WIM System Field Calibration and Validation Summary Report

Wisconsin SPS-1
SHRP ID – 550100

Validation Date: May 15, 2013
Submitted: June 13, 2013

APPLIED RESEARCH ASSOCIATES, INC.

U.S. Department of Transportation
Federal Highway Administration

LTPP

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1   Executive Summary

A WIM validation was performed on May 15, 2013 at the Wisconsin SPS-1 site located on route US-29, milepost 189.8, 2 miles west of SR 49.

This site was installed on June 20, 2007. The in-road sensors are installed in the westbound, righthand driving lane. The site is equipped with bending plate WIM sensors and an IRD iSINC WIM controller. The LTPP lane is identified as lane 1 in the WIM controller. From a comparison between the report of the most recent validation of this equipment on April 13, 2011 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. None of the in-road sensors show signs of damage or excessive wear and appear to be fully secured in the pavement.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 did not indicate any adverse dynamics that would 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. The summary results of the validation are provided in Table 1-1 below.

Table 1-1 – Validation Results – 15-May-13

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	$\pm$20 percent	-2.1 $\pm$ 3.3%	Pass
Tandem Axles	$\pm$15 percent	0.7 $\pm$ 2.4%	Pass
GVW	$\pm$10 percent	0.6 $\pm$ 1.3%	Pass
Vehicle Length	$\pm$3.0 percent (2.2 ft)	-0.2 $\pm$ 1.3 ft	Pass
Axle Length	$\pm$ 0.5 ft [150mm]	-0.2 $\pm$ 0.3 ft	Pass

Truck speeds were manually collected for each test run by a radar gun and compared with the speed reported by the WIM equipment. For this site, the error in speed measurement was -0.6 $\pm$ 1.9 mph, which is greater than the $\pm$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.

This site is providing research quality vehicle classification data for heavy trucks (Class 6 – 13). The heavy truck misclassification rate of 1.3% is within the 2.0% acceptability criterion for LTPP SPS WIM sites. The overall misclassification rate of 2.9% from the 103 vehicle sample (Class 4 – 13) was due to the misclassifications of two Class 5 vehicles and one Class 10 vehicle.

There were two test trucks used for the 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 boxed commercial goods.

- 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 rolls of paper.

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 Validation test truck weights and measurements are provided in Table 1-2.

Table 1-2 – Validation Test Truck Measurements

Test Truck	Weights (kips)							Spacings (feet)				
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	76.6	12.1	16.4	16.4	15.9	15.9	17.1	4.4	35.5	4.0	61.0	72.0
2	69.7	11.9	14.3	14.3	14.6	14.6	17.1	4.3	34.5	4.1	60.0	72.5

The posted speed limit at the site is 65 mph. During the testing, the speed of the test trucks ranged from to 52 to 65 mph, a range of 13 mph.

During test truck runs, pavement temperature was collected using a hand-held infrared temperature device. The validation pavement surface temperatures varied from 71.9 to 94.4 degrees Fahrenheit, a range of 22.5 degrees Fahrenheit. The mild weather conditions prevented the desired 30 degree range in temperatures.

A review of the LTPP Standard Release Database 27 shows that there are 5 years of level "E" WIM data for this site. This site requires no 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 April 29, 2013 (Data) to the most recent Comparison Data Set (CDS) from April 14, 2011. The assessments performed prior to the site visits are used to develop expected traffic flow characteristics 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 27 shows that there are 5 years of level "E" WIM data for this site. Table 2-1 provides a breakdown of the available data for years 2007 to 2012.

Table 2-1 – LTPP Data Availability

Year	Total Number of Days in Year	Number of Months
2007	57	2
2008	363	12
2009	365	12
2010	364	12
2011	365	12
2012	232	8

As shown in the table, this site requires no additional years of data to meet the minimum of five years of research quality data. The data does not meet the 210-day minimum requirement for calendar year 2007.

Table 2-2 provides a monthly breakdown of the available data for years 2007 through 2012.

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	
2007											26	31	2
2008	31	29	31	30	31	27	31	31	30	31	30	31	12
2009	31	28	31	30	31	30	31	31	30	31	30	31	12
2010	31	28	31	30	30	30	31	31	30	31	30	31	12
2011	31	28	31	30	31	30	31	31	30	31	30	31	12
2012	31	29	31	30	31	30	31	19					8

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 between the sample dataset from April 29, 2013 (Data) and the most recent comparison Data Set (CDS) from April 14, 2011.

	4	5	6	7	8	9	10	11	12	13	14	15
Data	0.8%	23.1%	4.7%	3.4%	3.9%	59.2%	3.4%	0.3%	0.2%	0.1%	0.0%	1.0%
CDS	1.1%	21.6%	3.5%	2.2%	3.7%	64.1%	2.2%	0.3%	0.2%	0.0%	0.0%	1.1%

Truck Classification
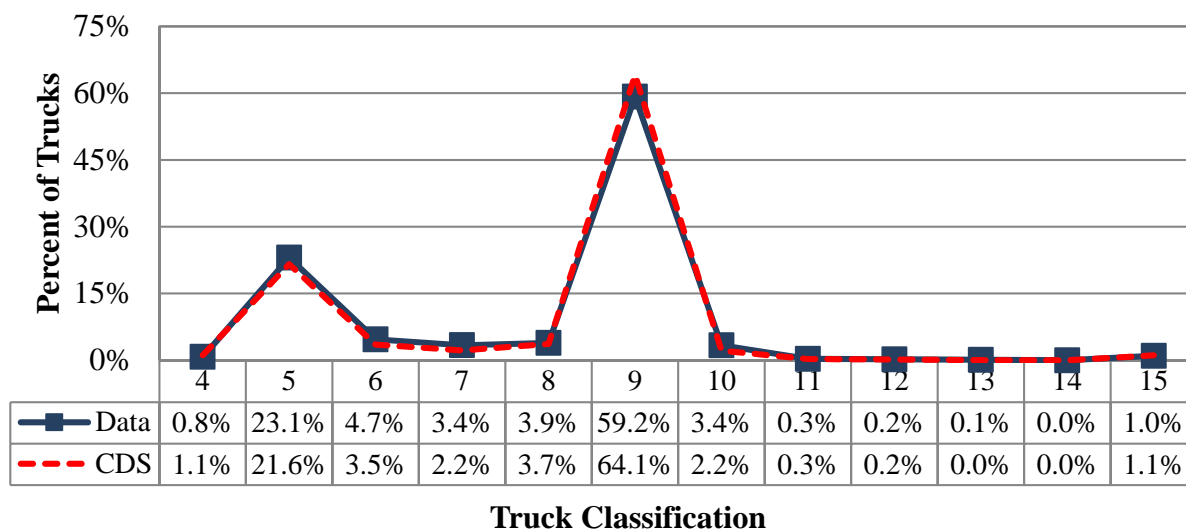
Figure 2-1 – Comparison of Truck Distribution

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 two most frequent truck types crossing the WIM scale are Class 9 (59.2%) and Class 5 (23.1%) vehicles.

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 1.0 percent of the vehicles at this site are unclassified.

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Table 2-3 – Truck Distribution from W-Card

Vehicle Classification	CDS		Data		Change
	Date				
	4/14/2011		4/29/2013		
4	112	1.1%	82	0.8%	-0.4%
5	2119	21.6%	2496	23.1%	1.4%
6	346	3.5%	509	4.7%	1.2%
7	217	2.2%	366	3.4%	1.2%
8	360	3.7%	421	3.9%	0.2%
9	6284	64.1%	6412	59.2%	-4.9%
10	212	2.2%	364	3.4%	1.2%
11	27	0.3%	35	0.3%	0.0%
12	18	0.2%	23	0.2%	0.0%
13	4	0.0%	11	0.1%	0.1%
14	0	0.0%	0	0.0%	0.0%
15	109	1.1%	109	1.0%	-0.1%

From the table it can be seen that the percentage of Class 9 vehicles has decreased by 4.9 percent from April 2011 and April 2013. Changes in the percentage of heavier trucks may be attributed to natural and seasonal variations in truck distributions and an increase in goods movement during current economic cycle. During the same time period, the percentage of Class 5, 6, and 7 trucks increased, likely due to increase in local economic activity. 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.

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Data	45	50	55	60	65	70	75	80	85	90	95
	0.5%	0.7%	1.8%	10.0%	47.3%	34.3%	4.5%	0.1%	0.0%	0.0%	0.0%
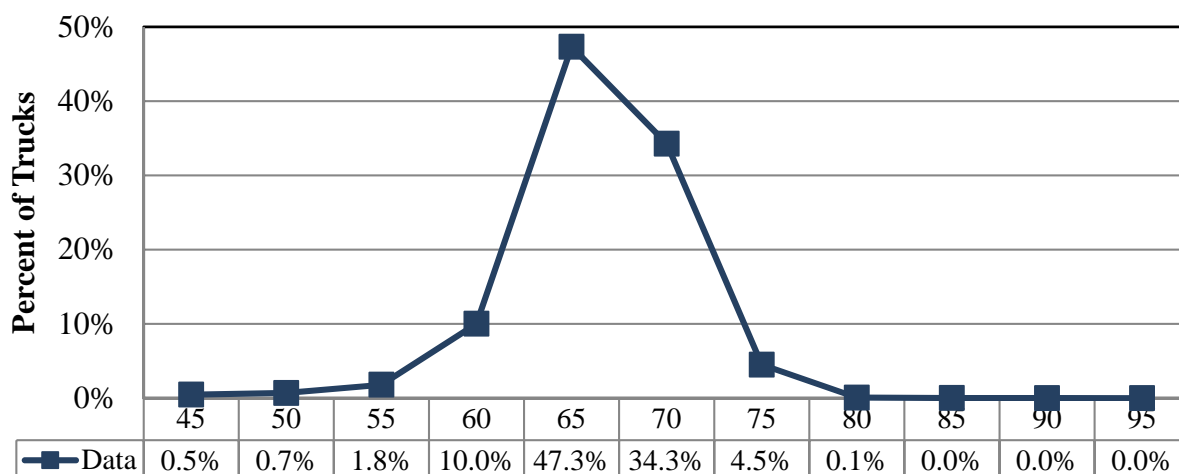
Figure 2-2 – Truck Speed Distribution – 14-Jan-13

As shown in Figure 2-2, the majority of the trucks at this site are traveling between 60 and 70 mph. The posted speed limit at this site is 65 and the 85th percentile speed for trucks at this site is 68 mph. The 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 April 2013 and the Comparison Data Set from April 2011.

