1.374	1.205	1.494			1.358

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 over the upper threshold. Indices that are above the upper thresholds are shown in italics. The highest values, on average, are the Peak LRI values in the left wheel path of the left shift passes (shown in bold and italics).

4.4 Recommended Pavement Remediation

Pavement remediation at the asphalt to PCC pavement transition 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 9:04 AM and continuing until 3:31 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 13 mph, from 43 to 56 mph. The measured validation pavement temperatures varied 12.9 degrees Fahrenheit, from 26.6 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	-4.7 ± 4.7%	Pass
Tandem Axles	±15 percent	-0.5 ± 5.2%	Pass
GVW	±10 percent	-1.3 ± 3.6%	Pass
Vehicle Length	±3.0 percent (2.0 ft)	-11.4 ± 1.1 ft	FAIL
Axle Length	± 0.5 ft [150mm]	-0.2 ± 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 0.3 ± 2.3 mph, which is greater than the ±1.0 mph tolerance established by the LTPP Field Guide. However, since the site is measuring axle spacing length with a mean error of -0.2 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
		43.0 to 47.3 mph	47.4 to 51.8 mph	51.9 to 56.0 mph
Steering Axles	±20 percent	-4.3 ± 5.3%	-5.0 ± 5.0%	-4.8 ± 5.1%
Tandem Axles	±15 percent	-0.5 ± 6.2%	-2.0 ± 5.0%	0.3 ± 3.8%
GVW	±10 percent	-1.3 ± 4.8%	-2.5 ± 3.8%	-0.6 ± 1.5%
Vehicle Length	±3.0 percent (2.0 ft)	-11.4 ± 0.9 ft	-11.7 ± 1.0 ft	-11.2 ± 1.5 ft
Vehicle Speed	± 1.0 mph	0.1 ± 2.4 mph	-0.1 ± 1.7 mph	0.6 ± 2.9 mph
Axle Length	± 0.5 ft [150mm]	-0.2 ± 0.2 ft	-0.3 ± 0.2 ft	-0.1 ± 0.3 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 slightly greater at the lower and medium speed ranges.

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 tend to underestimateGVW at all speeds, with highest underestimation at medium speed. The range in error is higher at low and medium speeds when compared to high speed.

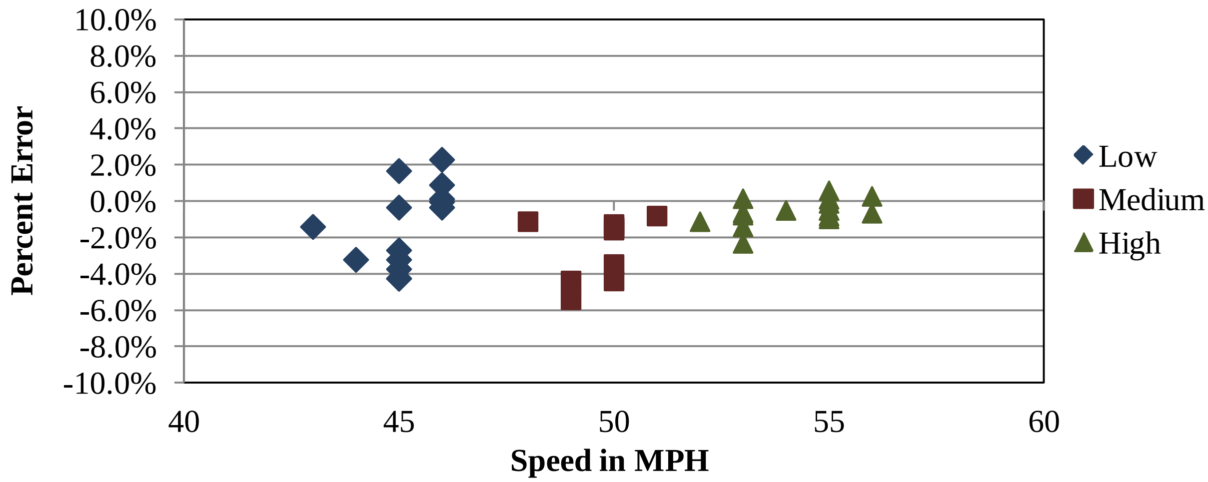


Figure 5-1 – Validation GVW Error by Speed – 13-Dec-11

5.1.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-2, the equipment consistently underestimates steering axle weights at all speeds. The range in error and bias are similar at all speeds.

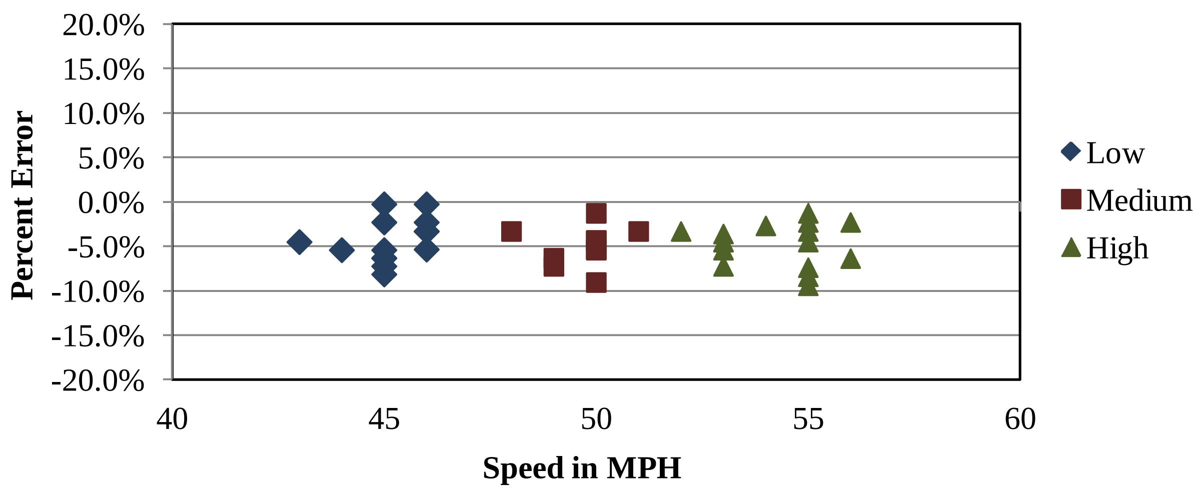


Figure 5-2 – Validation Steering Axle Weight Errors by Speed – 13-Dec-11

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 is slightly higher at low speeds when compared to medium and high speeds.

