WIM System Field Calibration and Validation Summary Report

Illinois SPS-6
SHRP ID – 170600

Validation Date: November 01, 2011
Submitted: November 18, 2011

Table of Contents

List of Figures

List of Tables

1 Executive Summary

A WIM validation was performed on November 1 and 2, 2011 at the Illinois SPS-6 site located on route I-57 at milepost 225.6, 8.5 miles south of Interstate 72.

This site was installed on July 27, 2005. 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 December 08, 2010 and this validation visit, it appears that no changes have occurred during this time to the basic operating condition of the equipment.

The equipment is in working order. Electronic and electrical checks of the WIM components determined that the the equipment is operating within the manufacturer's tolerances. Further equipment discussion is provided in Section 3.

During the on-site pavement evaluation, significant cracking was noted at a location 396 feet prior to scales. There is a transition from asphalt to concrete 421 feet prior to scales that indicates faulting. 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 – Post-Validation Results – 02-Nov-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	0.8 ± 5.5%	Pass
Tandem Axles	±15 percent	1.1 ± 5.2%	Pass
GVW	±10 percent	1.0 ± 3.8%	Pass
Vehicle Length	±1.5 ft	-0.2 ± 1.0 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.0 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 0.1 ± 1.5 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 8.0% from the 100 truck sample (Class 4 – 13) was due to the cross-classifications of Class 3, 4, 5, and 8 vehicles.

There were two test trucks used for the post-validation. They were configured and loaded as follows:

- The *Primary* truck was a Class 9 vehicle with air suspension on the tractor and trailer tandems, and standard (4 feet) tandem spacings. It was loaded with stone.

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

Prior to the validation, the test trucks were weighed and measured, cold tire pressures were taken, and photographs of the trucks, trailers and suspensions were obtained (see Section 7). Axle length (AL) was measured from the center hub of the first axle to the center hub of the last axle. Axle spacings were measured from the center hub of the each axle to the center hub of the subsequent axle. Overall length (OL) was measured from the edge of the front bumper to the edge of the rear bumper. The test trucks were re-weighed at the conclusion of the validation. The average post-validation test truck weights and measurements are provided in Table 1-2.

Table 1-2 – Post-Validation Test Truck Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	75.6	10.2	14.0	14.0	18.7	18.7	14.3	4.3	24.8	4.1	47.5	54.5
2	65.7	9.2	12.7	12.7	15.5	15.5	14.3	4.3	15.9	4.1	38.6	45.5

The posted speed limit at the site is 65 mph. During the testing, the speed of the test trucks ranged from to 54 to 65 mph, a range of 11 mph.

During test truck runs, pavement temperature was collected using a hand-held infrared temperature device. The post-validation pavement surface temperatures varied from 40.5 to 73.9 degrees Fahrenheit, a range of 33.4 degrees Fahrenheit. The partly cloudy weather conditions provided for the desired 30 degree range in temperatures.

A review of the LTPP Standard Release Database 25 shows that there are 6 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 September 19, 2011 (Data) to the most recent Comparison Data Set (CDS) from January 03, 2011. The assessments performed prior to the site visits are used to develop reasonable expectations for the validation. The results of further investigations performed as a result of the analyses are provided in Section 5 of this report.

2.1 LTPP WIM Data Availability

A review of the LTPP Standard Release Database 25 shows that there are 6 years of level "E" WIM data for this site. Table 2-1 provides a breakdown of the available data for years 2005 to 2011.

Table 2-1 – LTPP Data Availability

Year	Total Number of Days in Year	Number of Months
2005	135	5
2006	316	12
2007	347	12
2008	365	12
2009	365	12
2010	363	12
2011	250	9

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 meets the 210-day minimum requirement for a calendar year for years 2006 through 2011.

Table 2-2 provides a monthly breakdown of the available data for years 2005 through 2011.

Table 2-2 – LTPP Data Availability by Month

Year	Month												No. of Months
	1	2	3	4	5	6	7	8	9	10	11	12	
2005								17	30	30	27	31	5
2006	31	28	31	22	31	23	10	28	26	28	27	31	12
2007	27	25	31	30	25	30	31	31	30	28	28	31	12
2008	31	29	31	30	31	30	30	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	31	30	31	31	30	31	30	29	12
2011	29	26	31	30	31	30	31	31	11				9

2.2 Classification Data Analysis

The traffic data was analyzed to determine the expected truck distributions. This analysis provides a basis for the classification distribution study that was conducted on site. Figure 2-1 provides a comparison of the truck type distributions for the two datasets.