As shown in Figure 2-3, the unloaded and loaded peaks between the April 2011 Comparison Data Set (CDS) and the April 2013 two-week sample W-card dataset (Data) are similar. The results indicate that the calibration has not drifted during this period.

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	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
Data	0.0%	0.0%	0.1%	7.6%	27.2%	11.8%	9.8%	8.7%	8.0%	23.2%	3.0%	0.3%	0.1%	0.0%	0.0%
CDS	0.0%	0.0%	0.2%	9.9%	26.2%	11.1%	9.7%	7.2%	7.7%	23.4%	4.5%	0.1%	0.0%	0.0%	0.0%

GVW in Kips
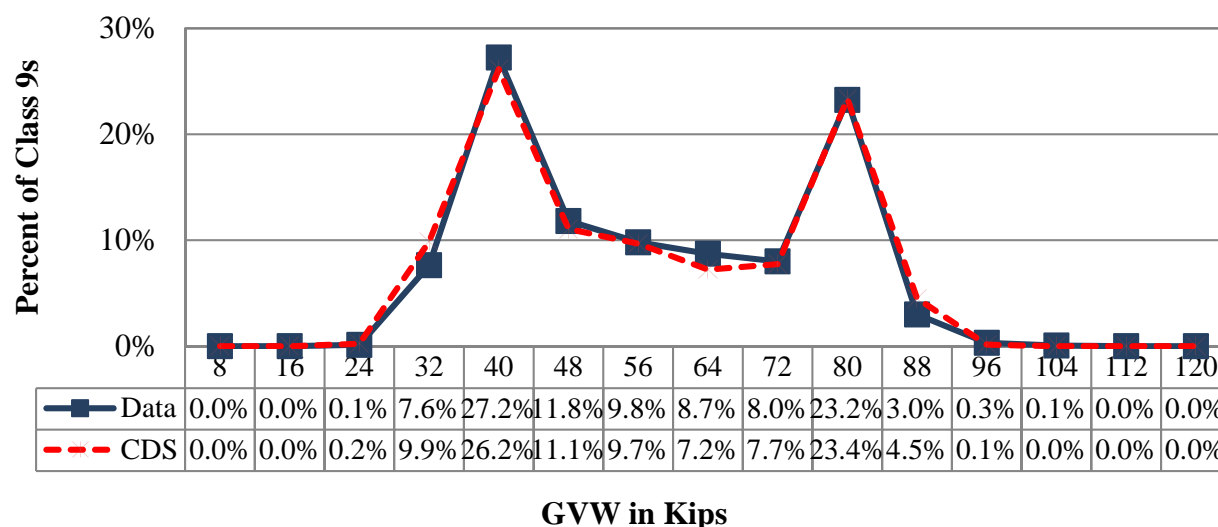
Figure 2-3 – Comparison of Class 9 GVW Distribution

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				
	4/14/2011		4/29/2013		
8	0	0.0%	0	0.0%	0.0%
16	0	0.0%	0	0.0%	0.0%
24	15	0.2%	8	0.1%	-0.1%
32	620	9.9%	487	7.6%	-2.2%
40	1639	26.2%	1736	27.2%	1.1%
48	693	11.1%	753	11.8%	0.8%
56	606	9.7%	625	9.8%	0.1%
64	453	7.2%	556	8.7%	1.5%
72	485	7.7%	510	8.0%	0.3%
80	1464	23.4%	1481	23.2%	-0.1%
88	283	4.5%	191	3.0%	-1.5%
96	9	0.1%	20	0.3%	0.2%
104	0	0.0%	4	0.1%	0.1%
112	0	0.0%	0	0.0%	0.0%
120	0	0.0%	0	0.0%	0.0%
Average =	53.5 kips		53.7 kips		0.2 kips

As shown in the table, the percentage of unloaded class 9 trucks in the 32 to 40 kips range increased by 1.1 percent while the percentage of loaded class 9 trucks in the 72 to 80 kips range decreased by 0.1 percent. During this time period the percentage of overweight trucks decreased by 1.3 percent. Based on the average Class 9 GVW values from the per vehicle records, the GVW average for this site increased by 0.3 percent, from 53.5 to 53.7 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 April 2013 and the Comparison Data Set from April 2011. The percentage of light axles (9.5 to 10.5 kips) decreased by approximately 0.1 percent and the percentage of heavy axles (11.5 to 12.5 kips) increased by approximately 5.2%, indicating a slight positive bias (overestimation of loads) in front axle measurement.

	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5
Data	3.4%	9.0%	9.9%	15.8%	30.4%	19.0%	9.6%	2.3%	0.6%	0.1%
CDS	6.1%	10.0%	11.4%	15.8%	30.2%	16.1%	7.8%	1.9%	0.6%	0.1%

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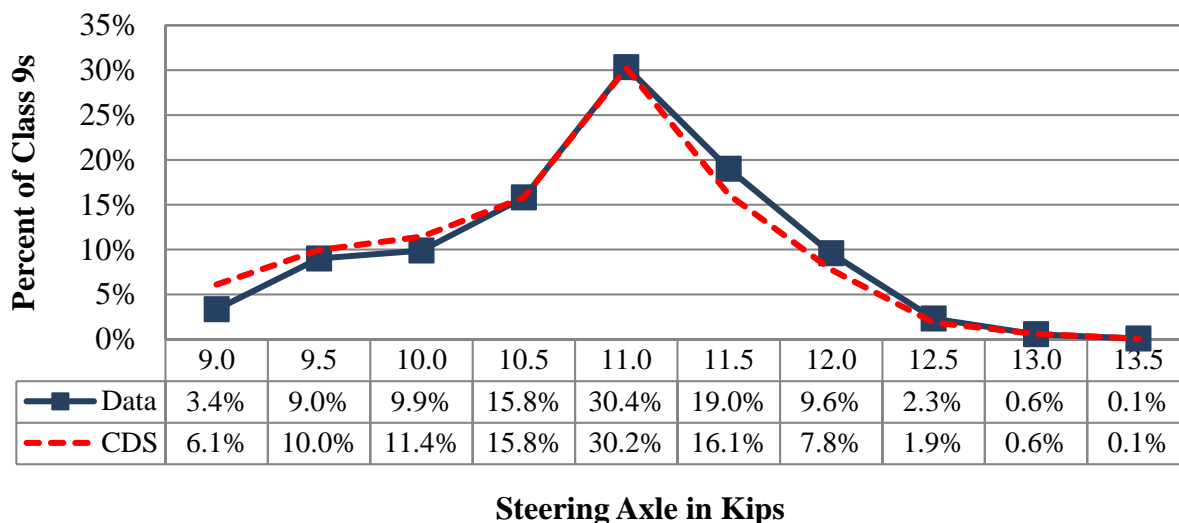
Figure 2-4 – Distribution of Class 9 Front Axle Weights

It can be seen in the figure that the greatest percentage of trucks have front axle weights measuring between 10.5 and 11.5 kips. The percentage of trucks in this range has increased by 3.0 percent between the April 2011 Comparison Data Set (CDS) and the April 2013 dataset (Data).

Table 2-5 provides the Class 9 front axle weight distribution data for the April 2011 Comparison Data Set (CDS) and the April 2013 dataset (Data).

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

F/A weight bins (kips)	CDS		Data		Change
	Date				
	4/14/2011		4/29/2013		
9.0	381	6.1%	213	3.4%	-2.8%
9.5	621	10.0%	573	9.0%	-0.9%
10.0	714	11.4%	629	9.9%	-1.6%
10.5	987	15.8%	1006	15.8%	0.0%
11.0	1887	30.2%	1930	30.4%	0.1%
11.5	1006	16.1%	1209	19.0%	2.9%
12.0	485	7.8%	610	9.6%	1.8%
12.5	116	1.9%	147	2.3%	0.5%
13.0	38	0.6%	36	0.6%	0.0%
13.5	4	0.1%	5	0.1%	0.0%
Average =	10.5 kips		10.6 kips		0.1 kips

The table shows that the average front axle weight for Class 9 trucks has increased 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 10.6 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.