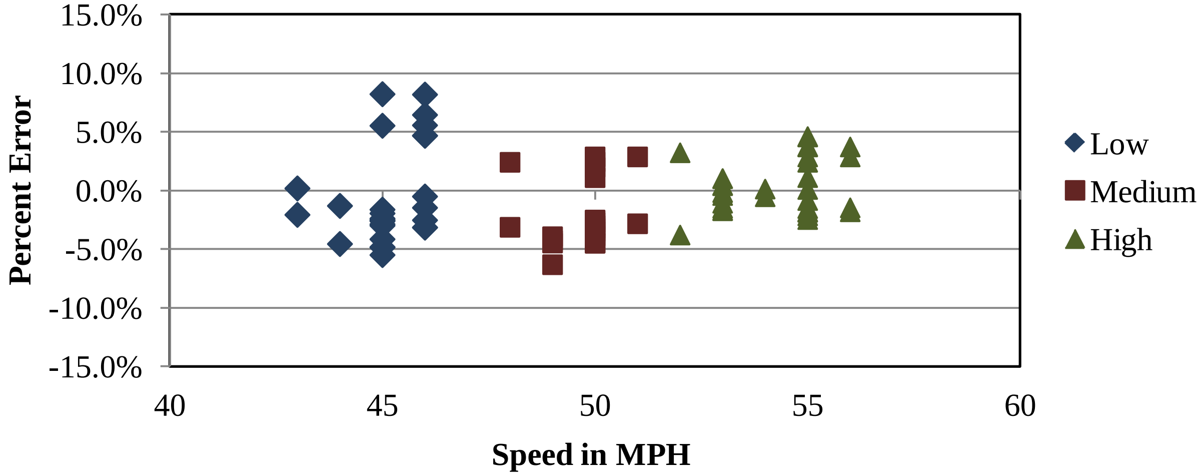


Figure 5-3 – Validation Tandem Axle Weight Errors by Speed – 13-Dec-11

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 underestimates GVW for the heavily loaded (Primary) truck at the low and medium speeds. Equipment precision and bias is similar at the high speeds. Distribution of errors is shown graphically in Figure 5-4.

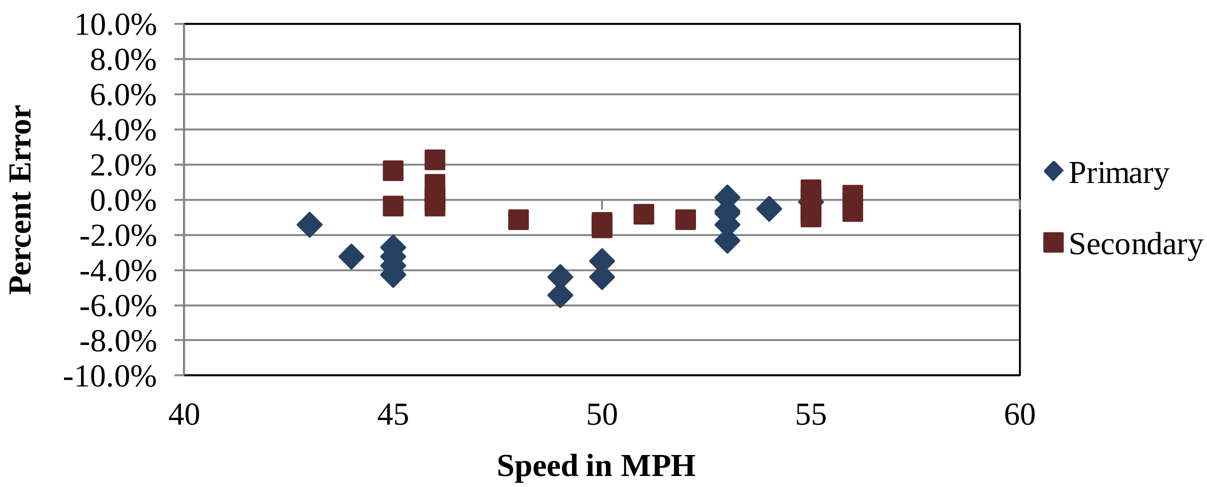


Figure 5-4 – Validation GVW Errors by Truck and Speed – 13-Dec-11

5.1.1.5 Axle Length Errors by Speed

For this site, the equipment slightly underestimated axle length measurement at all speeds. The range in axle length measurement error ranged from 0.0 feet to -0.4 feet. Distribution of errors is shown graphically in Figure 5-5.

