WIM System Field Calibration and Validation Summary Report

California SPS-2
SHRP ID – 060200

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Table of Contents

1 Executive Summary 1
2 WIM System Data Availability and Pre-Visit Data Analysis 3
2.1 LTPP WIM Data Availability 3
2.2 Classification Data Analysis 4
2.3 Speed Data Analysis 5
2.4 GVW Data Analysis 6
2.5 Class 9 Front Axle Weight Data Analysis 7
2.6 Class 9 Tractor Tandem Spacing Data Analysis 9
2.7 Data Analysis Summary 10
3 WIM Equipment Discussion 11
3.1 Description 11
3.2 Physical Inspection 11
3.3 Electronic and Electrical Testing 11
3.4 Equipment Troubleshooting and Diagnostics 11
3.5 Recommended Equipment Maintenance 11
4 Pavement Discussion 12
4.1 Pavement Condition Survey 12
4.2 LTPP Pavement Profile Data Analysis 12
4.3 Profile and Vehicle Interaction 14
4.4 Recommended Pavement Remediation 14
5 Statistical Reliability of the WIM Equipment 15

5.1 Validation 15
5.1.1 Statistical Speed Analysis 16
5.1.2 Statistical Temperature Analysis 20
5.1.3 Classification and Speed Evaluation 22
5.1.4 Final WIM System Compensation Factors 24
6 Post-Visit Data Analysis 25
6.1 Regression Analysis 25
6.1.1 Data 25
6.1.2 Results 26
6.1.3 Summary Results 27
6.1.4 Conclusions 28
6.1.5 Contribution of Two Trucks to Calibration 28
6.2 Misclassification Analysis 30
6.3 Traffic Data Analysis 30
7 Previous WIM Site Validation Information 31
7.1 Classification 31
7.2 Weight 31
8 Additional Information 32

List of Figures

Figure 2-1 – Comparison of Truck Distribution 4
Figure 2-2 – Truck Speed Distribution – 14-Jan-13 5
Figure 2-3 – Comparison of Class 9 GVW Distribution 6
Figure 2-4 – Distribution of Class 9 Front Axle Weights 8
Figure 2-5 – Comparison of Class 9 Tractor Tandem Spacing 9
Figure 5-1 – Validation GVW Errors by Speed – 24-Sep-13 17
Figure 5-2 – Validation Steering Axle Weight Errors by Speed – 24-Sep-13 17
Figure 5-3 – Validation Tandem Axle Weight Errors by Speed – 24-Sep-13 18
Figure 5-4 – Validation GVW Error by Truck and Speed – 24-Sep-13 18
Figure 5-5 – Validation Axle Length Error by Speed – 24-Sep-13 19
Figure 5-6 – Validation Overall Length Error by Speed – 24-Sep-13 19
Figure 5-7 – Validation GVW Errors by Temperature – 24-Sep-13 20
Figure 5-8 – Validation Steering Axle Weight Errors by Temperature – 24-Sep-13 21
Figure 5-9 – Validation Tandem Axle Weight Errors by Temperature – 24-Sep-13 21
Figure 5-10 – Validation GVW Error by Truck and Temperature – 24-Sep-13 22
Figure 6-1 – Influence of Speed on the Measurement Error of GVW 27
Figure 6-2– Influence of Speed on the GVW Measurement Error of Primary and Secondary Trucks 29

List of Tables

Table 1-1 – Validation Results – 24-Sep-13 1
Table 1-2 – Validation Test Truck Measurements 2
Table 2-1 – LTPP Data Availability 3
Table 2-2 – LTPP Data Availability by Month 3
Table 2-3 – Truck Distribution from W-Card 5
Table 2-4 – Class 9 GVW Distribution from W-Card 7
Table 2-5 – Class 9 Front Axle Weight Distribution from W-Card 8
Table 2-6 – Class 9 Axle 2 to 3 Spacing from W-Card 10
Table 4-1 – Recommended WIM Smoothness Index Thresholds 12
Table 4-2 – WIM Index Values 13
Table 5-1 - Validation Test Truck Measurements 15
Table 5-2 – Validation Overall Results – 24-Sep-13 15
Table 5-3 – Validation Results by Speed – 24-Sep-13 16
Table 5-4 – Validation Results by Temperature – 24-Sep-13 20
Table 5-5 – Validation Misclassifications by Pair – 24-Sep-13 23
Table 5-6 – Validation Classification Study Results – 24-Sep-13 23
Table 5-7 – Final Factors 24
Table 6-1 – Table of Regression Coefficients for Measurement Error of GVW 26
Table 6-2 – Summary of Regression Analysis 27
Table 6-3 – Validation Results by Truck Type – 24-Sep-13 29
Table 7-1 – Classification Validation History 31
Table 7-2 – Weight Validation History 31

1 Executive Summary

A WIM validation was performed on September 24, 2013 at the California SPS-2 site located on route SR-99, milepost 32.5, and 0.6 miles north of Collier Road exit.

This site was installed on November 30, 2007. The in-road sensors are installed in the northbound, 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 November 29, 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. The sensors do not show signs of 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, a crack was noted at a location 595 feet upstream of the WIM sensors. Adverse truck dynamics were noted in this area. A visual observation of the trucks as they approach, traverse, and leave the sensor area indicated that the truck dynamics diminishd prior to the truck crossing over the WIM scale. Consequently, the adverse affects did 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. The summary results of the validation are provided in Table 1-1 below.

Table 1-1 – Validation Results – 24-Sep-13

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	1.2 ± 3.7%	Pass
Tandem Axles	±15 percent	0.2 ± 2.7%	Pass
GVW	±10 percent	0.4 ± 2.1%	Pass
Vehicle Length	±3.0 percent (1.9 ft)	-0.1 ± 1.3 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.1 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 -0.9 ± 3.0 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 0.0 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 0.0% is within the 2.0% acceptability criterion for LTPP SPS WIM sites. The overall misclassification rate of 0.7% from the 138 vehicle sample (Class 4 – 13) was due to the misclassification of a single Class 5 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 concrete mix, bagged and palletized.

- 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 trailer. The Secondary truck was loaded with concrete mix, bagged and palletized.

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 8). 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	74.4	11.1	15.9	15.9	15.8	15.8	16.5	4.3	31.8	4.2	56.8	63.3
2	65.0	11.7	13.9	13.9	12.8	12.8	17.6	4.3	32.2	4.3	58.4	65.3

The posted speed limit at the site is 55 mph. During the testing, the speed of the test trucks ranged from to 46 to 59 mph, a variance 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 80.3 to 102.3 degrees Fahrenheit, a range of 22.0 degrees Fahrenheit. The cloudy weather and cooler ambient temperatures during the validation 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 does not require any additional 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 January 14, 2013 (Data) to the most recent Comparison Data Set (CDS) from January 31, 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 2008 to 2012.

Table 2-1 – LTPP Data Availability

Year	Total Number of Days in Year	Number of Months
2008	339	12
2009	344	12
2010	351	12
2011	357	12
2012	225	8

As shown in the table, this site does not require any additional years of data to meet the minimum of five years of research quality data.

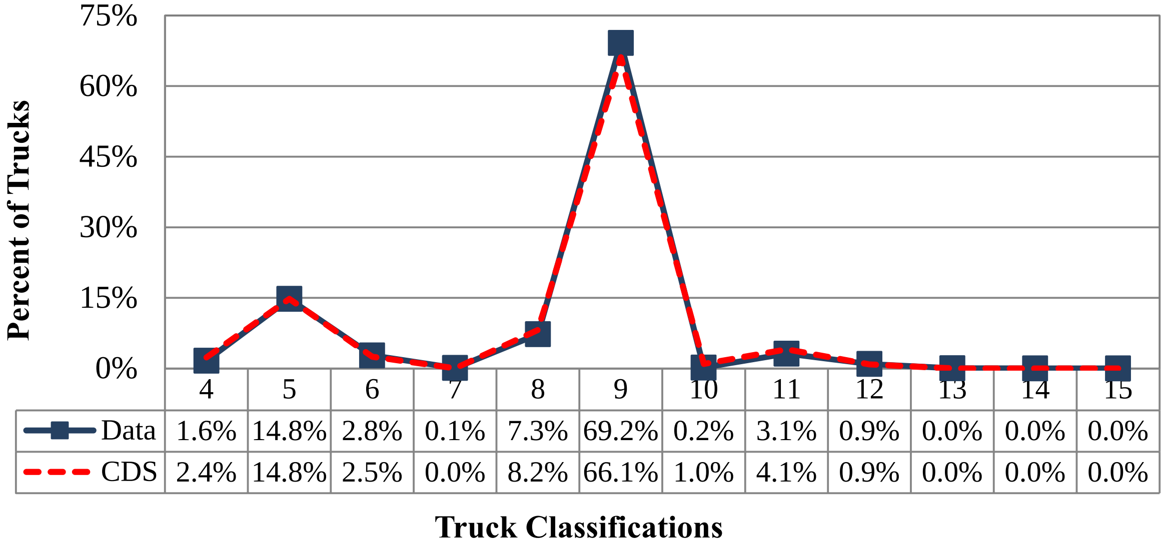
Table 2-2 provides a monthly breakdown of the available data for years 2008 through 2012.