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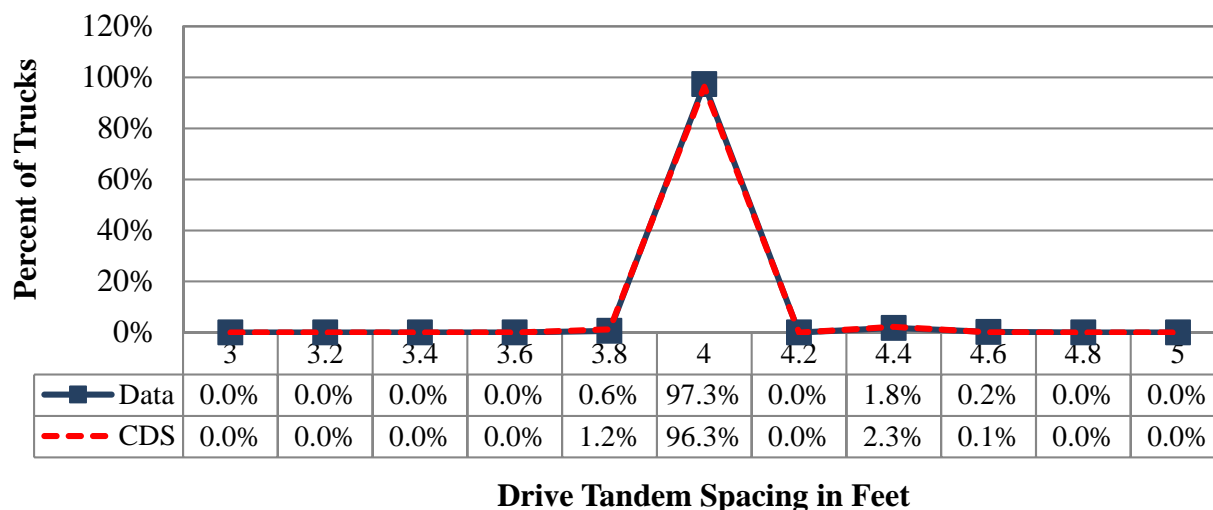
Figure 2-5 – Comparison of Class 9 Tractor Tandem Spacing

As seen in the figure, the Class 9 tractor tandem spacings for the April 2011 Comparison Data Set and the April 2013 Data are nearly identical.

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				
	4/14/2011		4/29/2013		
3.0	0	0.0%	0	0.0%	0.0%
3.2	0	0.0%	0	0.0%	0.0%
3.4	2	0.0%	0	0.0%	0.0%
3.6	0	0.0%	0	0.0%	0.0%
3.8	78	1.2%	41	0.6%	-0.6%
4.0	6037	96.3%	6202	97.3%	1.0%
4.2	0	0.0%	0	0.0%	0.0%
4.4	143	2.3%	115	1.8%	-0.5%
4.6	7	0.1%	14	0.2%	0.1%
4.8	0	0.0%	0	0.0%	0.0%
5.0	0	0.0%	0	0.0%	0.0%
Average =	4.0 feet		4.0 feet		0.0 feet

From the table it can be seen that the drive tandem spacing of Class 9 trucks at this site is between 3.8 and 4.4 feet. Based on the average Class 9 drive tandem spacing values from the per vehicle records, the average tractor tandem spacing is 4.0, which is identical to the expected

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average of 4.0 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 (April 2011) based on the last calibration with the most recent two-week WIM data sample from the site (April 2013). Comparison of vehicle class distribution data indicates a 4.9 percent decrease in the percentage of Class 9 vehicles. Analysis of Class 9 weight data indicates that front axle weights have increased by 1.0 percent and average Class 9 GVW has increased by 0.3 percent for the April 2013 data. The data indicates an average truck tandem spacing of 4.0 feet, which is identical to the expected average of 4.0 feet.

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3 WIM Equipment Discussion

From a comparison between the report of the most recent validation of this equipment on April 13, 2011 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 June 20, 2007 by International Road Dynamics. It is instrumented with bending plate weighing sensors and an IRD iSINC WIM Controller. As the installation contractor, IRD also performs routine equipment maintenance and data quality checks of the WIM data.

3.2 Physical Inspection

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

3.5 Recommended Equipment Maintenance

No unscheduled equipment maintenance actions are recommended.

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4   Pavement Discussion

4.1   Pavement Condition Survey

During a visual distress survey of the pavement conducted from the shoulder, There were no pavement distresses noted that may affect the accuracies of the WIM system.

4.2   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.

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Table 4-2 – WIM Index Values

Profiler Passes			Pass 1	Pass 2	Pass 3	Pass 4	Pass 5	Avg
Left	LWP	LRI (m/km)	0.800	0.782	0.785			0.789
		SRI (m/km)	*0.473*	0.528	0.548			0.516
		Peak LRI (m/km)	0.974	0.872	0.855			0.900
		Peak SRI (m/km)	*0.614*	0.781	*0.582*			*0.659*
	RWP	LRI (m/km)	0.687	0.560	0.678			0.642
		SRI (m/km)	0.605	*0.394*	0.502			0.500
		Peak LRI (m/km)	0.775	0.764	0.781			0.773
		Peak SRI (m/km)	*0.660*	*0.487*	*0.550*			*0.566*
Center	LWP	LRI (m/km)	0.506	0.574	0.616	0.591	0.604	0.578
		SRI (m/km)	*0.354*	*0.446*	*0.410*	0.507	*0.431*	*0.430*
		Peak LRI (m/km)	0.532	0.672	0.624	0.599	0.651	0.616
		Peak SRI (m/km)	*0.470*	*0.549*	*0.502*	*0.544*	*0.507*	*0.514*
	RWP	LRI (m/km)	0.841	0.778	0.801	1.004	0.726	0.830
		SRI (m/km)	1.075	1.016	0.658	0.903	0.856	0.902
		Peak LRI (m/km)	0.844	0.814	0.801	1.006	0.775	0.848
		Peak SRI (m/km)	**1.163**	**1.036**	**0.799**	**2.522**	**1.028**	**1.310**
Right	LWP	LRI (m/km)	0.727	0.866	0.800			0.798
		SRI (m/km)	0.646	0.618	0.621			0.628
		Peak LRI (m/km)	0.980	0.941	0.910			0.944
		Peak SRI (m/km)	*0.654*	*0.730*	*0.731*			*0.705*
	RWP	LRI (m/km)	0.851	0.883	0.747			0.827
		SRI (m/km)	0.935	1.377	0.910			1.074
		Peak LRI (m/km)	0.874	0.898	0.809			0.860
		Peak SRI (m/km)	1.074	1.381	1.063			1.173

From Table 4-2 it can be seen that most of the indices computed from the profiles are between the upper and lower threshold values, with the remaining values under the lower threshold. Indices that are below the lower thresholds are shown in italics. The highest values, on average, are the Peak SRI values in the right wheel path of the center passes (shown in bold and italics).

4.3 Profile and Vehicle Interaction

Profile data was collected on July 26, 2012 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 262 in/mi and is located approximately 673 feet prior to the WIM scale. The highest IRI value within the 400 foot approach section was 98 in/mi and is located approximately 337 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. There were no distresses observed at these locations that would influence truck dynamics in the WIM scale area.

Additionally, a visual observation of the trucks as they approach, traverse and leave the sensor area did not indicate any visible motion of the trucks that would affect the performance of the WIM scales. Trucks appear to track down the center of the lane.

4.4　Recommended Pavement Remediation

No pavement remediation is recommended.

5   Statistical Reliability of the WIM Equipment

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

5.3   Validation

The 40 Validation test truck runs were conducted on May 15, 2013, beginning at approximately 8:34 AM and continuing until 5:38 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with boxed commercial products, 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 paper rolls, and equipped with air suspension on the tractor, air suspension on the trailer, with standard tandem spacing on the tractor and trailer.

The test trucks were weighed prior to the Validation and 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 Measurements

Test Truck	Weights (kips)							Spacings (feet)				
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	76.6	12.1	16.4	16.4	15.9	15.9	17.1	4.4	35.5	4.0	61.0	72.0
2	69.7	11.9	14.3	14.3	14.6	14.6	17.1	4.3	34.5	4.1	60.0	72.5

Test truck speeds varied by 13 mph, from 52 to 65 mph. The measured Validation pavement temperatures varied 22.5 degrees Fahrenheit, from 71.9 to 94.4. The mild weather conditions prevented the desired minimum 30 degree temperature range. Table 5-2 is a summary of post validation results.

Table 5-2 – Validation Overall Results – 15-May-13

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-2.1 ± 3.3%	Pass
Tandem Axles	±15 percent	0.7 ± 2.4%	Pass
GVW	±10 percent	0.6 ± 1.3%	Pass
Vehicle Length	±3.0 percent (2.2 ft)	-0.2 ± 1.3 ft	Pass
Axle Length	± 0.5 ft [150mm]	-0.2 ± 0.3 ft	Pass

Truck speed was manually collected for each test run using a radar gun and compared with the speed reported by the WIM equipment. For this site, the average error in speed measurement for all speeds was -0.6 ± 1.9 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 length measurements are based on the distance between the axle detector sensors, it can be concluded that the distance factor is set correctly and that the speeds being reported by the WIM equipment are within similar acceptable ranges.

5.3.1   Statistical Speed Analysis

Statistical analysis was conducted on the test truck run data to investigate whether a relationship exists between speed and WIM equipment weight and distance measurement accuracy. The posted speed limit at this site is 65 mph. The test runs were divided into three speed groups - low, medium and high speeds, as shown in Table 5-3.