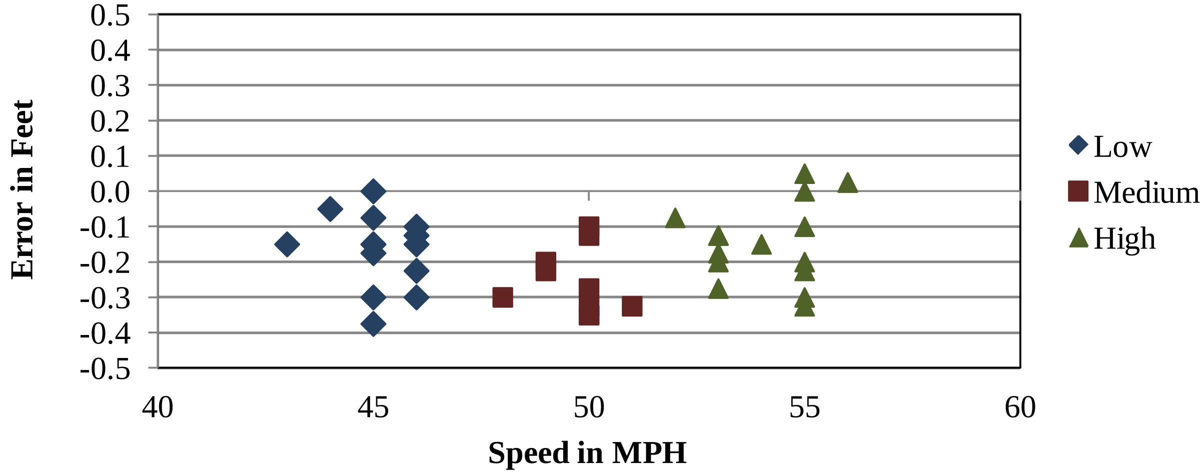


Figure 5-5 – Validation Axle Length Errors by Speed – 13-Dec-11

5.1.1.6 Overall Length Errors by Speed

For this system, the WIM equipment reports axle length as overall vehicle length, which caused the equipment to demonstrate a significant underestimation of overall vehicle length, with an error range of -10.1 feet to -12.5 feet.

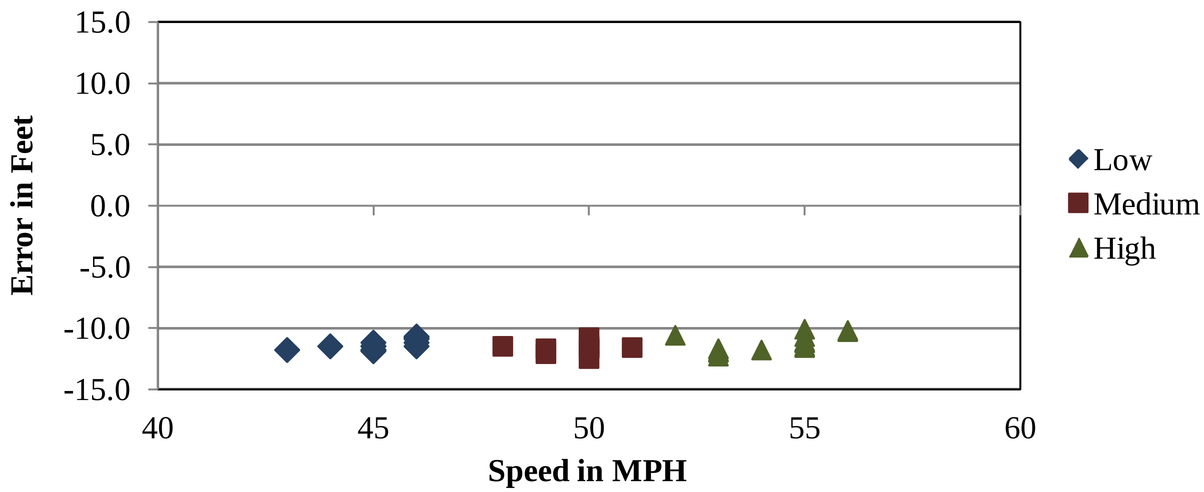


Figure 5-6 – Validation Overall Length Error by Speed – 13-Dec-11

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 only 12.9 degrees, from 26.6 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 group, as shown in Table 5-4.

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

Parameter	95% Confidence Limit of Error	Medium 26.6 to 39.5 degF
Steering Axles	±20 percent	-4.7 ± 4.7%
Tandem Axles	±15 percent	-0.5 ± 5.2%
GVW	±10 percent	-1.3 ± 3.6%
Vehicle Length	±3.0 percent (2.0 ft)	-11.4 ± 1.1 ft
Vehicle Speed	± 1.0 mph	0.3 ± 2.3 mph
Axle Length	± 0.5 ft [150mm]	-0.2 ± 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, on average, underestimated GVW with across the range of temperatures observed in the field.