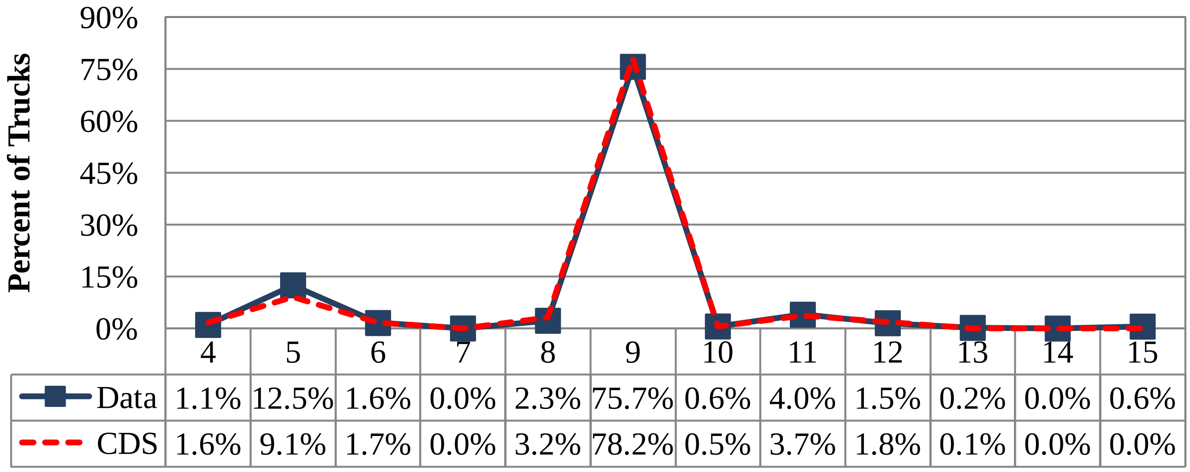


Figure 2-1 – Comparison of Truck Distribution

Table 2-3 provides statistics for the truck distributions at the site for the two periods represented by the two datasets. The table shows that according to the most recent data, the most frequent truck types crossing the WIM scale are Class 9 (75.7%) and Class 5 (12.5%). 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 0.6 percent of the vehicles at this site are unclassified.

Table 2-3 – Truck Distribution from W-Card

Vehicle Classification	CDS		Data		Change
	Date				
	1/3/20011		9/19/2011		
4	561	1.6%	436	1.1%	-0.6%
5	3110	9.1%	5173	12.5%	3.4%
6	598	1.7%	662	1.6%	-0.1%
7	11	0.0%	11	0.0%	0.0%
8	1086	3.2%	933	2.3%	-0.9%
9	26781	78.2%	31317	75.7%	-2.5%
10	185	0.5%	250	0.6%	0.1%

Vehicle Classification	CDS		Data		Change
	Date				
	1/3/20011		9/19/2011		
11	1280	3.7%	1659	4.0%	0.3%
12	618	1.8%	637	1.5%	-0.3%
13	35	0.1%	80	0.2%	0.1%
14	0	0.0%	0	0.0%	0.0%
15	0	0.0%	232	0.6%	0.6%

From the table it can be seen that the number of Class 9 vehicles has decreased by 2.5 percent from January 2011 and September 2011. Changes in the number of heavier trucks may be attributed to seasonal variations in truck distributions. During the same time period, the number of Class 5 trucks increased by 3.4 percent. These differences may be attributed to changes in the use of the roadway for local deliveries, cross-classifications of type 3 and 5 vehicles, as well as natural variations in truck volumes.

2.3 Speed Data Analysis

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

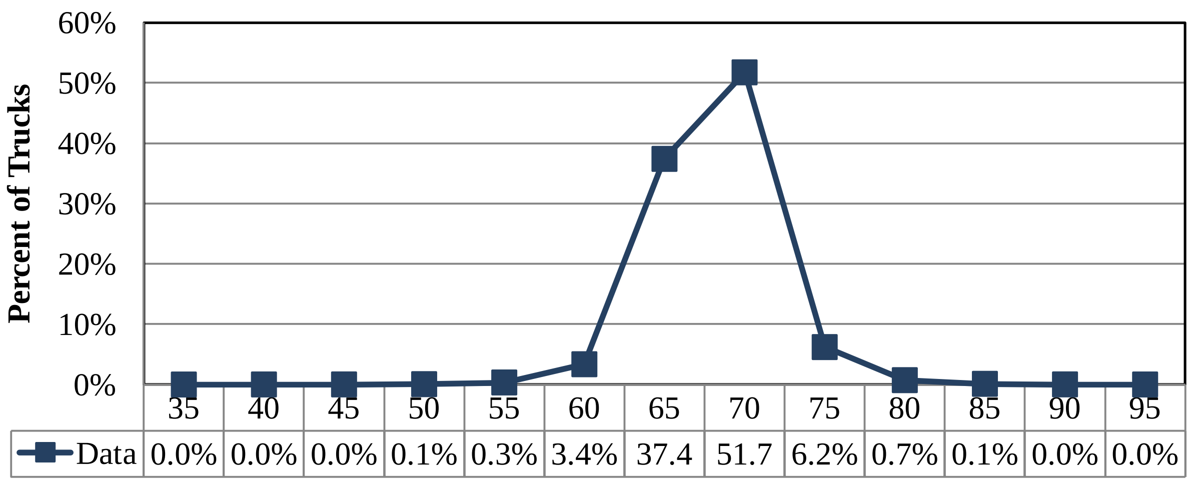


Figure 2-2 – Truck Speed Distribution – 19-Sep-11

As shown in Figure 2-2, the majority of the trucks at this site are traveling between 65 and 75 mph. The posted speed limit at this site is 65 and the 85th percentile speed for trucks at this site is 69 mph. The range of truck speeds for the validation was 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 September 2011 and the Comparison Data Set from January 2011.