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	
2008	4	29	31	30	31	30	31	31	30	31	30	31	12
2009	31	28	31	30	31	30	31	31	30	31	30	10	12
2010	21	28	31	30	31	28	29	31	30	31	30	31	12
2011	31	28	30	30	31	23	31	31	30	31	30	31	12
2012	31	29	31	30	31	30	31	12					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 is conducted on site. Figure 2-1 provides a comparison of the truck type distributions between the sample dataset from January 14, 2013 (Data) and the most recent comparison Data Set (CDS) from January 31, 2011.



	4	5	6	7	8	9	10	11	12	13	14	15
Data	1.6%	14.8%	2.8%	0.1%	7.3%	69.2%	0.2%	3.1%	0.9%	0.0%	0.0%	0.0%
CDS	2.4%	14.8%	2.5%	0.0%	8.2%	66.1%	1.0%	4.1%	0.9%	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 two most frequent truck types crossing the WIM scale are Class 9 (69.2%) and Class 5 (14.8%) 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 0.0 percent of the vehicles at this site are unclassified.

Table 2-3 – Truck Distribution from W-Card

Vehicle Classification	CDS		Data		Change
	Date				
	1/31/2011		1/14/2013		
4	1443	2.4%	968	1.6%	-0.7%
5	9035	14.8%	8714	14.8%	0.0%
6	1531	2.5%	1626	2.8%	0.2%
7	26	0.0%	53	0.1%	0.0%
8	5004	8.2%	4290	7.3%	-0.9%
9	40348	66.1%	40801	69.2%	3.0%
10	593	1.0%	110	0.2%	-0.8%
11	2489	4.1%	1851	3.1%	-0.9%
12	536	0.9%	556	0.9%	0.1%
13	10	0.0%	20	0.0%	0.0%
14	0	0.0%	0	0.0%	0.0%
15	0	0.0%	0	0.0%	0.0%

From the table it can be seen that the percentage of Class 9 vehicles has increased by 3.0 percent from January 2011 and January 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 trucks remained the same.

2.3 Speed Data Analysis

The traffic data received from the Phase II Contractor was analyzed to determine the expected truck speed distributions. This provides a basis for determining the speed of the test trucks during validation testing. The distribution of speeds is shown in Figure 2-2.

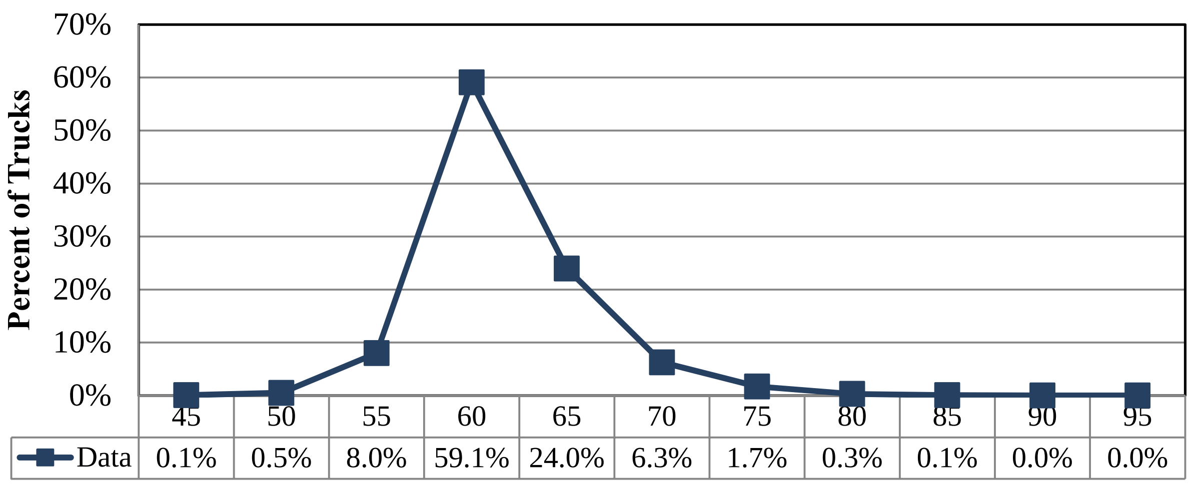
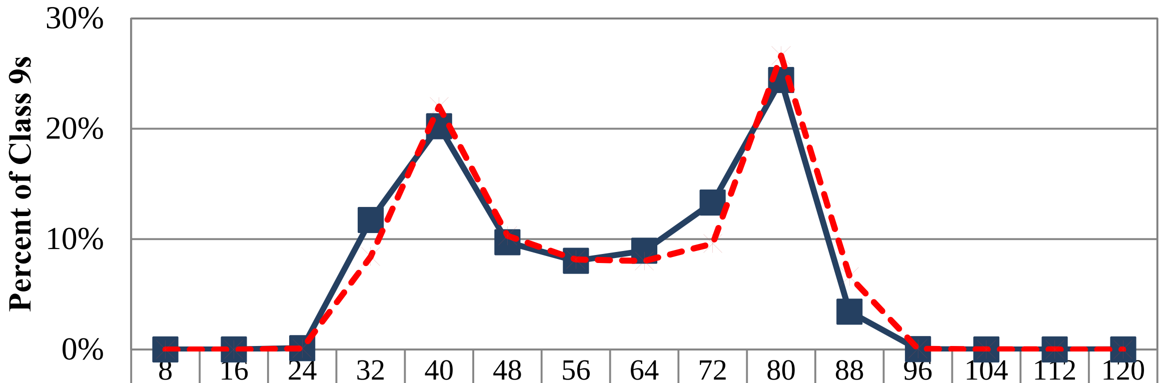


Figure 2-2 – Truck Speed Distribution – 14-Jan-13

As shown in Figure 2-2, the majority of the trucks at this site are traveling between 55 and 65 mph. The posted speed limit at this site is 55 and the 85th percentile speed for trucks at this site is 63 mph. Due to the high volume of truck traffic at this site, and the safety implications of running trucks at speeds below 50 mph, the expected range of truck speeds for the validation is 50 to 60 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 January 2013 and the Comparison Data Set from January 2011. The unloaded and loaded peaks for the January 2011 Comparison Data Set (CDS) and the January 2013 two-week sample W-card dataset (Data) are similar.



	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
Data	0.0%	0.0%	0.1%	11.7	20.2	9.7%	8.0%	8.9%	13.3	24.4	3.4%	0.0%	0.0%	0.0%	0.0%
CDS	0.0%	0.0%	0.1%	8.4%	22.0	10.3	8.2%	8.0%	9.6%	26.6	6.6%	0.1%	0.0%	0.0%	0.0%

Figure 2-3 – Comparison of Class 9 GVW Distribution

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

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

GVW weight bins (kips)	CDS		Data		Change
	Date				
	1/31/2011		1/14/2013		
8	0	0.0%	0	0.0%	0.0%
16	2	0.0%	2	0.0%	0.0%
24	38	0.1%	50	0.1%	0.0%
32	3216	8.4%	4576	11.7%	3.3%
40	8402	22.0%	7895	20.2%	-1.8%
48	3933	10.3%	3792	9.7%	-0.6%
56	3116	8.2%	3134	8.0%	-0.1%
64	3064	8.0%	3491	8.9%	0.9%
72	3662	9.6%	5196	13.3%	3.7%
80	10164	26.6%	9527	24.4%	-2.2%
88	2530	6.6%	1335	3.4%	-3.2%
96	27	0.1%	11	0.0%	0.0%
104	7	0.0%	1	0.0%	0.0%
112	3	0.0%	2	0.0%	0.0%
120	2	0.0%	4	0.0%	0.0%
Average =	56.3 kips		54.8 kips		-1.5 kips

As shown in the table, the percentage of unloaded class 9 trucks in the 32 to 40 kips range decreased by 1.8 percent while the percentage of loaded class 9 trucks in the 72 to 80 kips range decreased by 2.2 percent. During this time period the percentage of overweight trucks decreased by 3.2 percent. Based on the average Class 9 GVW values from the per vehicle records, the GVW average for this site decreased by 2.8 percent, from 56.3 to 54.8 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 provides 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 January 2013 and the Comparison Data Set from January 2011. The percentage of light axles (9.5 to 10.5 kips) increased by approximately 0.6 percent and the percentage of heavy axles (11.5 to 12.5 kips) increased by approximately 0.1%.