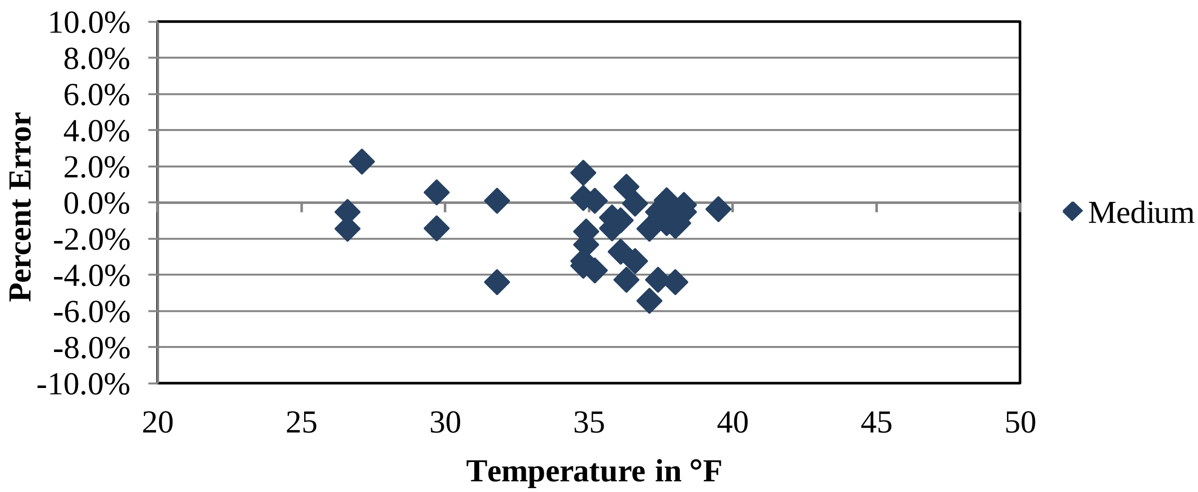


Figure 5-7 – Validation GVW Errors by Temperature – 13-Dec-11

5.1.2.2 Steering Axle Weight Errors by Temperature

Figure 5-8 illustrates that for steering axles, the WIM equipment underestimates steering axle weights across the range of temperatures observed in the field.

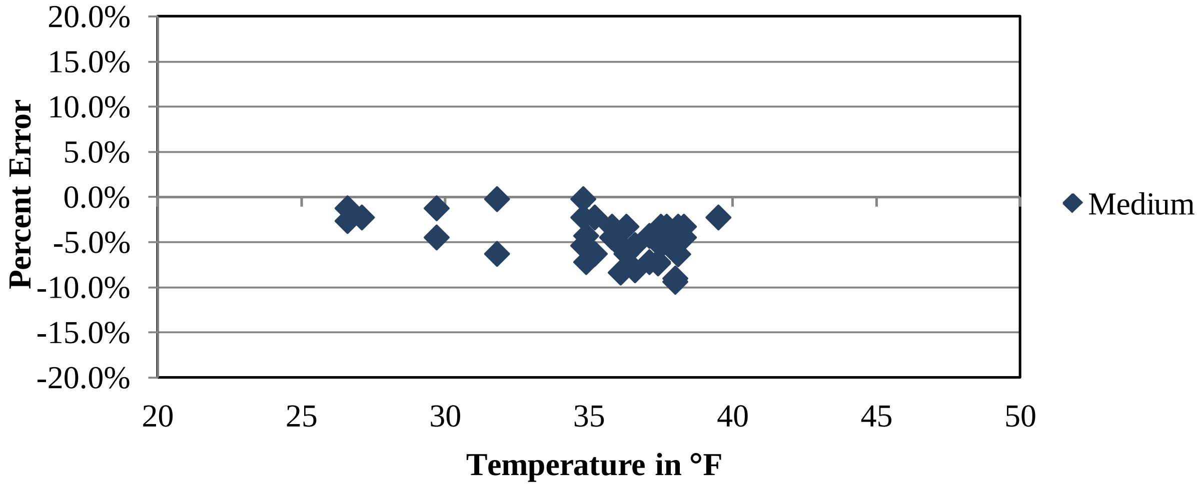


Figure 5-8 – Validation Steering Axle Weight Errors by Temperature – 13-Dec-11

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.

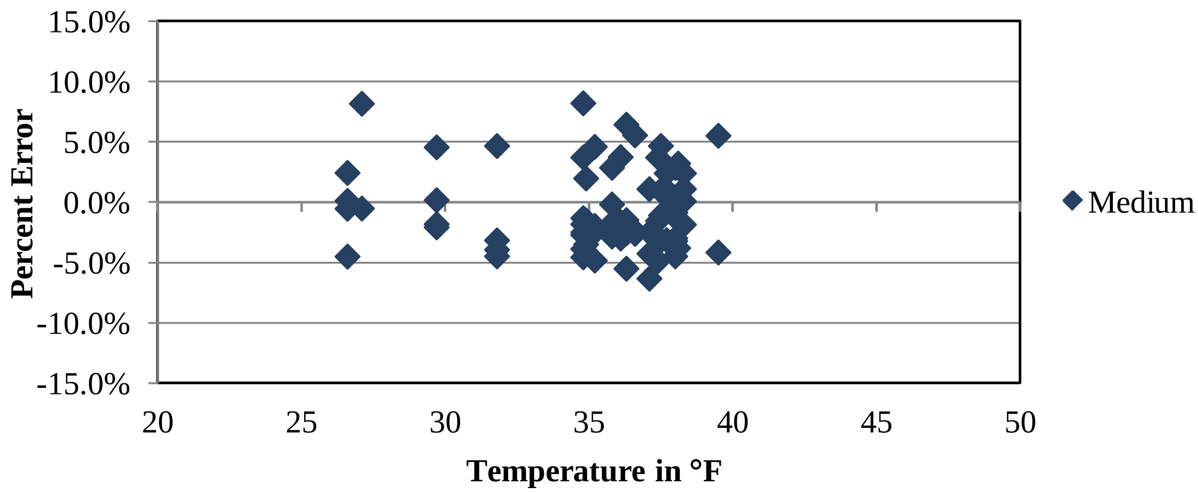


Figure 5-9 – Validation Tandem Axle Weight Errors by Temperature – 13-Dec-11

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 generally underestimates GVW for the heavily loaded (Primary) truck while estimating GVW with reasonable accuracy for the partially loaded (Secondary) truck. Distribution of errors is shown graphically in Figure 5-10.