Table 5-3 – Validation Results by Speed – 15-May-13

Parameter	95% Confidence Limit of Error	Low 52.0 to 56.3 mph	Medium 56.4 to 60.8 mph	High 60.9 to 65.0 mph
Steering Axles	±20 percent	-3.4 ± 2.7%	-1.8 ± 2.8%	-1.2 ± 3.2%
Tandem Axles	±15 percent	1.1 ± 2.1%	1.2 ± 2.5%	1.2 ± 3.1%
GVW	±10 percent	0.3 ± 1.1%	0.6 ± 1.2%	0.8 ± 1.8%
Vehicle Length	±3.0 percent (2.2 ft)	0.0 ± 1.3 ft	-0.3 ± 0.9 ft	-0.1 ± 1.9 ft
Vehicle Speed	± 1.0 mph	-0.2 ± 0.3 mph	-0.2 ± 0.3 mph	-0.2 ± 0.3 mph
Axle Length	± 0.5 ft [150mm]	-0.5 ± 1.4 ft	-0.7 ± 2.6 ft	-0.6 ± 1.9 ft

From the table, it can be seen that the WIM equipment estimates all weights with similar accuracy at all speeds. For steering axles, the system demonstrates a slightly greater negative bias at the lower speeds. There does not appear to be a significant relationship between weight estimates and speed at this site.

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

5.3.1.1   GVW Errors by Speed

As shown in Figure 5-1, the equipment estimated GVW with similar accuracy at all speeds. The range in error and bias is similar throughout the entire speed range.
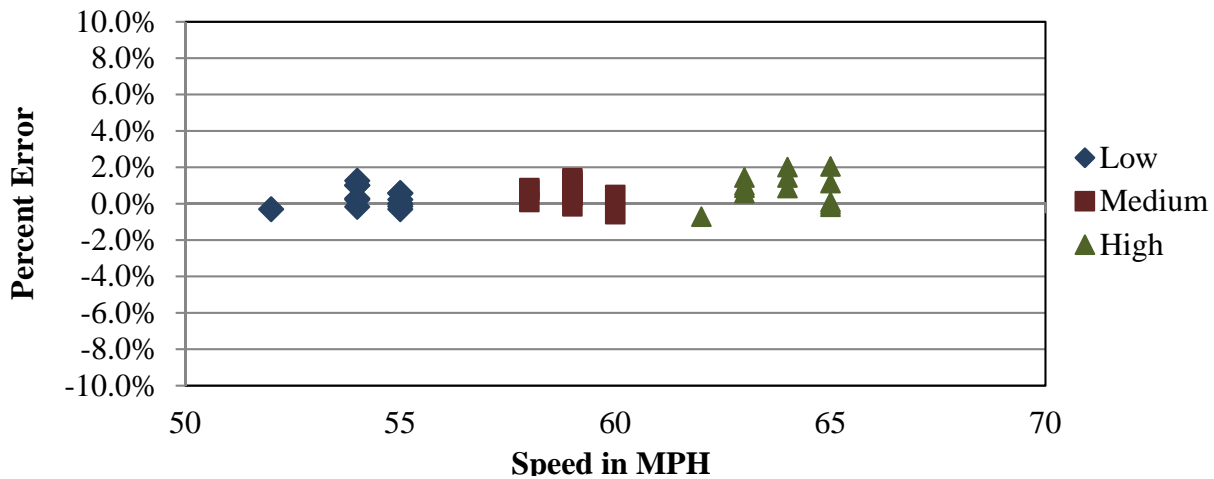
Figure 5-1 – Validation GVW Errors by Speed – 15-May-13

5.3.1.2   Steering Axle Weight Errors by Speed

As shown in Figure 5-2, the equipment estimated steering axle weights with similar accuracy at the medium and high speeds. The system demonstrates a slightly greater negative bias at the lower speeds. The range in error is similar throughout the entire speed range. There does not appear to be a significant correlation between speed and weight estimates at this site.
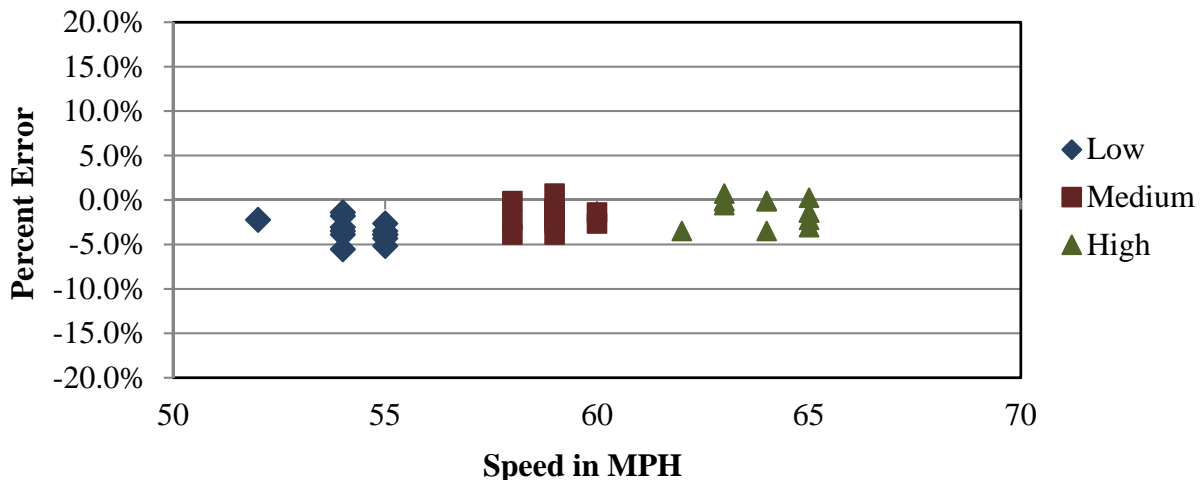
Figure 5-2 – Validation Steering Axle Weight Errors by Speed – 15-May-13

5.3.1.3　Tandem Axle Weight Errors by Speed

As shown in Figure 5-3, the equipment estimated tandem axle weights with similar accuracy at all speeds. The range in error and bias is similar throughout the entire speed range.
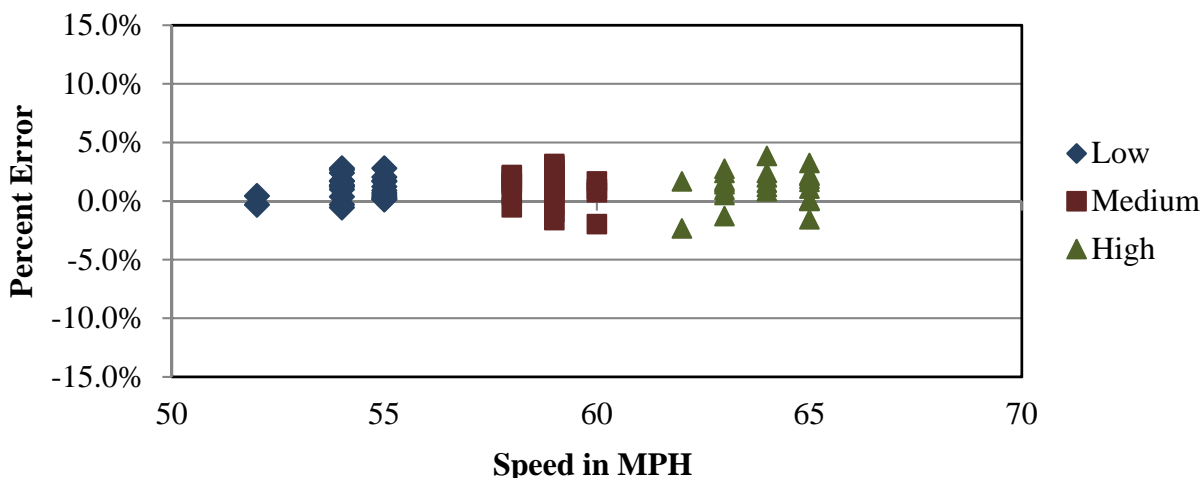
Figure 5-3 – Validation Tandem Axle Weight Errors by Speed – 15-May-13

5.3.1.4　GVW Errors by Speed and Truck Type

It can be seen in Figure 5-4 that when the GVW errors are analyzed by truck type, the WIM equipment precision and bias is similar for both the heavily loaded (Primary) truck and the partially loaded (Secondary) truck.
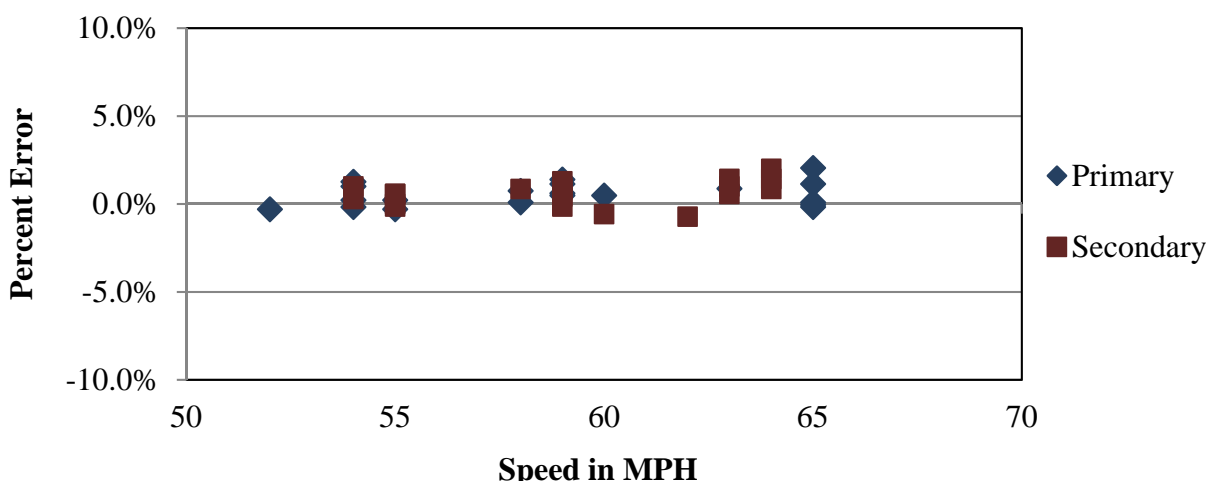
Figure 5-4 – Validation GVW Error by Truck and Speed – 15-May-13