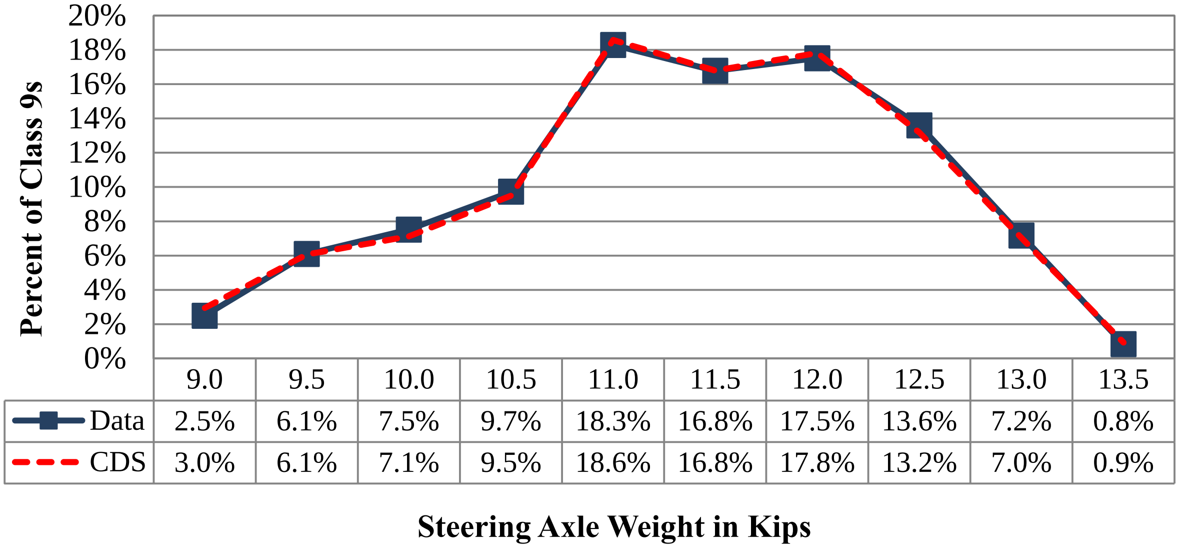


Figure 2-4 – Distribution of Class 9 Front Axle Weights

It can be seen in the figure that the greatest percentage of trucks have front axle weights measuring between 11.0 and 12.0 kips. The percentage of trucks in this range has decreased by 0.3 percent between the January 2011 Comparison Data Set (CDS) and the January 2013 dataset (Data).

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

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

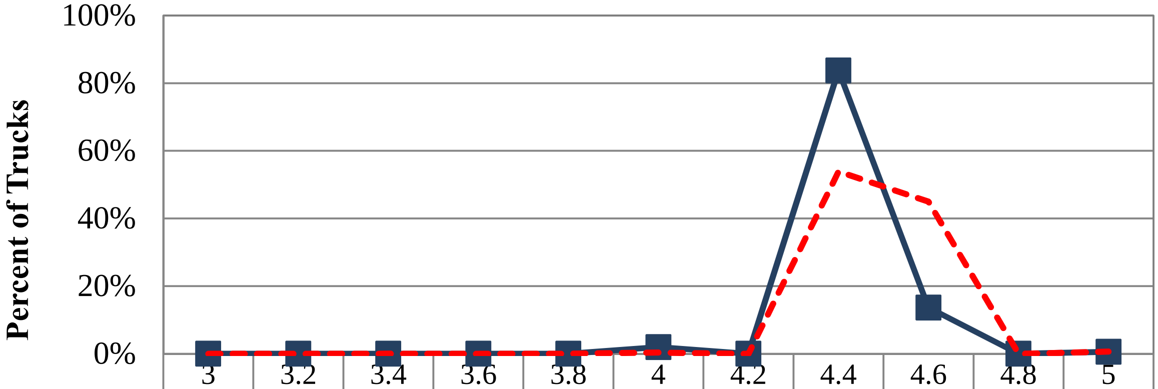
F/A weight bins (kips)	CDS		Data		Change
	Date				
	1/31/2011		1/14/2013		
9.0	1121	3.0%	967	2.5%	-0.5%
9.5	2302	6.1%	2365	6.1%	0.0%
10.0	2702	7.1%	2918	7.5%	0.4%
10.5	3603	9.5%	3776	9.7%	0.2%
11.0	7046	18.6%	7100	18.3%	-0.3%
11.5	6369	16.8%	6514	16.8%	0.0%
12.0	6757	17.8%	6799	17.5%	-0.3%
12.5	4999	13.2%	5280	13.6%	0.4%
13.0	2668	7.0%	2785	7.2%	0.1%
13.5	355	0.9%	326	0.8%	-0.1%
Average =	11.1 kips		11.1 kips		0.0 kips

The table shows that the average front axle weight for Class 9 trucks has remained the same. According to the values from the per vehicle records, the average front axle weight for Class 9 trucks is 11.1 kips.

2.6 Class 9 Tractor Tandem Spacing Data Analysis

The CDS data received from the Regional Support Contractor was analyzed to determine the expected average tractor tandem spacing. This will provide a basis for the evaluation of the accuracy of the equipment distance and speed measurements by comparing the observed average tractor tandem spacing 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	3.2	3.4	3.6	3.8	4	4.2	4.4	4.6	4.8	5
Data	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	0.0%	83.8%	13.7%	0.0%	0.6%
CDS	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.0%	53.9%	45.0%	0.0%	0.7%

Tractor 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 January 2011 Comparison Data Set and the January 2013 Data are different. It appears that there are more tandem axle spacings of 4.0 feet and less tandem axle spacings of 4.4 feet from the sample data (Data) with the expected average tractor tandem spacing from the comparison data set (CDS).

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				
	1/31/2011		1/14/2013		
3.0	0	0.0%	0	0.0%	0.0%
3.2	0	0.0%	0	0.0%	0.0%
3.4	12	0.0%	0	0.0%	0.0%
3.6	0	0.0%	0	0.0%	0.0%
3.8	14	0.0%	6	0.0%	0.0%
4.0	141	0.4%	771	2.0%	1.6%
4.2	0	0.0%	0	0.0%	0.0%
4.4	20539	53.9%	32661	83.8%	29.9%
4.6	17145	45.0%	5328	13.7%	-31.3%
4.8	0	0.0%	0	0.0%	0.0%
5.0	251	0.7%	229	0.6%	-0.1%
Average =	4.5 feet		4.4 feet		-0.1 feet

From the table it can be seen that the majority of drive tandem spacings for Class 9 trucks at this site are between 4.4 and 4.6 feet. Based on the average Class 9 drive tandem spacing values from the per vehicle records, the average tractor tandem spacing is 4.4, which is less than the average of 4.5 from the CDS per vehicle records. Further axle spacing analyses are performed during the validation analysis.

2.7 Data Analysis Summary

Historical data analysis involved the comparison of the most recent Comparison Data Set (January 2011) based on the last calibration with the most recent two-week WIM data sample from the site (January 2013). Comparison of vehicle class distribution data indicates a 3.0 percent increase in the percentage of Class 9 vehicles. Analysis of Class 9 weight data indicates that front axle weights have remained the same and average Class 9 GVW has decreased by 2.8 percent for the January 2013 data. The data indicates an average truck tandem spacing of 4.4 feet, which is less than the average of 4.5 feet observed in the previous CDS.

3 WIM Equipment Discussion

From a comparison between the report of the most recent validation of this equipment on November 29, 2011 and this validation visit, it appears that no changes have occurred during this time to the basic operating condition of the equipment, however, the solar panel has been replaced.

3.1 Description

This site was installed on November 30, 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 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 8.

3.3 Electronic and Electrical Testing

Electronic and electrical checks of all system components were conducted prior to the 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, the distress shown in Photo 4-1 was noted at a location 595 feet prior to the WIM scales. The adverse truck dynamics noted at this location appeared to diminish prior to crossing the WIM scales and consequently did not appear to affect the accuracy of the WIM sensors.

Photo 4-1 – Pavement Distress 595 Feet Prior to WIM Scales

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 4 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)	0.891	0.995	0.955			0.947
		SRI (m/km)	0.573	0.617	0.528			0.573
		Peak LRI (m/km)	1.240	1.165	1.421			1.275
		Peak SRI	0.773	0.772	0.810			0.785
	RWP	LRI (m/km)	0.916	0.974	1.029			0.973
		SRI (m/km)	1.047	0.987	1.314			1.116
		Peak LRI (m/km)	0.974	1.087	1.029			1.030
		Peak SRI (m/km)	1.093	1.199	1.407			1.233
Center	LWP	LRI (m/km)	0.798	0.800	0.860	0.772		0.808
		SRI (m/km)	0.528	0.831	*0.424*	*0.473*		0.564
		Peak LRI (m/km)	1.019	0.867	1.010	0.959		0.964
		Peak SRI (m/km)	0.767	1.031	0.785	*0.745*		0.832
	RWP	LRI (m/km)	0.887	0.817	0.943	0.791		0.860
		SRI (m/km)	0.890	0.629	0.930	0.934		0.846
		Peak LRI (m/km)	1.071	1.003	1.026	1.040		1.035
		Peak SRI (m/km)	1.016	1.109	1.193	1.104		1.106
Right	LWP	LRI (m/km)	0.919	1.024	0.893			0.945
		SRI (m/km)	*0.257*	0.694	*0.487*			*0.479*
		Peak LRI (m/km)	1.031	1.164	0.893			1.029
		Peak SRI (m/km)	0.826	0.798	0.972			0.865
	RWP	LRI (m/km)	1.167	1.003	1.320			1.163
		SRI (m/km)	0.991	0.547	0.734			0.757
		Peak LRI (m/km)	1.185	1.115	1.320			1.207
		Peak SRI (m/km)	**1.539**	**1.377**	**2.147**			**1.688**

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 right shift passes (shown in bold).