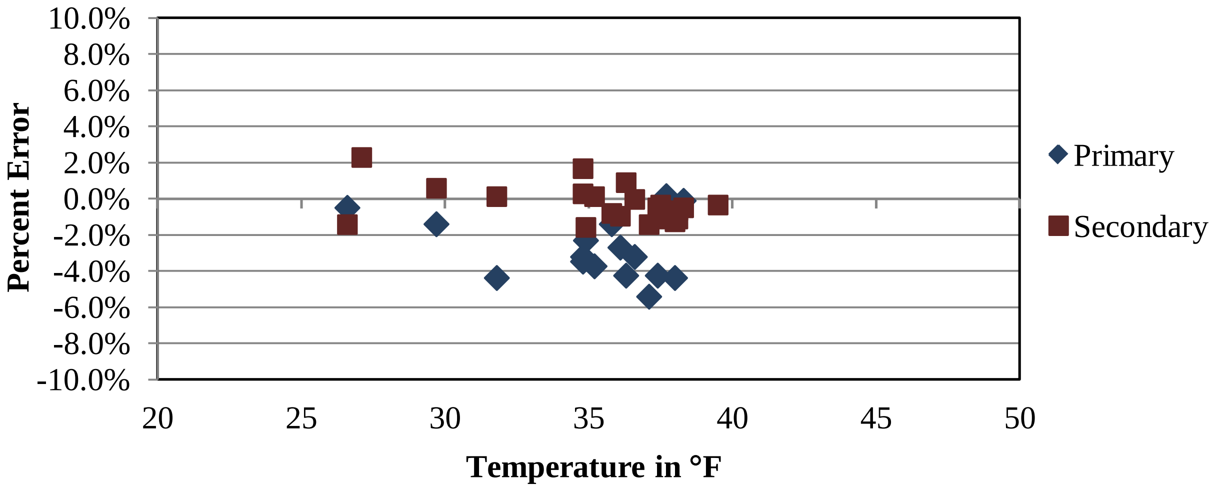


Figure 5-10 – Validation GVW Error by Truck and Temperature – 13-Dec-11

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.

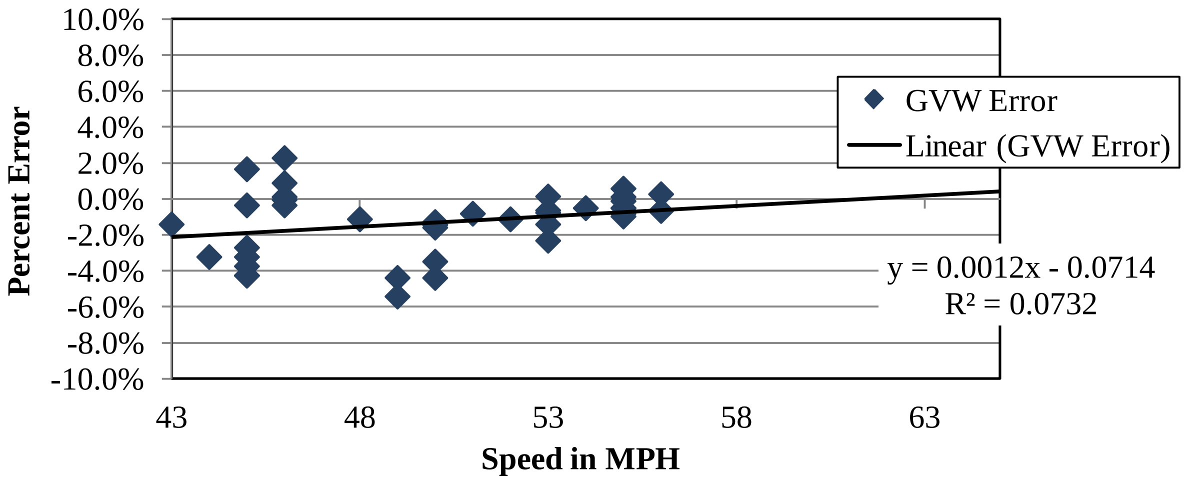


Figure 5-11 – GVW Error Trend by Speed

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

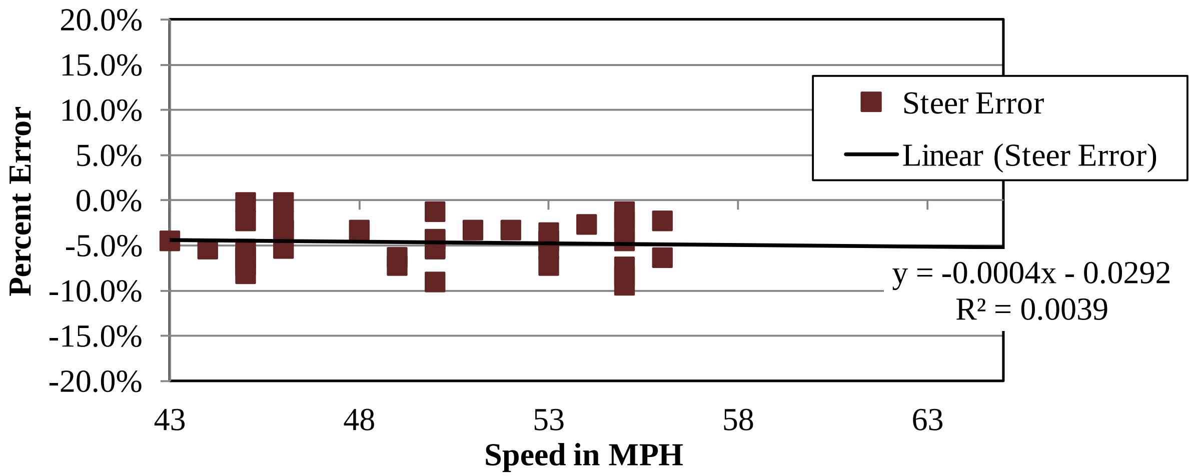


Figure 5-12 – Steering Axle Trend by Speed

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 43 to 56 mph.
- Pavement temperature. Pavement temperature ranged from 26.6 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	-2.7323	3.2926	-0.8298	0.4121
Speed	0.0786	0.0533	1.4735	0.1493
Temp	-0.1044	0.0649	-1.6105	0.1160
Truck	2.1289	0.4322	4.9257	0.0002

The lowest probability value in Table 5-5 was 0.0002 for Truck Type. This means that there is about 0.02 percent chance that the value of regression coefficient for truck type (2.1289) can occur by chance alone. Consequently, truck type had a highly statistically significant effect on the GVW measurement error. The statistical significance of the speed and temperature on the GVW measurement error is questionable.