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5.3.1.5   Axle Length Errors by Speed

For this site, the error in axle length measurement was consistent at all speeds. The range in axle length measurement error was from 0.0 feet to -0.4 feet. Distribution of errors is shown graphically in Figure 5-5.
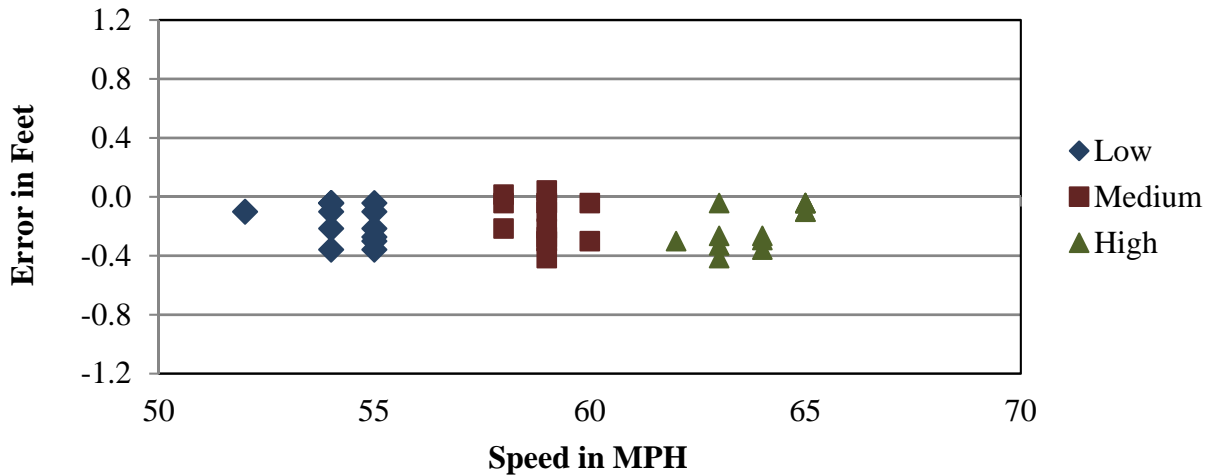
Figure 5-5 – Validation Axle Length Error by Speed – 15-May-13

5.3.1.6   Overall Length Errors by Speed

For this system, the WIM equipment measures overall length consistently over the entire range of speeds, with errors ranging from -1.5 to 1.0 feet. Distribution of errors is shown graphically in Figure 5-6.
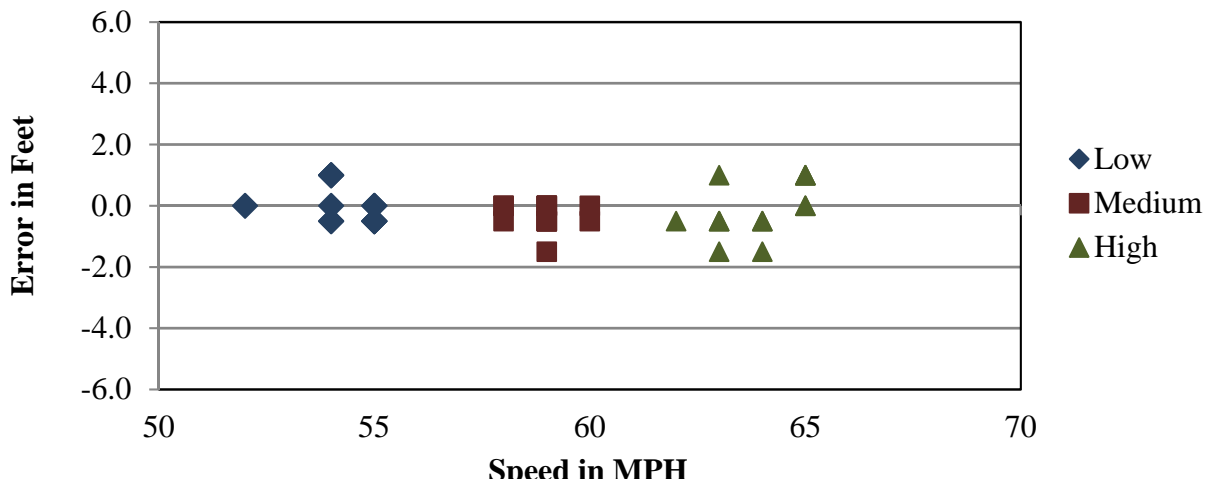
Figure 5-6 – Validation Overall Length Error by Speed – 15-May-13

5.3.2   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 was 22.5 degrees, from 71.9 to 94.4 degrees Fahrenheit. The Validation test runs are reported under three temperature groups – low, medium and high, as shown in Table 5-4 below.

**Table 5-4 – Validation Results by Temperature – 15-May-13**

Parameter	95% Confidence Limit of Error	Low 71.9 to 81 degF	Medium 81.1 to 87.0 degF	High 87.1 to 94.4 degF
Steering Axles	±20 percent	-1.1 ± 2.9%	-2.5 ± 4.2%	-2.7 ± 2.6%
Tandem Axles	±15 percent	1.1 ± 2.7%	0.9 ± 2.5%	1.5 ± 2.3%
GVW	±10 percent	0.6 ± 1.1%	0.3 ± 1.5%	0.8 ± 1.5%
Vehicle Length	±3.0 percent (2.2 ft)	-0.5 ± 1.4 ft	-0.2 ± 1.2 ft	0.1 ± 1.4 ft
Vehicle Speed	± 1.0 mph	-0.2 ± 0.3 mph	-0.2 ± 0.3 mph	-0.1 ± 0.2 mph
Axle Length	± 0.5 ft [150mm]	-0.3 ± 2.1 ft	-1.0 ± 2.5 ft	-0.6 ± 1.1 ft

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

5.3.2.1   GVW Errors by Temperature

From Figure 5-7, it can be seen that the equipment appears to estimate GVW with similar accuracy across the range of temperatures observed in the field. There does not appear to be a correlation between temperature and weight estimates at this site.
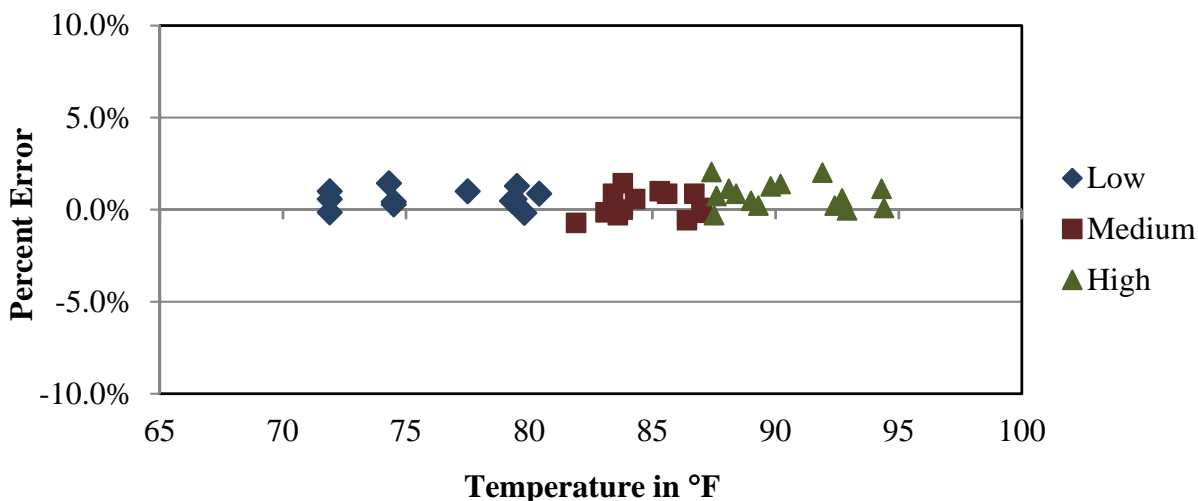
Figure 5-7 – Validation GVW Errors by Temperature – 15-May-13

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5.3.2.2   Steering Axle Weight Errors by Temperature

Figure 5-8 demonstrates that for steering axles, the WIM equipment appears to estimate weights with increasing negative bias as temperature increases. There does appear to be a slight correlation between temperature and steering axle weight estimates at this site. The range in error is similar for different temperature groups.
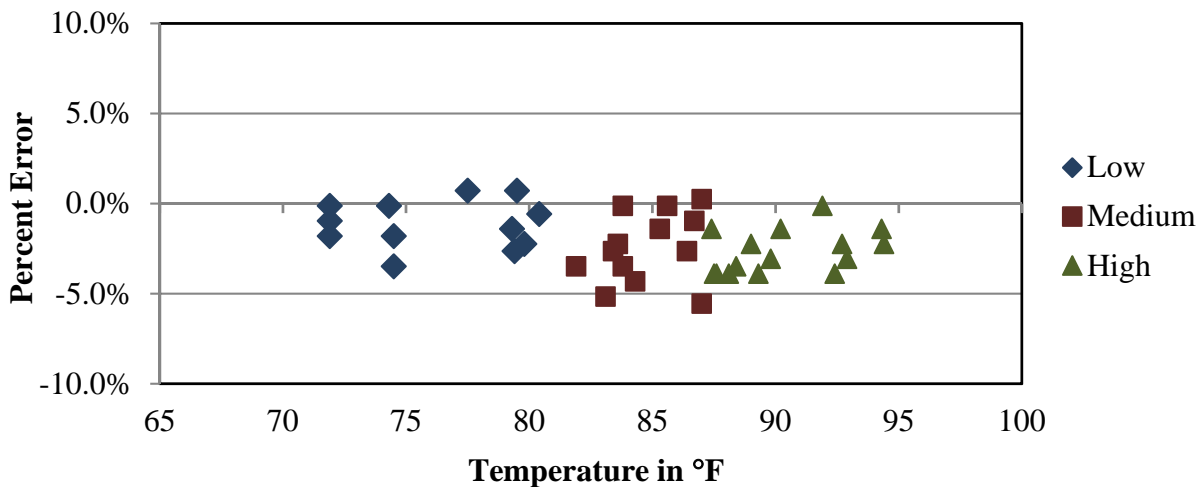
Figure 5-8 – Validation Steering Axle Weight Errors by Temperature – 15-May-13