4.3 Profile and Vehicle Interaction

Profile data was collected on November 15, 2012 by the Western 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, 10 profile passes were made, 4 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 580 in/mi and is located approximately 585 feet prior to the WIM scale. The highest IRI value within the 400 foot approach section was 160 in/mi and is located approximately 389 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.

As a result of the pavement interaction study, where bouncing was detected at a location approximately 585 feet prior to the WIM scales, a specific pavement condition survey in this area was performed. A transverse crack in the pavement was noted at this location. The truck dynamics caused by the distress appeared to diminish prior to the trucks crossing over the WIM scales.

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 validation test truck runs, as well as information resulting from the classification and speed studies. All analyses of test truck data and information on necessary equipment adjustments are provided.

5.1 Validation

The 40 validation test truck runs were conducted on September 24, 2013, beginning at approximately 9:53 AM and continuing until 4:13 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with concrete mix, bagged and palletized, 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 concrete mix, bagged and palletized, and equipped with air suspension on the tractor, air suspension on the trailer, with standard tandem spacing on the tractor and on the 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	74.4	11.1	15.9	15.9	15.8	15.8	16.5	4.3	31.8	4.2	56.8	63.3
2	65.0	11.7	13.9	13.9	12.8	12.8	17.6	4.3	32.2	4.3	58.4	65.3

Test truck speeds varied by 13 mph, from 46 to 59 mph. The measured validation pavement temperatures varied 22.0 degrees Fahrenheit, from 80.3 to 102.3. The cooler ambient temperatures prevented the desired minimum 30 degree temperature range. Table 5-2 is a summary of post validation results.

Table 5-2 – Validation Overall Results – 24-Sep-13

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	1.2 ± 3.7%	Pass
Tandem Axles	±15 percent	0.2 ± 2.7%	Pass
GVW	±10 percent	0.4 ± 2.1%	Pass
Vehicle Length	±3.0 percent (1.9 ft)	-0.1 ± 1.3 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.1 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 -0.9 ± 3.0 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 0.0 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.

5.1.1 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 – 24-Sep-13

Parameter	95% Confidence Limit of Error	Low	Medium	High
		46.0 to 50.3 mph	50.4 to 54.8 mph	54.9 to 59.0 mph
Steering Axles	±20 percent	0.4 ± 4.2%	1.3 ± 3.6%	1.7 ± 3.9%
Tandem Axles	±15 percent	0.2 ± 2.2%	-0.5 ± 2.5%	0.7 ± 3.0%
GVW	±10 percent	0.3 ± 1.8%	-0.2 ± 2.1%	0.9 ± 2.1%
Vehicle Length	±3.0 percent (1.9 ft)	0.0 ± 1.0 ft	0.1 ± 2.0 ft	-0.2 ± 1.2 ft
Vehicle Speed	± 1.0 mph	-1.3 ± 3.2 mph	-1.1 ± 3.9 mph	-0.3 ± 2.3 mph
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.1 ft	0.0 ± 0.1 ft	0.0 ± 0.2 ft

From the table, it can be seen that the WIM equipment estimates all weights with similar accuracy at all speeds. There does not appear to be a relationship between weight estimates and speed at this site.

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

5.1.1.1 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.

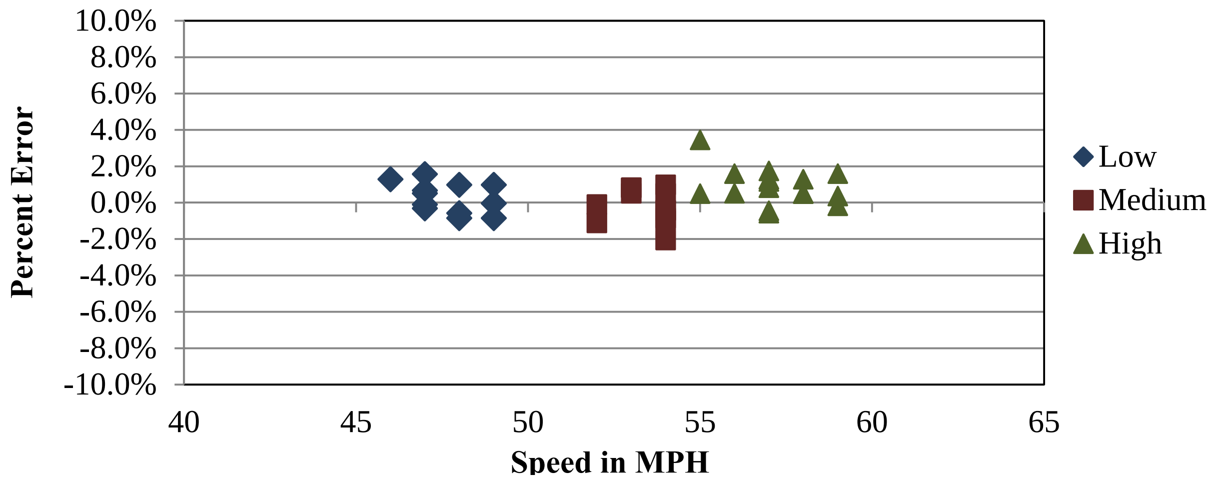


Figure 5-1 – Validation GVW Errors by Speed – 24-Sep-13

5.1.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-2, the equipment estimated steering axle weights with similar accuracy at all speeds. The range in error is similar throughout the entire speed range. There does not appear to be a correlation between speed and weight estimates at this site.

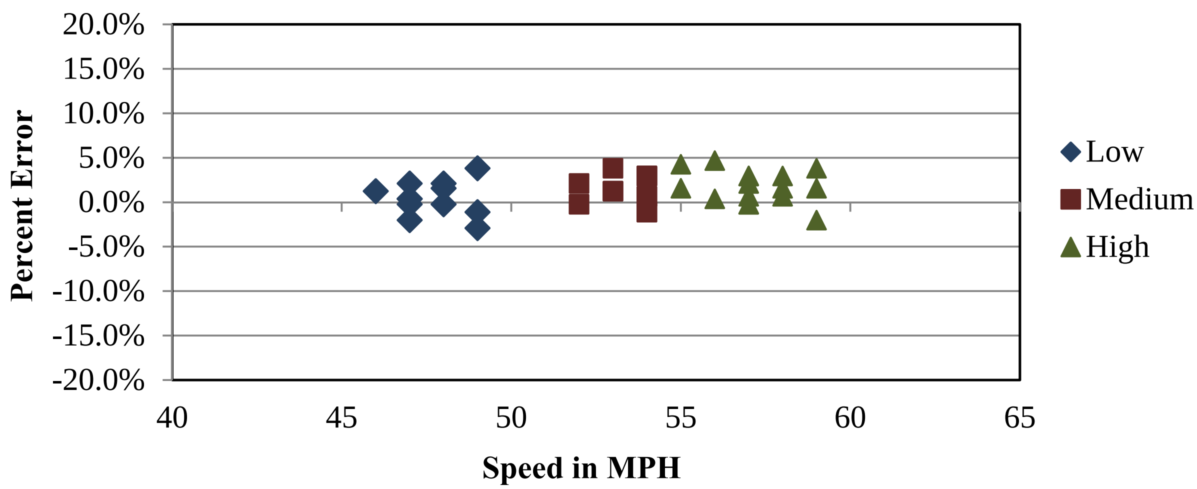


Figure 5-2 – Validation Steering Axle Weight Errors by Speed – 24-Sep-13

5.1.1.3 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.

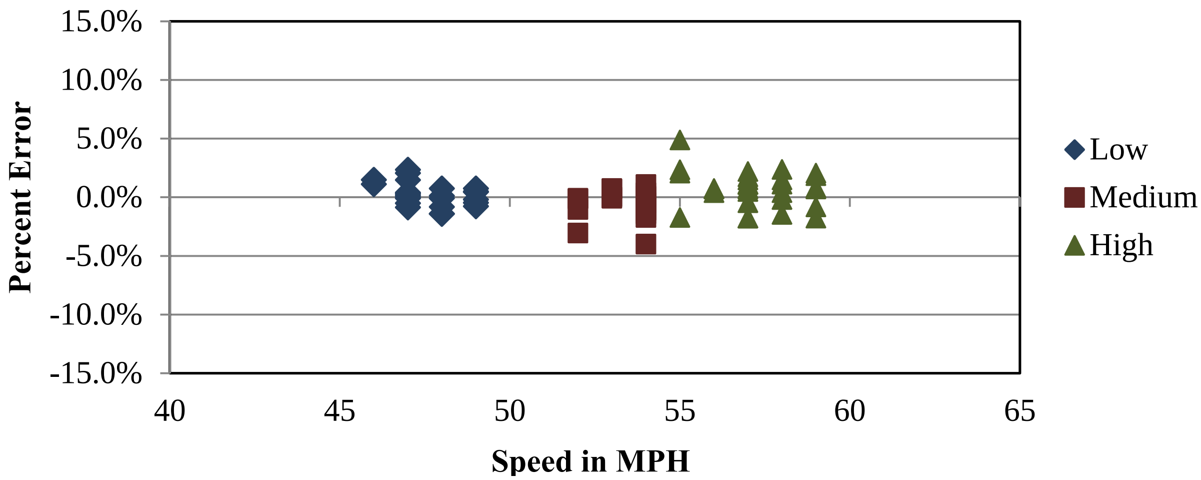


Figure 5-3 – Validation Tandem Axle Weight Errors by Speed – 24-Sep-13

5.1.1.4 GVW Errors by Speed and Truck Type

It can be seen in Figure 5-4 that when the GVW errors are analyzed by truck type, the WIM equipment slightly underestimates GVW for the fully-loaded (Primary) truck and slightly overestimates GVW for the partially loaded (Secondary) truck.