The relationship between speed and GVW measurement error is shown in Figure 5-13. The figure includes 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.

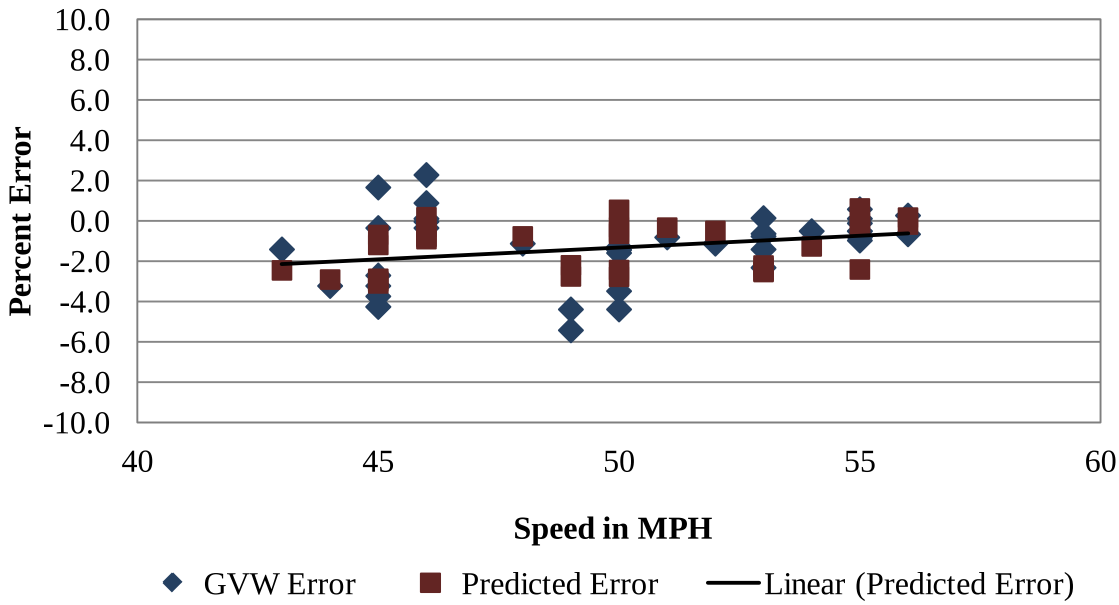


Figure 5-13 – Influence of Speed on the Measurement Error of GVW

The quantification is provided by the value of the regression coefficient, in this case -0.0786 (in Table 5-5). This means, for example, that for a 10 mile per hour increase in speed, the % error is increased by about 0.8 % (0.0786 x 10). The statistical assessment of the relationship is provided by the probability value of the regression coefficient (p = 0.1493). There is about 15 % chance that the relationship between the GWV measuring error and speed occurred by chance alone.

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	0.0786	0.1493	-0.1044	0.1160	2.1289	0.0000
Steering axle	-	-	-0.2887	0.0035	2.0934	0.0017
Tandem axle tractor	-	-	-0.1285	0.1678	6.0852	0.0000
Tandem axle trailer	0.2364	0.0001	-	-	-0.5795	0.1956

5.1.4.4 Conclusions

1. Speed had statistically significant effect on GVW and trailer tandem axle measurement errors. Measurement errors for steering and tractor tandem axles were unaffected by speed, only the errors for the trailer tandem axles were affected. The effect of the trailer tandem axles was so strong that it also affected the GVW measurement error. The statistically significant relationship between speed and tractor tandem axles is shown in Figure 5-14.

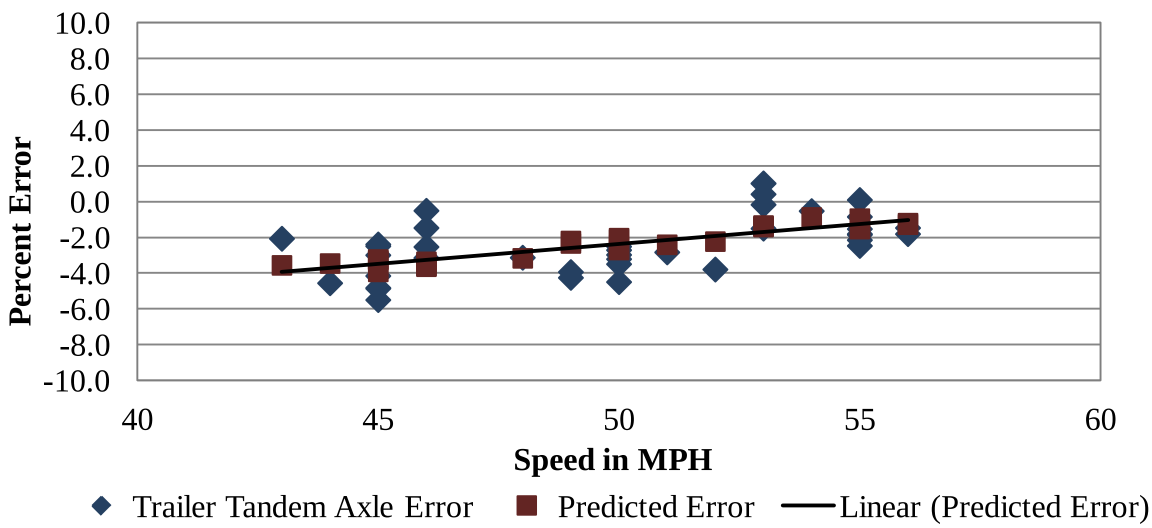


Figure 5-14 – Influence of Speed on the Measurement Error of Trailer Tandem Axle

2. Temperature had statistically significant effect on the measurement errors of steering axles, and marginally statistically significant effect on the measurement error of the GVW. It should be pointed out that the temperature range was only from 26.6 to 39.5 degrees Fahrenheit.