5.3.2.3   Tandem Axle Weight Errors by Temperature

As shown in Figure 5-9, the WIM equipment appears to estimate tandem axle weights with similar accuracy across the range of temperatures observed in the field. There does not appear to be a correlation between temperature and tandem axle weight estimates at this site. The range in tandem axle errors is consistent for the three temperature groups.
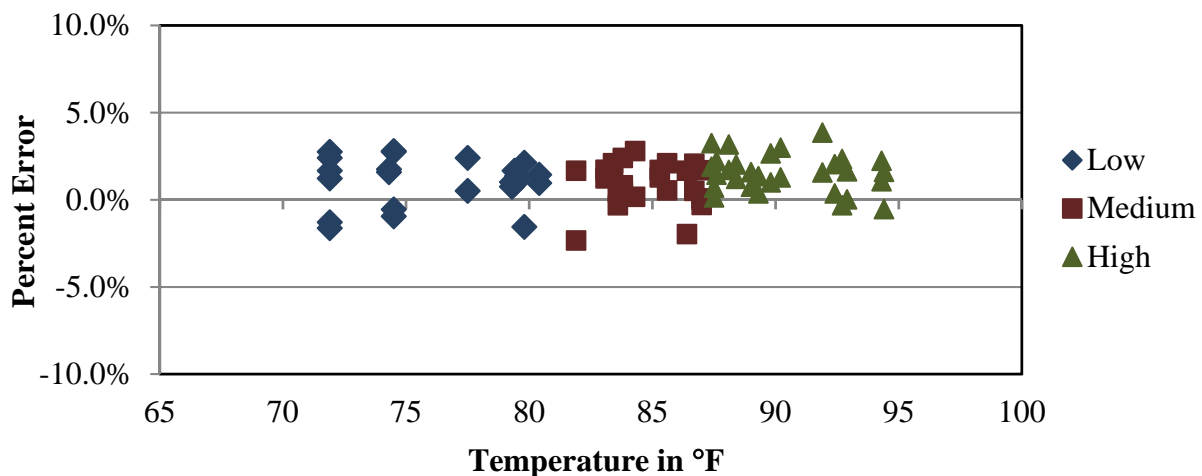
Figure 5-9 – Validation Tandem Axle Weight Errors by Temperature – 15-May-13

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5.3.2.4   GVW Errors by Temperature and Truck Type

As shown in Figure 5-10, when analyzed by truck type, GVW measurement errors for both trucks are similar at all temperatures. For both trucks, the range of errors and bias are reasonably consistent over the range of temperatures.
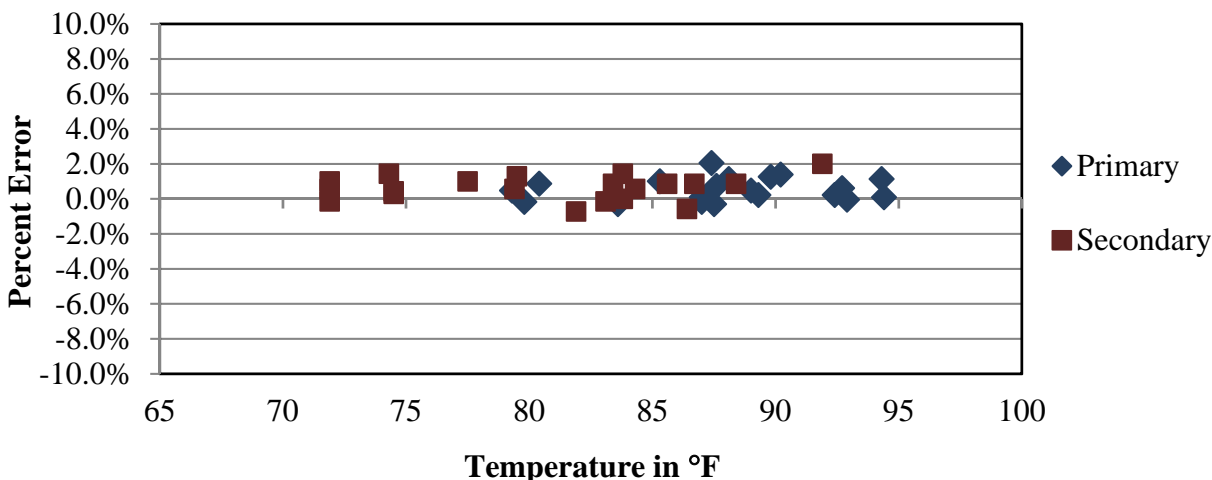
Figure 5-10 – Validation GVW Error by Truck and Temperature – 15-May-13

5.3.3   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 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 type of vehicle but identified by the WIM equipment as another type of vehicle. The misclassifications by pair are provided in Table 5-5. The table illustrates the breakdown of vehicles observed and identified by the equipment for the manual classification study. As shown in Table 5-5, one Class 5 vehicle was misclassified as a Class 4 vehicle, one Class 5 vehicle was misclassified as a Class 8 vehicle, and one Class 9 was misclassified as a Class 15 vehicle (unclassified) by the WIM equipment.

Table 5-5 – Validation Misclassifications by Pair – 15-May-13

		WIM												
		3	4	5	6	7	8	9	10	11	12	13	14	15
	3	-												
	4		-											
	5		1	-			1							
	6				-									
Observed	7					-								
	8						-							
	9							-						1
	10								-					
	11									-				
	12										-			
	13												-	-	

As shown in the table, a total of 3 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 1.3% for heavy trucks (vehicle classes 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 2.9 percent, due to misclassification of two lightweight Class 5 vehicles.

The causes for the misclassifications were not investigated in the field. A post-visit investigation of misclassified vehicles was performed using the collected video. The analysis determined that the Class 9 was a Class 6 truck pulling a loaded two-axle trailer.

The combined results of the misclassifications resulted in an undercount of two Class 5 vehicles, and one Class 9 vehicle, and an overcount of one Class 4 vehicle and 1 Class 8 vehicle, as shown in Table 5-6. The misclassified percentage represents the percentage of the misclassified vehicles in the manual sample.

Table 5-6 – Validation Classification Study Results – 15-May-13

Class	3	4	5	6	7	8	9	10	11	12	13
Observed Count	0	0	23	5	5	1	64	5	0	0	0
WIM Count	0	1	21	5	5	2	64	4	0	0	0
Observed Percent	0.0	0.0	22.3	4.9	4.9	1.0	62.1	4.9	0.0	0.0	0.0
WIM Percent	0.0	1.0	20.4	4.9	4.9	1.9	62.1	3.9	0.0	0.0	0.0
Misclassified Count	0	0	2	0	0	0	0	1	0	0	0
Misclassified Percent	0.0	0.0	8.7	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0
Unclassified Count	0	0	0	0	0	0	0	1	0	0	0
Unclassified Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	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 5-7.

Table 5-7 – Validation Unclassified Trucks by Pair – 15-May-13

Observed Class	Unclassified	Observed Class	Unclassified	Observed Class	Unclassified
3	0	7	0	11	0
4	0	8	0	12	0
5	0	9	0	13	0
6	0	10	1		

Based on the manually collected sample of the 103 trucks, 1.0 percent 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 -0.7 mph; the range of errors was 1.1 mph.

Since the equipment is measuring all weight and distance parameters within the LTPP requirements for SPS WIM sites and with a very low bias (the average measurement error for GVW is 0.6 percent), a calibration of the system was not required or needed, and therefore was not carried out.

5.3.4   Final WIM System Compensation Factors

The final factors left in place at the conclusion of the validation are provided in Table 5-8.

Table 5-8 – Final Factors

Speed Point	MPH	Left	Right
		2	1
80	50	3296	3183
88	55	3330	3214
96	60	3350	3234
104	65	3337	3222
112	70	3222	3111
Axle Distance (cm)		369	
Dynamic Comp (%)		100	
Loop Width (cm)		336	

6 Post-Visit Data Analysis

A post-visit data analysis is conducted to further evaluate the validation truck data to determine if any relationships exist between WIM system weight and distance measurement error based on speed, temperature and/or truck type. Additionally, an analysis of the post-visit misclassifications noted during the Validation classification and speed study is conducted to possibly determine the cause of each truck misclassification.

If necessary, a traffic data sample from the days immediately following the validation to the date of the report submission may be conducted to further investigate anomalies in the traffic data that may have resulted from the calibration of the system or any other changes to the WIM system

6.1 Regression 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.

6.1.1 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. 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 52 to 65 mph.

- Pavement temperature. Pavement temperature ranged from 71.9 to 94.4 degrees Fahrenheit.

6.1.2   Results

For analysis of GVW weights, the value of regression coefficients and their statistical properties are summarized in Table 6-1. 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 6-1 are for the null hypothesis that assumes that the regression coefficients are equal to zero. The p-value reported in Table 6-1 is for the probability that the regression coefficient, given in Table 5-5, occur by chance alone.