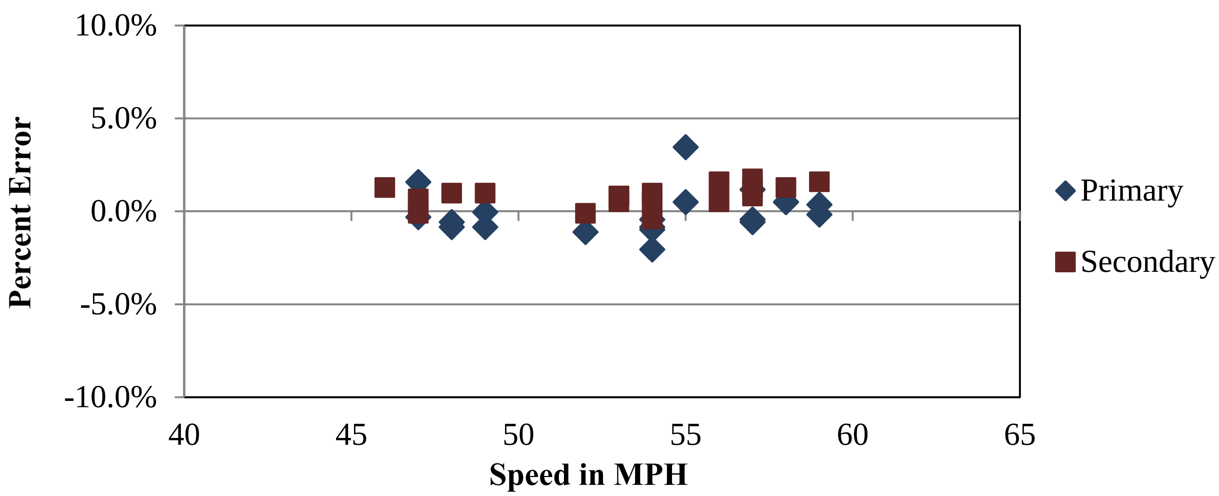


Figure 5-4 – Validation GVW Error by Truck and Speed – 24-Sep-13

5.1.1.5 Axle Length Errors by Speed

For this site, the error in axle length measurement was consistent at all speeds. The range in axle length measurement error was from -0.2 feet to 0.1 feet. Distribution of errors is shown graphically in Figure 5-5.

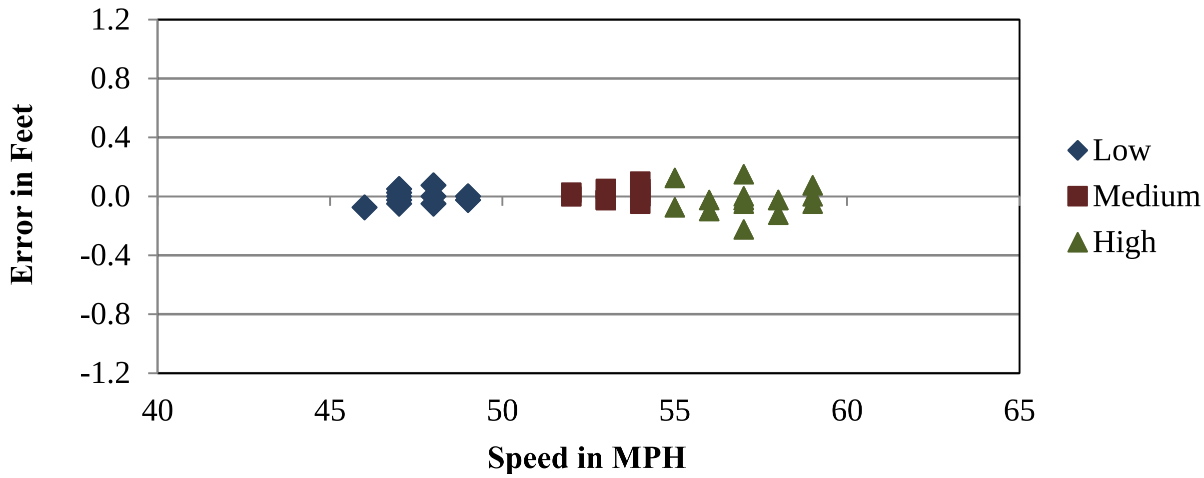


Figure 5-5 – Validation Axle Length Error by Speed – 24-Sep-13

5.1.1.6 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 -1.3 to 2.7 feet. Distribution of errors is shown graphically in Figure 5-6.

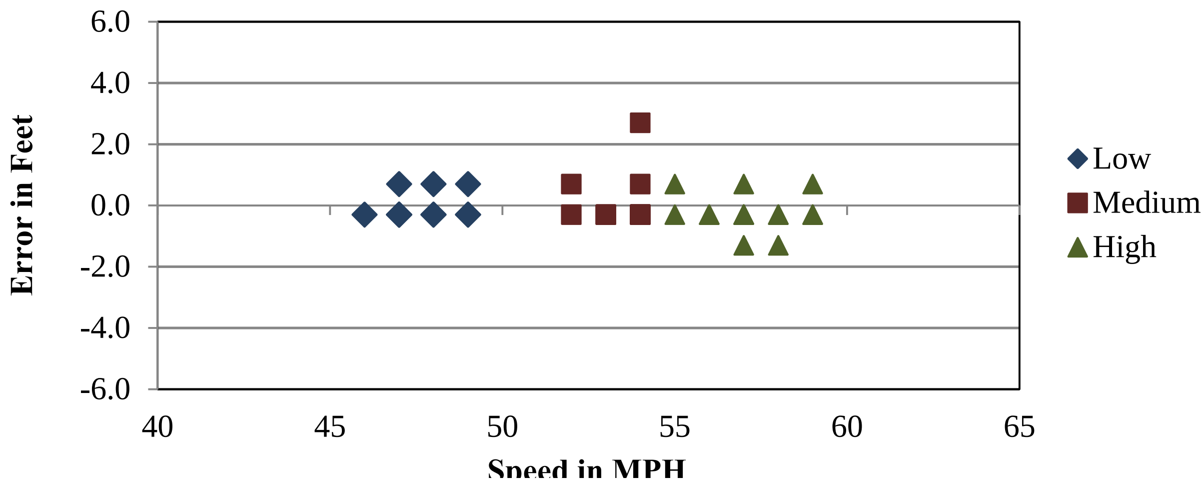


Figure 5-6 – Validation Overall Length Error by Speed – 24-Sep-13

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 was 22.0 degrees, from 80.3 to 102.3 degrees Fahrenheit. The validation test runs are reported under two temperature groups – low and high, as shown in Table 5-4 below.

Table 5-4 – Validation Results by Temperature – 24-Sep-13

Parameter	95% Confidence Limit of Error	Low	High
		80.3 to 91.3 degF	91.4 to 102.3 degF
Steering Axles	+20 percent	1.0 ± 4.7%	1.3 ± 3.6%
Tandem Axles	+15 percent	0.0 ± 2.3%	0.3 ± 2.9%
GVW	+10 percent	0.3 ± 1.8%	0.4 ± 2.3%
Vehicle Length	±3.0 percent (1.9 ft)	0.0 ± 1.0 ft	-0.1 ± 1.5 ft
Vehicle Speed	± 1.0 mph	-1.3 ± 3.6 mph	-0.7 ± 2.8 mph
Axle Length	+ 0.5 ft [150mm]	0.0 ± 0.1 ft	0.0 ± 0.1 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.

5.1.2.1 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.