3. Truck type had statistically significant effect on the measurement errors of GVW, steering axle weights, and weights of tandem axles on tractors 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 2.1 %.

4. Even though speed, temperature 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 103 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 5-8. As shown in the table, a total of 5 vehicles, including 1 heavy truck (6 – 13) were misclassified by the equipment. Based on the vehicles observed during the validation study, the misclassification percentage is 1.2% for heavy trucks (6 – 13), which is within the 2.0% acceptability criteria for LTPP SPS WIM sites. The overall misclassification rate for all vehicles (3 – 15) is 4.9%.

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
3/8	2	6/4	0	9/6	0
4/5	1	6/7	0	9/7	1
4/6	0	6/8	0	9/10	0
5/2	1	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	0	8/3	0	12/11	0
5/8	0	8/5	0	13/10	0
5/9	0	8/9	0	13/11	0

As shown in Table 5-7, two Class 3 vehicles were misclassified as Class 8 vehicles, one Class 4 vehicle was misclassified as a Class 5 vehicle, and one Class 5 vehicle was misclassified as Class 2 vehicle by the equipment. For heavy trucks, one Class 9 vehicle was misclassified as a Class 7 vehicle 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.

Table 5-7 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 two Class 3 vehicles, one Class 4 vehicle, and one Class 9 vehicle, and an overcount of one Class 7 and two Class 8 vehicles, as shown in Table 5-8. The Class 5 vehicle that was misclassified as a Class 2 is not represented. The two misclassifications involving Class 5 vehicles canceled each other out.

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

Class	3	4	5	6	7	8	9	10	11	12	13
Observed Count	3	3	12	9	0	3	72	0	0	1	0
WIM Count	1	2	12	9	1	5	71	0	0	1	0
Observed Percent	2.9	2.9	11.7	8.7	0.0	2.9	69.9	0.0	0.0	1.0	0.0
WIM Percent	1.0	1.9	11.7	8.7	1.0	4.9	68.9	0.0	0.0	1.0	0.0
Misclassified Count	2	1	1	0	0	0	1	0	0	0	0
Misclassified Percent	66.7	33.3	8.3	0.0	0.0	0.0	1.4	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 0.6 mph; the range of errors was 2.7 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 -1.3 %. 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 weights or overall vehicle length measurement.

The final factors left in place at the conclusion of the validation are provided in Table 5-10.

Table 5-10 – Final Factors

Parameter	Factor
Heavy -	.9414167

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.

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	0	14	0	60	0	0	14	0	-	-	0
15-Apr-04	67	57	6	-	0	1	100	-	100	0	0
11-May-05	75	60	50	-	0	0	0	-	-	-	0
12-May-05	80	80	0	-	0	0	-	-	-	-	0
28-Sep-10	-	42	100	-	0	0	0	-	-	-	1
29-Sep-10	-	-	-	-	-	-	-	-	-	-	0
13-Dec-11	33	0	0	0	0	0	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.

Table 6-2 – Weight Validation History

Date	Mean Error and 1SD		
	GVW	Single Axles	Tandem
14-Apr-04	4.0 ± 4.7	-1.8 ± 2.7	8.3 ± 6.8
15-Apr-04	1.8 ± 4.7	-4.8 ± 2.3	6.7 ± 7.2
11-May-05	-1.3 ± 5.0	-3.2 ± 5.8	-0.9 ± 5.9
12-May-05	3.5 ± 3.0	1.4 ± 2.8	3.9 ± 4.2
28-Sep-10	-1.9 ± 1.1	-4.4 ± 1.7	-1.6 ± 1.6
29-Sep-10	-1.8 ± 1.3	-3.8 ± 2.2	-1.5 ± 1.9
13-Dec-11	-1.3 ± 1.8	-4.7 ± 2.3	-0.5 ± 2.6

The variability of the weight errors appears to have decreased since the site was first validated. The table also demonstrates the effectiveness of the validations in keeping the weight estimations within LTPP SPS WIM equipment tolerances.

6.2 Comparison of Past Validation Results

A comparison of the post-validation results from previous visits is provided in Table 6-3. 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	-4.8 ± 5.9	1.4 ± 5.7	-3.8 ± 4.5	-4.7 ± 4.7
Tandem Axles	±15 percent	6.7 ± 14.4	3.9 ± 8.3	-1.5 ± 3.9	-0.5 ± 5.2
GVW	±10 percent	1.8 ± 9.5	3.5 ± 6.0	-1.8 ± 2.6	-1.3 ± 3.6

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.