Table 6-1 – Table of Regression Coefficients for Measurement Error of GVW

Parameter	Regression coefficients	Standard error	Value of t-distribution	Probability value (p-value)
Intercept	-3.3943	2.2559	-1.5046	0.1412
Speed	0.0472	0.0263	1.7960	0.0809
Temp	0.0132	0.0201	0.6561	0.5160
Truck	0.1627	0.2528	0.6437	0.5238

The lowest probability value given in Table 6-1 was 0.0809 for speed. This means that there is only about an 8 percent chance that the value of regression coefficient for speed (0.0472) can occur by chance alone. The relationship between speed and measurement errors is shown in Figure 6-1. The figure includes a trend line for the predicted percent error. Besides the visual assessment of the relationship, Figure 6-1 provides quantification and statistical assessment of the relationship.

$y = 0.0489x - 2.3035$
$R^2 = 0.8665$
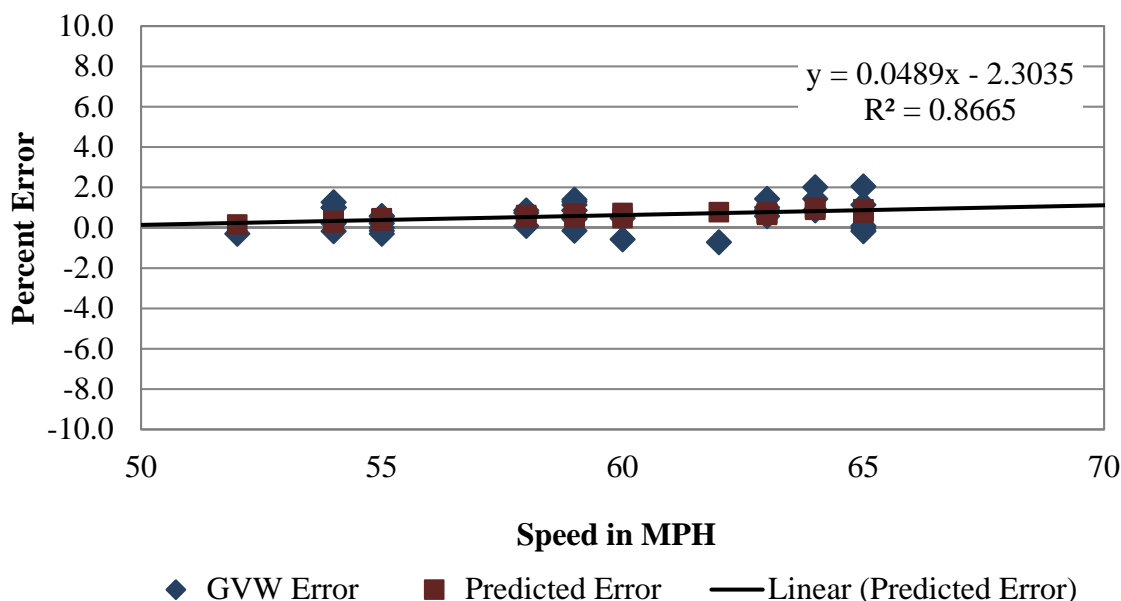
Figure 6-1 – Influence of Speed on the Measurement Error of GVW

The quantification of the relationship is provided by the value of the regression coefficient, in this case 0.0472 (in Table 6-1). This means, for example, that for a 10 mph increase in speed, the error is increased by about 0.4 percent (0.0472 x 10). The statistical assessment of the relationship is provided by the probability value of the regression coefficient (0.0809) and is not statistically significant at 95% confidence level (values equal or less than 0.05 would indicate statistical significance in this case).

6.1.3   Summary Results

Table 6-2 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 6-2 indicate that the probability that the relationship can occur by chance alone was greater than 20 percent.

Table 6-2 – Summary of Regression Analysis

Parameter	Factor					
	Speed		Temperature		Truck type	
	Regression coefficient	Probability value (p-value)	Regression coefficient	Probability value (p-value)	Regression coefficient	Probability value (p-value)
GVW	0.0472	0.0809	-	-	-	-
Steering axle	0.2201	0.0002	-0.0771	0.0626	-	-
Tandem axle tractor	-	-	-	-	1.4165	0.0004
Tandem axle trailer	-	-	-	-	-	-

6.1.4   Conclusions

1. According to Table 6-2, speed had a statistically significant effect on the measurement errors of steering axles only. This assumes that p-value must be smaller than 0.05 for the effect to be statistically significant.

2. Temperature did not have a statistically significant effect on any of the measurements. However, it is noted that the range of pavement temperature during the validation was only 22.5º F.

3. Truck type had statistically significant effect only on tandem axle measurement errors at 0.0004 probability value for tandem axles on tractors. The regression coefficients for truck type in Table 6-1 and Table 6-2 represent the difference between the mean errors for the Primary and Secondary trucks. (Truck type is an indicator variable with values of

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0 or 1). Thus, for example, the difference in the average measurement error for GVW between the Primary and Secondary trucks was about 0.2% (0.1627 in Table 6-1). The effect of truck type is further analyzed in 6.1.5.

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

6.1.5   Contribution of Two Trucks to Calibration

Calibration of WIM systems installed in LTPP lanes is carried out by adjusting calibration factors based on measurement errors of GVW obtained for calibration trucks. During the calibration process, the GVW measurement errors obtained for two calibration trucks are combined when calculating and setting calibration factors. Different calibration factors are used for different speed points (truck speeds). The question addressed in this section is: What would be the calibration factors (calibration results) if only one truck (either Primary or Secondary) was used?

The contribution of using Primary and Secondary trucks for the calibration of the WIM system is illustrated using Figure 6-2 and supported by the associated statistical analysis. It is noted that the influence of pavement temperature is not directly used in the calibration process and thus is not considered in this analysis.

Figure 6-2 and associated statistical analysis show that speed had similar influences on the GVW measurement for each truck and that trends in GVW errors are similar for both trucks with primary truck showing slightly greater negative bias (difference in bias values about 0.2 percent). Overall GVW error dependency on speed was very low for both trucks.
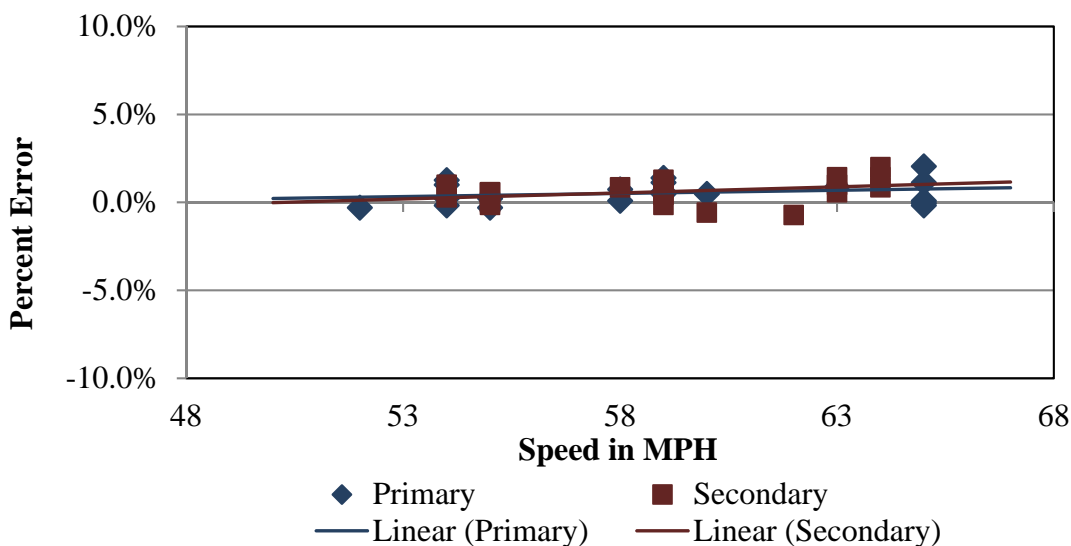
Figure 6-2– Influence of Speed on the GVW Measurement Error of Primary and Secondary Trucks

The use of two calibration trucks provided verification of the trends and speeded up the time required to obtain 40 pre-validation runs. However for this site, the use of only one of the trucks (Primary or Secondary) with 20 calibration runs would have resulted in similar verification results based on similarities in observed errors for both trucks.

More detailed analysis of the influence of calibration trucks on the verification/calibration results would be beneficial. In this case, the Primary and the Secondary trucks had similar dimensions and suspension systems, and also similar influence on the verification results.

6.2   Misclassification Analysis

A post-visit analysis was conducted on the truck misclassifications identified during the Validation conducted in the field. For this site, a total of 3 vehicles, including 1 heavy truck (6 – 13) were misclassified by the equipment. The single heavy truck misclassification was a Class 9 which was identified by the WIM system as a Class 15 vehicle (unclassified). According to the Sheet 20, this vehicle was vehicle number 20191. The capture of the real-time record for vehicle 20190 is provided in Figure 6-3.