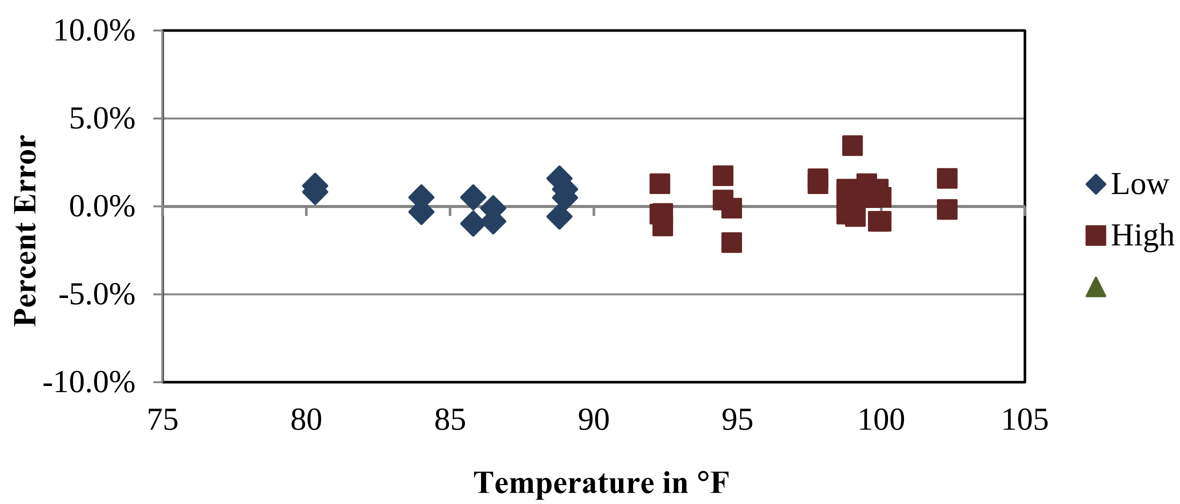


Figure 5-7 – Validation GVW Errors by Temperature – 24-Sep-13

5.1.2.2 Steering Axle Weight Errors by Temperature

Figure 5-8 demonstrates that for steering axles, the WIM equipment appears to estimate weights with similar accuracy across the range of temperatures observed in the field. The range in error is similar for different temperature groups.

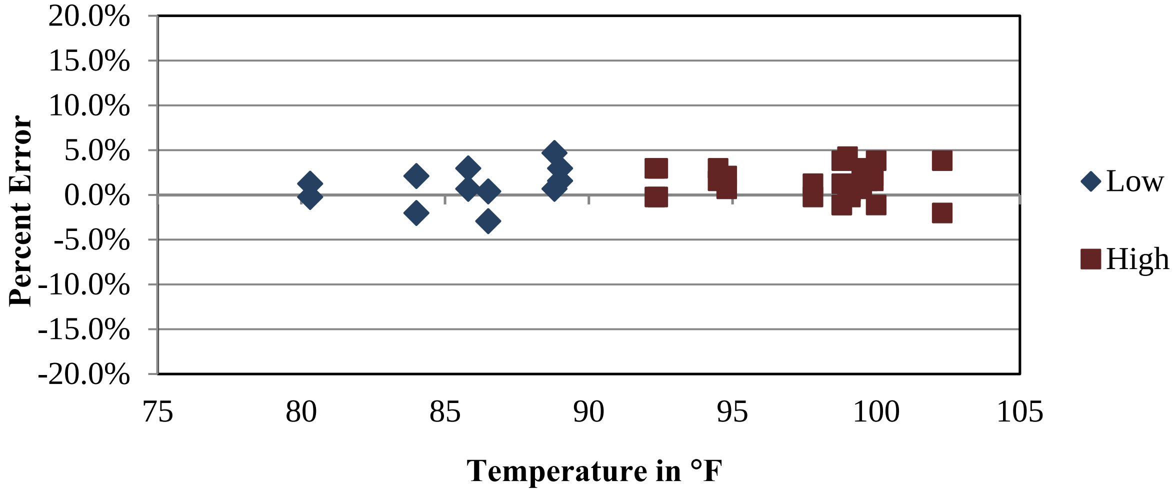


Figure 5-8 – Validation Steering Axle Weight Errors by Temperature – 24-Sep-13

5.1.2.3 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. The range in tandem axle errors is consistent for the two temperature groups.

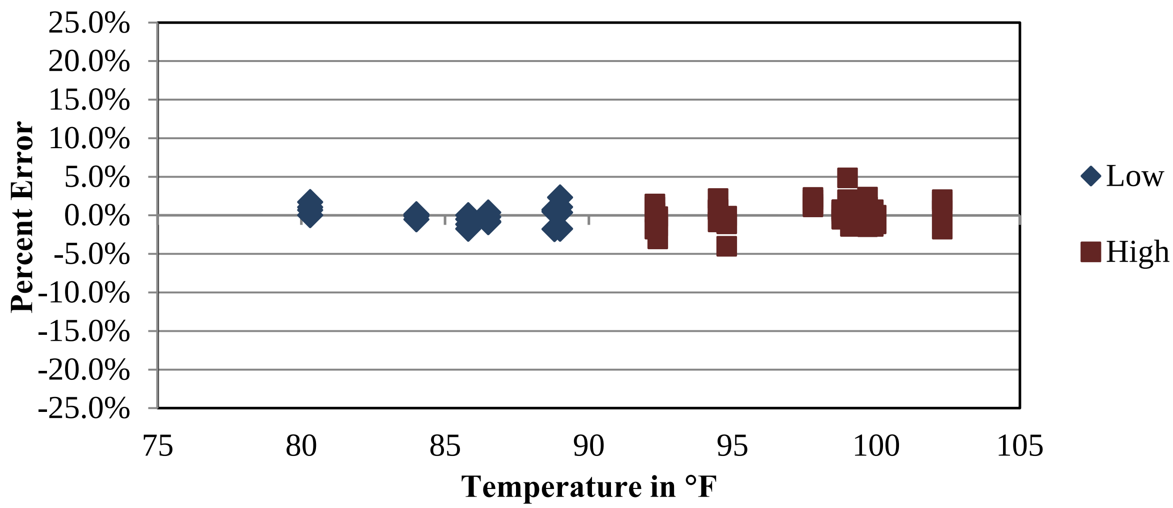


Figure 5-9 – Validation Tandem Axle Weight Errors by Temperature – 24-Sep-13

5.1.2.4 GVW Errors by Temperature and Truck Type

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

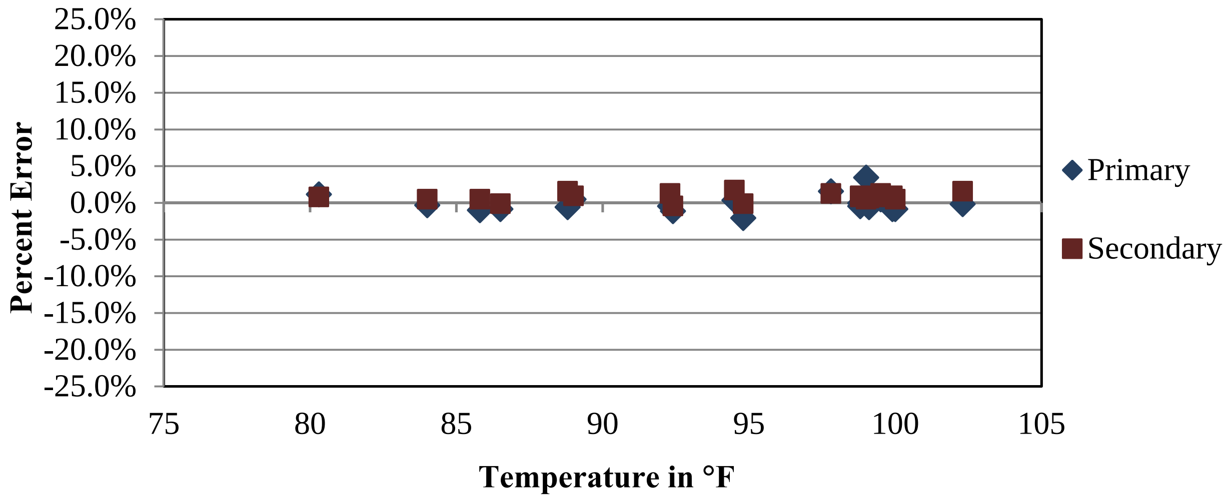


Figure 5-10 – Validation GVW Error by Truck and Temperature – 24-Sep-13

5.1.3 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 138 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 8 vehicle by the WIM equipment.

Table 5-5 – Validation Misclassifications by Pair – 24-Sep-13

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

As shown in the table, one vehicle, including 0 heavy trucks (6 – 13) was misclassified by the equipment. Based on the vehicles observed during the validation study, the misclassification percentage is 0.0% 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 0.7 percent due to misclassification of one Class 5 as a Class 8. The cause for the misclassification was not investigated in the field.

The combined results of the misclassifications resulted in an undercount of one Class 5 and an overcount of one 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 – 24-Sep-13

Class	3	4	5	6	7	8	9	10	11	12	13
Observed Count	0	0	19	1	0	5	93	0	18	2	0
WIM Count	0	0	18	1	0	6	93	0	18	2	0
Observed Percent	0.0	0.0	13.8	0.7	0.0	3.6	67.4	0.0	13.0	1.4	0.0
WIM Percent	0.0	0.0	13.0	0.7	0.0	4.3	67.4	0.0	13.0	1.4	0.0
Misclassified Count	0	0	1	0	0	0	0	0	0	0	0
Misclassified Percent	0.0	0.0	5.3	0.0	0.0	0.0	0.0	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. Based on the manually collected sample of the

138 trucks, 0.0 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 0.0 mph; the range of errors was 5.3 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 0.4 percent), a calibration of the system was not required and therefore was not carried out.