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/C – Site Photograph Logs
- Updated Handout Guide

WIM System Field Calibration and Validation - Photos

Ohio, SPS-1
SHRP ID: 390100

Validation Date: December 13, 2011

Photo 1 – Cabinet Exterior

Photo 2 – Cabinet Interior (Front)

Photo 3 – Leading Loop

Photo 4 – Leading WIM Sensor

Photo 5 – Trailing WIM Sensor

Photo 6 – Telephone Pedestal

Photo 7 – Downstream

Photo 8 – Upstream

Photo 9 – Truck 1

Photo 10 – Truck 1 Tractor

Photo 11 – Truck 1 Trailer and Load

Photo 12 – Truck 1 Suspension 1

Photo 13 – Truck 1 Suspension 2

Photo 14 – Truck 1 Suspension 3

Photo 15 – Truck 1 Suspension 4

Photo 16 – Truck 1 Suspension 5

Photo 17 – Truck 2

Photo 18 – Truck 2 Tractor

Photo 19 – Truck 2 Trailer and Load

Photo 20 – Truck 2 Suspension 1

Photo 21 – Truck 2 Suspension 2

Photo 22 – Truck 2 Suspension 3

Photo 23 – Truck 2 Suspension 4

Photo 24 – Truck 2 Suspension 5

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 39 SPS WIM ID: 390100 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 -

	Mean		Standard Deviation
Dynamic and Static GVW:	-1.3%	Standard Deviation:	1.8%
Dynamic and Static Single Axle:	-4.7%	Standard Deviation:	2.3%
Dynamic and Static Double Axles:	-0.5%	Standard Deviation:	2.6%

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

9. DEFINE SPEED RANGES IN MPH:

			Low		High	Runs
a.	Low	-	43.0	to	47.3	14
b.	Medium	-	47.4	to	51.8	10
c.	High	-	51.9	to	56.0	16
d.		-		to		
e.		-		to		

Traffic Sheet 16	STATE CODE:	39
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	390100
SITE CALIBRATION SUMMARY	DATE (mm/dd/yyyy)	12/13/2011

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 0.94142

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:	-1.0	FHWA Class	5	-	0.0
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: **Dean J. Wolf**

Contact Information: Phone: 717-975-3550

E-mail: dwolf@ara.com

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 39 SPS WIM ID: 390100 DATE (mm/dd/yyyy) 12/13/2011

Count - 103 Time = 1:07:16 Trucks (4-15) - 100 Class 3s - 3

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
58	6	7535	57	6	50	9	7900	50	9
61	9	7569	61	9	59	5	7933	59	5
41	9	7593	42	9	53	9	7943	54	9
55	9	7625	53	9	55	9	7946	55	9
58	9	7630	55	9	57	9	7966	58	9
56	9	7654	54	9	**57**	**2**	**8011**	**56**	**5**
60	9	7668	56	9	59	5	8021	59	5
54	9	7671	56	9	56	9	8022	55	9
57	**5**	**7692**	**55**	**4**	59	5	8024	60	5
54	9	7700	52	9	54	9	8045	53	9
57	6	7719	55	6	54	9	8046	56	9
59	12	7722	59	12	56	6	8063	53	6
61	9	7723	59	9	57	9	8067	55	9
57	6	7740	58	6	59	9	8081	58	9
59	6	7743	56	6	55	9	8085	53	9
54	9	7756	53	9	57	6	8119	54	6
56	9	7775	54	9	53	9	8120	51	9
55	5	7793	54	5	57	8	8148	53	8
57	9	7798	56	9	55	5	8186	54	5
55	9	7807	56	9	58	9	8193	57	9
54	4	7819	54	4	57	6	8197	54	6
55	9	7845	53	9	59	9	8205	56	9
58	4	7849	54	4	59	6	8217	60	6
54	9	7872	55	9	55	9	8222	54	9
57	9	7890	55	9	55	9	8228	55	9

Sheet 1 - 0 to 50 Start: 10:35:56 Stop: 11:10:17

Recorded By: ar Verified By: djw

Validation Test Truck Run Set - Pre

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 39 SPS WIM ID: 390100 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
60	6	8243	60	6	57	9	8556	55	9
59	9	8260	57	9	53	9	8564	52	9
59	9	8265	55	9	54	9	8567	55	9
55	9	8273	62	9	55	9	8579	55	9
57	9	8280	58	9	54	5	8580	54	5
54	9	8293	55	9	56	9	8601	53	9
53	5	8295	53	5	58	3	8624	57	3
55	9	8313	53	9	54	9	8631	55	9
54	9	8319	54	9	56	9	8651	53	9
56	9	8326	55	9	56	9	8653	54	9
55	9	8332	56	9	50	9	8657	49	9
64	**8**	**8341**	**63**	**3**	57	9	8676	55	9
57	**8**	**8361**	**55**	**3**	56	9	8678	57	9
59	9	8395	57	9	**40**	**7**	**8691**	**60**	**9**
55	9	8409	54	9	59	9	8701	57	9
54	9	8417	55	9	53	9	8717	55	9
60	5	8441	58	5	57	9	8740	56	9
58	9	8472	56	9	56	8	8742	56	8
59	5	8473	60	5	57	9	8749	61	9
59	9	8487	55	9	56	9	8757	56	9
57	9	8504	54	9	53	8	8785	53	8
53	9	8507	55	9	58	9	8786	58	9
57	9	8512	57	9	57	9	8789	56	9
57	5	8524	54	5	55	5	8810	54	5
58	9	8551	55	9	57	9	8824	55	9

Sheet 2 - 51 to 100 Start: 11:11:24 Stop: 11:41:29

Recorded By: ar Verified By: djw

Validation Test Truck Run Set - Pre

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 39 SPS WIM ID: 390100 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
59	9	8852	59	9					
57	9	8853	58	9					
56	9	8860	54	9					

Sheet 3 - 101 - 150 Start: 11:42:20 Stop: 11:43:12

Recorded By: ar Verified By: djw

Validation Test Truck Run Set - Pre