(20191) LANE #1 CLASS 15 GVW 95.1 kips LENGTH 55 ft				
SPEED 64 mph MAX GVW 0.0 kips Tue May 14 2013 12:55:38 (1559)				
AXLE	SEPARATION	LEFT WT	RIGHT WT	TOTAL WT	ALLOWABLE
	(ft)	(kips)	(kips)	(kips)	(kips)
1 S		7.8	8.4	16.1	
2 T	15.8	5.1	4.9	10.0	
3 T	4.5	9.5	9.2	18.7	
4 T	4.5	9.3	8.9	18.2	
5 S	13.9	9.3	7.5	16.8	
6 S	12.5	7.8	7.4	15.2	

Figure 6-3 – Vehicle Record 20191

The video capture of vehicle 20191 is provided in Photo 6-1. As the photo illustrates, the misclassification involved a Class 6 truck pulling a loaded two-axle trailer. The atypical spacings between the third and fourth axles and the fourth and fifth axles are not currently programmed into the system's algorithm for a Class 9 vehicle. Therefore, the vehicle was identified as a Class 15 vehicle (unclassified) by the WIM system.

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Photo 6-1 – Video Capture of Vehicle 20191

6.3   Traffic Data Analysis

Since there was no calibration of the WIM system operating parameters performed during this validation, the post-visit data analysis was not performed.

7 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 Validation results.

7.1 Classification

The information in Table 7-1 data was extracted from the most recent previous validation and was updated to include the results of this validation.

Table 7-1 – Classification Validation History

| Date | Misclassification Percentage by Class | | | | | | | | | | | Pct Unclass |
	3	4	5	6	7	8	9	10	11	12	13	
27-Nov-07	-	67	33	25	0	0	0	0	-	-	-	0.0
28-Nov-07	-	100	46	13	0	0	0	0	-	-	-	0.0
20-May-08	-	67	23	0	0	13	1	33	-	-	-	0.0
21-May-08	-	0	14	0	0	33	0	33	-	-	0	0.0
12-Apr-11	-	0	18	0	0	0	0	0	0	0	0	1.2
13-Apr-11	-	100	14	0	0	0	0	0	0	0	0	2.0
15-May-13	0	0	9	0	0	0	2	0	0	0	0	3.0

7.2 Weight

Table 7-2 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, steering and single axles and tandems for prior pre- and Validations.

Table 7-2 – Weight Validation History

| Date | Mean Error and 2SD | | |
	GVW	Single Axles	Tandem
27-Nov-07	-1.8 ± 6.4	-5.4 ± 7.5	-1.0 ± 8.2
28-Nov-07	-0.5 ± 5.6	-2.0 ± 7.5	-0.2 ± 7.7
20-May-08	3.2 ± 7.3	4.7 ± 7.4	2.9 ± 7.8
21-May-08	0.2 ± 2.2	0.8 ± 3.0	0.2 ± 4.2
12-Apr-11	0.8 ± 2.8	2.1 ± 5.0	0.5 ± 3.4
13-Apr-11	0.1 ± 2.2	-3.9 ± 4.5	1.0 ± 2.9
15-May-13	0.6 ± 1.3	-2.1 ± 3.3	0.7 ± 2.4

The variability of the weight errors appears to have consistently decreased over time, since the site was first validated. It appears that the system demonstrates a tendency for the equipment to

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hold its calibration and not drift significantly between validation/calibration visits. The table also demonstrates the effectiveness of the calibrations in bringing the weight estimations within LTPP SPS WIM equipment tolerances.

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8   Additional Information

The following information is provided in the attached appendix:

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

Wisconsin, SPS-1
SHRP ID: 550100

Validation Date: May 15, 2013

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Photo 1 – Cabinet Exterior

Photo 2 – Cabinet Interior (Front)

Photo 3 – Cabinet Interior (Back)

Photo 4 – Leading Loop

Photo 5 – Leading WIM Sensor

Photo 6 – Trailing WIM Sensor

Photo 7 – Trailing Loop Sensor

Photo 8 – Power Service Box

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Photo 9 – Telephone Service Box

Photo 13 – Truck 1 Suspension 1

Photo 10 – Truck 1

Photo 14 – Truck 1 Suspension 2

Photo 11 – Truck 1 Tractor

Photo 15 – Truck 1 Suspension 3

Photo 12 – Truck 1 Trailer and Load

Photo 16 – Truck 1 Suspension 4

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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

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Photo 25 – Truck 2 Suspension 5

Traffic Sheet 16 **LTPP MONITORED TRAFFIC DATA** **SITE CALIBRATION SUMMARY**	STATE CODE: 55 SPS WIM ID: 550100 DATE (mm/dd/yyyy) 5/15/2013

SITE CALIBRATION INFORMATION

1. DATE OF CALIBRATION {mm/dd/yy}   5/15/13

2. TYPE OF EQUIPMENT CALIBRATED: Both

3. REASON FOR CALIBRATION: LTPP Validation

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

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

5. EQUIPMENT MANUFACTURER: IRD iSINC

WIM SYSTEM CALIBRATION SPECIFICS

6. CALIBRATION TECHNIQUE USED: Test Trucks

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

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

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

Mean Difference Between -

Dynamic and Static GVW:	0.6%	Standard Deviation:	0.7%
Dynamic and Static Single Axle:	-2.1%	Standard Deviation:	1.6%
Dynamic and Static Double Axles:	0.7%	Standard Deviation:	1.2%

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

9. DEFINE SPEED RANGES IN MPH:

		Low		High	Runs
a.	Low	52.0	to	56.3	13
b.	Medium	56.4	to	60.8	14
c.	High	60.9	to	65.0	13
d.			to		
e.			to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE:	55
	SPS WIM ID:	550100
	DATE (mm/dd/yyyy)	5/15/2013

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED)   3222 | 3111

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:	0.0	FHWA Class	5	-	-9.0
FHWA Class 8:	100.0	FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 1.0%

Validation Test Truck Run Set -   Pre

Person Leading Calibration Effort: Kevin Trousdale

Contact Information: Phone: 717-975-3550

E-mail: ktrousdale@ara.com

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	Traffic Sheet 20				STATE CODE:		55		
	LTPP MONITORED TRAFFIC DATA				SPS WIM ID:		550100		
	SPEED AND CLASSIFICATION STUDIES				DATE (mm/dd/yyyy)		5/15/2013		
Count -	103	Time =	3:47:56		Trucks (4-15) - 103			Class 3s -	0
WIM speed	WIM Class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
59	6	19615	58	6	**66**	**4**	**19755**	**66**	**5**
62	5	19620	62	5	59	5	19756	60	5
64	6	19628	65	6	61	9	19758	61	9
67	5	19635	68	5	60	9	19760	60	9
67	9	19638	67	9	66	9	19766	66	9
70	9	19647	71	9	69	5	19767	69	5
64	9	19649	65	9	47	5	19768	49	5
63	9	19651	67	9	59	9	19771	58	9
64	9	19673	64	9	65	9	19773	65	9
68	9	19675	69	9	64	10	19778	65	10
58	5	19680	65	5	61	6	19788	60	6
67	5	19684	72	5	67	9	19790	66	9
66	7	19696	66	7	61	9	19793	61	9
68	5	19698	70	5	64	9	19798	65	9
65	7	19699	65	7	68	9	19808	68	9
65	7	19703	65	7	61	10	19823	61	10
60	9	19706	61	9	67	9	19849	67	9
68	9	19708	69	9	57	9	19850	56	9
67	9	19709	69	9	68	5	19853	69	5
68	9	19714	68	9	64	9	19856	64	9
68	9	19725	68	9	64	9	19858	65	9
65	9	19736	65	9	57	9	1986	57	9
71	10	19740	71	10	65	5	19861	66	5
68	5	19745	68	5	64	9	19862	64	9
68	9	19750	67	9	66	9	19875	66	9

Sheet 1 - 0 to 50   Start: 9:44:49   Stop: 11:15:50

Recorded By: GAH   Verified By: djw

Validation Test Truck Run Set -   Pre

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES					STATE CODE: 55 SPS WIM ID: 550100 DATE (mm/dd/yyyy) 5/15/2013				

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
65	9	19877	65	9	64	7	20099	64	7
62	9	19879	63	9	63	7	20100	63	7
65	9	19892	66	9	65	9	20108	66	9
63	9	19894	63	9	63	9	20112	65	9
64	9	19898	64	9	63	9	20115	64	9
65	9	19922	67	9	66	8	20119	66	8
64	9	19947	65	9	64	9	20125	65	9
66	9	19952	66	9	62	6	20130	63	6
65	9	19955	65	9	64	9	20134	65	9
65	9	19956	65	9	64	9	20135	65	9
68	5	19958	68	5	65	9	20136	66	9
62	9	19960	63	9	66	10	20172	67	10
60	9	19961	62	9	65	9	20183	66	9
65	5	19965	67	5	**64**	**15**	**20191**	**64**	**10**
66	6	19968	69	6	67	9	20192	67	9
64	9	19991	65	9	64	9	20194	65	9
68	5	19996	68	5	66	5	20195	67	5
60	9	19997	60	9	67	5	20215	67	5
60	9	20001	61	9	**64**	**8**	**20216**	**64**	**5**
68	5	20025	69	5	64	5	20220	65	5
63	9	20053	64	9	57	5	20223	59	5
66	9	20054	67	9	67	9	20225	68	9
70	9	20059	70	9	64	9	20261	65	9
57	9	20097	58	9	64	9	20269	64	9
62	9	20098	62	9	65	9	20270	66	9

Sheet 2 - 51 to 100   Start: 11:15:59   Stop: 13:28:54

Recorded By: GAH   Verified By: djw

Validation Test Truck Run Set -   Pre

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
66	5	20271	66	5					
48	5	20283	49	5					
60	9	20288	60	9					

Sheet 3 - 101 - 150   Start: _____13:29:03_____   Stop: _____13:32:45_____

Recorded By: _____GAH_____   Verified By: _____djw_____

Validation Test Truck Run Set - _____Pre_____