5.1.4 Final WIM System Compensation Factors

The final factors left in place at the conclusion of the validation are provided in Table 5-7.

Table 5-7 – Final Factors

Speed Point	MPH	Left	Right
		2	1
80	50	3277	3277
88	55	3262	3262
96	60	3273	3273
104	65	3171	3171
112	70	3171	3171
Axle Distance (cm)		270	
Dynamic Comp (%)		101	
Loop Width (cm)		314	

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 of heavy trucks 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 46 to 59 mph.
- Pavement temperature. Pavement temperature ranged from 80.3 to 102.3 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-values reported in Table 6-1 are for the probability that the regression coefficients 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	-4.2093	2.8014	-1.5026	0.1417
Speed	0.0463	0.0361	1.2831	0.2077
Temp	0.0177	0.0234	0.7574	0.4537
Truck	0.9087	0.2928	3.1031	0.0037

The lowest probability value given in Table 6-1 was 0.0037 for truck type. This means that there is about 0.4 percent chance that the value of regression coefficient for truck type (0.9087) can occur by chance alone. Assuming that p-values equal or less than 0.05 indicate statistical significance, the effect of truck type on measurement errors was statistically significant.

The regression coefficients for truck type represent the difference between the mean errors for the Primary and Secondary trucks. (Truck type was modeled an indicator variable with values of 0 or 1). Thus, the average GVW measurement error for the Secondary truck was about 0.91 percent higher than the corresponding error for the Primary truck.

For illustrative purposes, the relationship between speed and measurement errors is shown in Figure 6-1. The figure includes a trend line for the predicted percent error. The quantification of the relationship is provided by the value of the regression coefficient, in this case 0.0463 (in Table 6-1). This means, for example, that for a 10 mph increase in speed, the error is increased by about 0.5 percent (0.0463 x 10). The statistical assessment of the relationship is provided by the probability value of the regression coefficient (0.2077) and is not statistically significant.

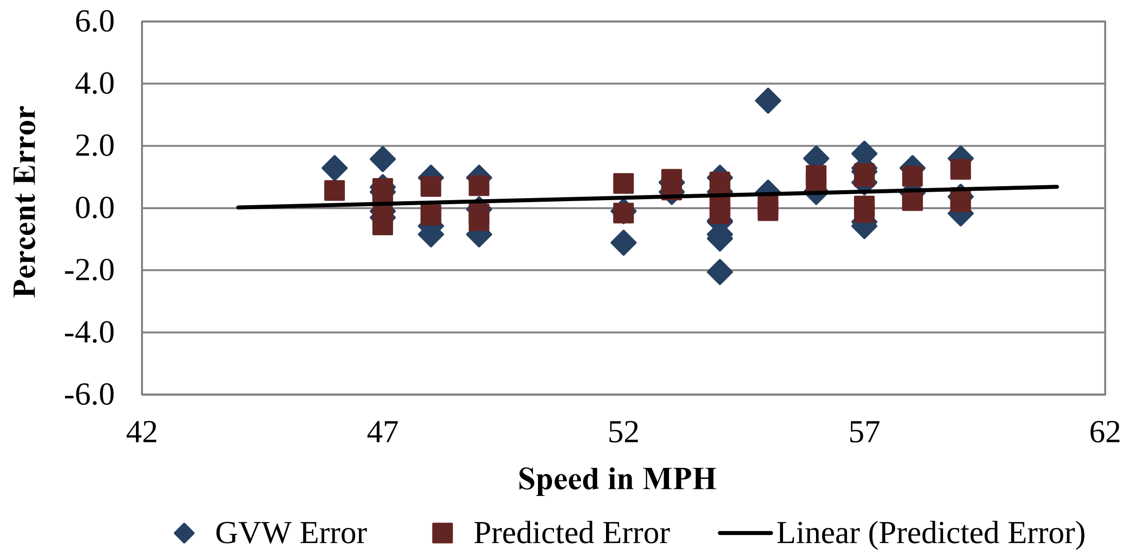


Figure 6-1 – Influence of Speed on the Measurement Error of GVW

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 indicates that the relationship was not statistically significant (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	-	-	-	-	0.9087	0.0037
Steering axle	0.1326	0.0179	-	-	2.3624	3.83E-06
Tandem axle tractor	0.0730	0.0991	0.0416	0.1464	-	-
Tandem axle trailer	-	-	-	-	0.6766	0.1707

6.1.4 Conclusions

1. According to Table 6-2, speed had a statistically significant effect on only steering axle measurement errors. However, the value of the regression coefficient was low (0.1326) indicating small influence of speed on the measurement error.

2. Temperature did not have statistically significant effect on measurement errors, except for tandem tractor axle. However, the range of pavement temperature was relatively small (80.3 to 102.3 ºF).

3. Truck type had statistically significant effect on GVW and steering axle weight measurement errors. The influence of truck type on measurement errors is further discussed in Section 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 validation results.

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 not considered in this analysis.

Figure 6-2 shows that speed had minor influence on the GVW measurement for each truck, with both the Primary truck and Secondary truck showing a slight positive correlation with speed. The trend lines for the two trucks are not statistically significant. Combined, the overall GVW error dependency on speed was also not statistically significant ($p = 0.2077$ in Table 6-1).

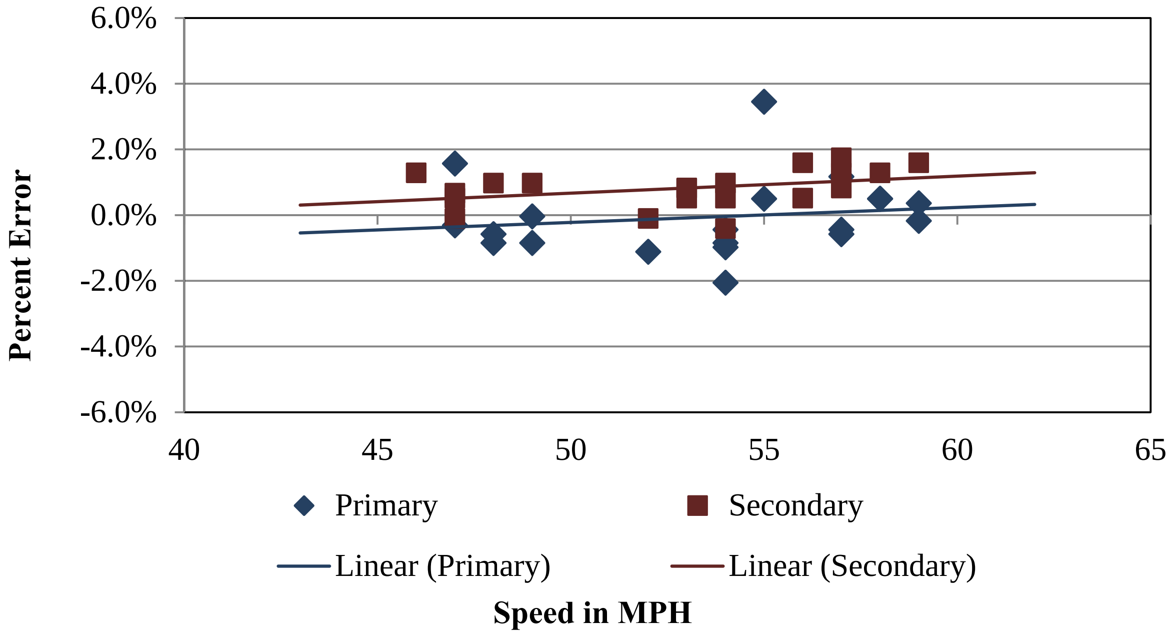


Figure 6-2– Influence of Speed on the GVW Measurement Error of Primary and Secondary Trucks

The use of two calibration trucks provided verification of the trends and speeded up the time required to obtain 40 validation runs. For this site, the use of only one of the trucks (Primary or Secondary) would have resulted in similar verification and calibration results as shown in Table 6-3, based on the similar GVW mean errors for both trucks. Also, shown in the table are combined results for the two trucks using the arithmetic mean. The use of the arithmetic mean is appropriate considering small error difference between the two trucks.

Table 6-3 – Validation Results by Truck Type – 24-Sep-13

Parameter	95% Confidence Limit of Error	Primary	Secondary	Combined
Steering Axles	±20 percent	0.1 ± 3.4%	2.4 ± 2.6%	1.2 ± 3.7%
Tandem Axles	±15 percent	0.0 ± 3.5%	0.4 ± 1.6%	0.2 ± 2.7%
GVW	±10 percent	-0.1 ± 2.5%	0.8 ± 1.2%	0.4 ± 2.1%
Vehicle Length	±3.0 percent (1.9 ft)	0.2 ± 1.7 ft	-0.3 ± 0.5 ft	-0.1 ± 1.3 ft
Vehicle Speed	± 1.0 mph	-0.6 ± 2.4 mph	-1.2 ± 3.5 mph	-0.9 ± 3.0 mph
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.1 ft	0.0 ± 0.1 ft	0.0 ± 0.1 ft

6.2 Misclassification Analysis

For this site, one vehicle, including no heavy truck (6 – 13) were misclassified by the equipment. Consequently, a post-visit analysis was not conducted.

6.3 Traffic Data Analysis

Since there was no calibration of the system required, no post-visit data analysis was 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. The entries in the table show the percentages of misclassified vehicles observed in the manual sample for each vehicle class. The last column shows the percentage of unclassified vehicles observed in the manual sample.

Table 7-1 – Classification Validation History

Date	Misclassification Percentage by Class											Pct Unclass
	3	4	5	6	7	8	9	10	11	12	13	
17-Aug-10	-	-	6	0	-	0	0	0	0	-	-	0.0
18-Aug-10	-	-	25	0	100	0	0	-	0	0	-	0.8
29-Nov-11	57	100	15	0	0	0	0	0	0	0	0	0.0
29-Nov-11	83	50	0	0	0	0	0	0	0	0	0	0.0
24-Sep-13	0	0	5.3	0	0	0	0	0	0	0	0	0.0

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 post-validations.

Table 7-2 – Weight Validation History

Date	Mean Error and 2SD		
	GVW	Single Axles	Tandem
17-Aug-10	3.2 ± 2.5	3.0 ± 4.2	3.6 ± 4.1
18-Aug-10	-0.1 ± 2.5	-1.1 ± 4.3	0.2 ± 3.7
29-Nov-11	1.4 ± 3.3	1.0 ± 6.2	1.5 ± 5.1
29-Nov-11	0.3 ± 3.0	0.4 ± 6.0	0.1 ± 4.7
24-Sep-13	0.4 ± 2.1	1.2 ± 3.7	0.2 ± 3.7

The variability of the weight errors appears to have remained reasonably consistent since the site was first validated. The table demonstrates the effectiveness of the validations in bringing the weight estimations within LTPP SPS WIM equipment tolerances.

8 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

California, SPS-2
SHRP ID: 060200

Validation Date: September 24, 2013

Photo 1 – Cabinet Exterior

Photo 2 – Cabinet Interior (Front)

Photo 3 – Cabinet Interior Second

Photo 4 – Leading Loop

Photo 5 – Leading WIM Sensor

Photo 6 – Trailing WIM Sensor

Photo 7 – Trailing Loop Sensor

Photo 8 – Modem

Photo 9 – Downstream

Photo 10 – Upstream

Photo 11 – Truck 1 Tractor

Photo 12 – Truck 1 Trailer

Photo 13 – Truck 1 Suspension 1

Photo 14 – Truck 1 Suspension 2

Photo 15 – Truck 1 Suspension 3

Photo 16 – Truck 1 Suspension 4

Photo 17 – Truck 1 Suspension 5

Photo 18 – Truck 2 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	STATE CODE:	06
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	060200
SITE CALIBRATION SUMMARY	DATE (mm/dd/yyyy)	9/24/2013

SITE CALIBRATION INFORMATION

1. DATE OF CALIBRATION {mm/dd/yy} 9/24/13

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:	0.4%	Standard Deviation:	1.0%
Dynamic and Static Single Axle:	1.2%	Standard Deviation:	1.8%
Dynamic and Static Double Axles:	0.2%	Standard Deviation:	1.3%

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

9. DEFINE SPEED RANGES IN MPH:

			Low		High	Runs
a.	Low	-	46.0	to	50.3	12
b.	Medium	-	50.4	to	54.8	12
c.	High	-	54.9	to	59.0	16
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: SPS WIM ID: DATE (mm/dd/yyyy)	06 060200 9/24/2013

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3171 | 3171

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: Time

14. MEAN DIFFERENCE IN VOLUMES BY VEHICLES CLASSIFICATION:

FHWA Class 9:	0.0	FHWA Class	5	-	-5.0
FHWA Class 8:	20.0	FHWA Class	11	-	0.0
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 0.0%

Validation Test Truck Run Set - Pre

Person Leading Calibration Effort:

Contact Information: Phone:

E-mail:

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 06 SPS WIM ID: 060200 DATE (mm/dd/yyyy) 9/24/2013

Count - 138 Time = 1:02:16 Trucks (4-15) - 138 Class 3s - 0

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
59	9	21870	60	9	58	9	21946	60	9
57	9	21871	60	9	59	11	21997	59	11
55	9	21872	55	9	54	9	21999	57	9
57	9	21882	62	9	54	5	22000	52	5
56	11	21884	60	11	55	9	22001	55	9
62	12	21885	62	12	60	11	22002	56	11
60	9	21891	61	9	57	9	22003	56	9
58	9	21896	58	9	56	9	22006	57	9
59	11	21897	58	11	57	9	22007	58	9
54	9	21899	57	9	56	9	22013	62	9
56	9	21900	52	9	56	9	22014	55	9
58	9	21902	59	9	57	11	22015	50	11
61	5	21905	65	5	53	11	22016	52	11
58	9	21906	58	9	54	9	22018	62	9
60	9	21911	63	9	54	9	22019	55	9
57	9	21915	60	9	54	9	22021	54	9
66	5	21917	58	5	56	9	22022	55	9
57	11	21922	58	11	56	9	22023	55	9
57	9	21923	60	9	54	9	22024	54	9
59	9	21927	60	9	57	11	22025	52	11
55	6	21928	56	6	59	9	22027	60	9
57	11	21930	50	11	55	9	22029	56	9
56	5	21932	52	5	55	9	22030	54	9
57	9	21934	56	9	55	9	22031	55	9
55	9	21935	50	9	55	9	22032	55	9

Sheet 1 - 1 to 50 Start: 12:50:37 Stop: 13:03:27

Recorded By: GHL Verified By: ABL

Validation Test Truck Run Set - Pre

Traffic Sheet 20	STATE CODE:	06
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	060200
SPEED AND CLASSIFICATION STUDIES	DATE (mm/dd/yyyy)	9/24/2013

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
58	5	22097	56	5	54	11	22208	52	11
57	8	22098	58	8	57	9	22211	57	9
56	9	22100	56	9	55	9	22212	55	9
57	9	22101	58	9	**62**	**8**	**22216**	**61**	**5**
57	9	22102	57	9	55	9	22219	55	9
60	5	22103	60	5	58	11	22226	58	11
61	9	22104	61	9	57	8	22228	54	8
57	9	22128	64	9	57	9	22257	59	9
59	11	22129	59	11	57	9	22258	58	9
58	9	22130	51	9	58	5	22259	57	5
59	9	22139	60	9	60	9	22260	59	9
57	9	22140	57	9	57	9	22262	57	9
58	9	22141	58	9	65	5	22273	65	5
55	9	22145	58	9	59	9	22280	63	9
59	9	22146	60	9	56	9	22284	58	9
55	5	22147	55	5	55	9	22285	55	9
59	9	22148	60	9	60	9	22286	59	9
57	9	22152	58	9	58	9	22287	58	9
55	9	22154	55	9	60	9	22288	61	9
55	9	22155	55	9	57	9	22293	61	9
58	9	22157	58	9	58	11	22294	60	11
55	11	22158	55	11	62	5	22297	63	5
57	9	22176	58	9	56	9	22298	56	9
58	9	22177	58	9	57	9	22301	62	9
59	8	22183	60	8	59	9	22304	60	9

Sheet 2 - 51 to 100 Start: 13:09:35 Stop: 13:26:04

Recorded By: GHL ABL

Validation Test Truck Run Set - Pre

Traffic Sheet 20	STATE CODE:	06
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	060200
SPEED AND CLASSIFICATION STUDIES	DATE (mm/dd/yyyy)	9/24/2013

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
57	8	22314	59	8	59	8	22594	59	8
57	12	22328	60	12	57	9	22599	62	9
58	9	22329	57	9	56	9	22603	58	9
59	9	22336	64	9	64	5	22605	59	5
55	9	22337	62	9	59	9	22607	50	9
56	5	22338	55	5	59	9	22638	64	9
59	5	22343	59	5	57	11	22639	56	11
58	9	22345	60	9	54	9	22645	53	9
57	9	22346	60	9	58	9	22649	61	9
57	9	22347	5	9	60	9	22657	61	9
54	9	22355	54	9	62	11	22661	59	11
57	9	22361	55	9	59	9	22662	60	9
55	9	22362	55	9	60	5	22665	60	5
62	5	22363	63	5					
57	9	22452	55	9					
55	9	22465	60	9					
60	5	22466	61	5					
66	5	22470	65	5					
57	9	22471	66	9					
59	9	22472	61	9					
59	9	22473	58	9					
57	11	22474	58	11					
59	9	22543	55	9					
57	11	22547	55	11					
62	5	22572	62	5					

Sheet 3 - 101 to 150 Start: 13:26:49 Stop: 13:52:53

Recorded By: GHL ABL