As shown in Figure 2-3, there is a shift to the right for the loaded peak between the January 2011 Comparison Data Set (CDS) and the September 2011 two-week sample W-card dataset (Data). The results indicate that there may have been a decrease in the weights of fully loaded trucks or a drift in the system calibration.

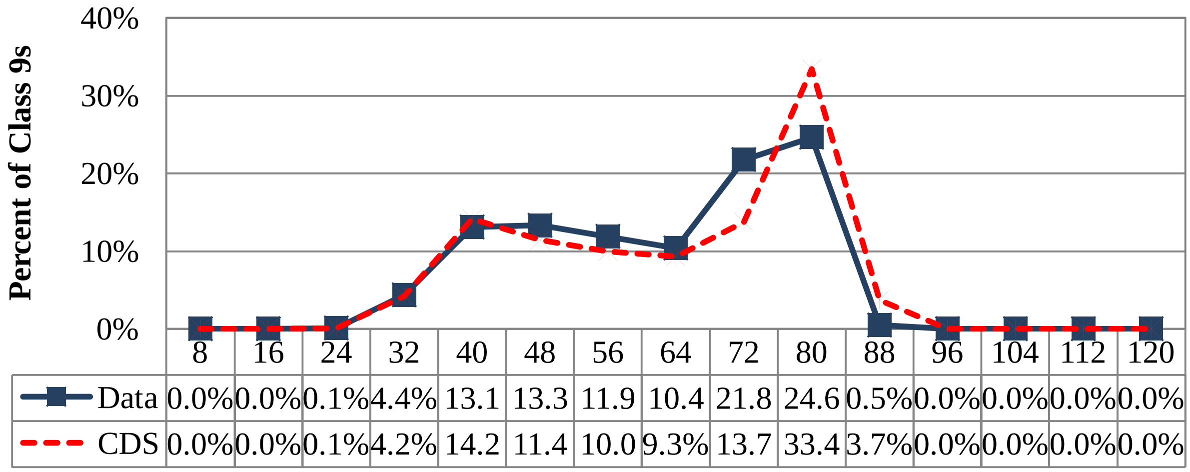


Figure 2-3 – Comparison of Class 9 GVW Distribution

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				
	1/3/20011		9/19/2011		
8	0	0.0%	0	0.0%	0.0%
16	1	0.0%	0	0.0%	0.0%
24	31	0.1%	32	0.1%	0.0%
32	1121	4.2%	1363	4.4%	0.2%
40	3773	14.2%	4088	13.1%	-1.1%
48	3042	11.4%	4156	13.3%	1.9%
56	2655	10.0%	3712	11.9%	1.9%

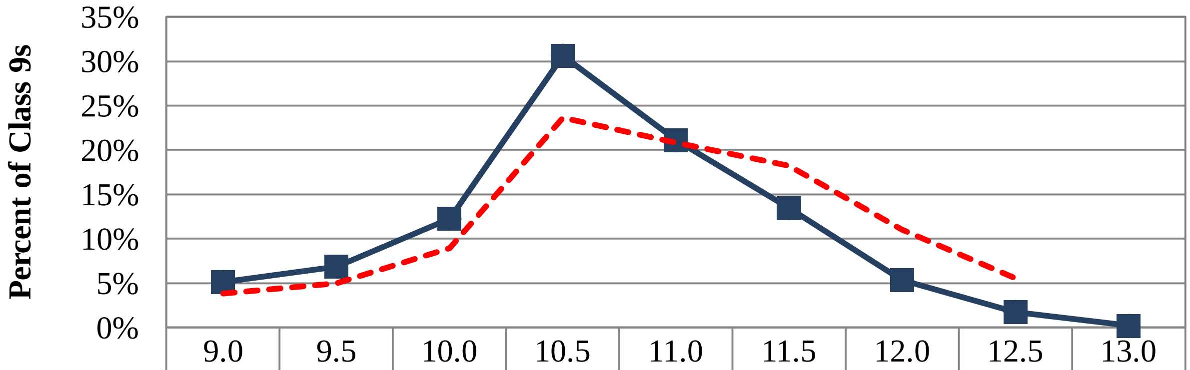
GVW weight bins (kips)	CDS		Data		Change
	Date				
	1/3/20011		9/19/2011		
64	2474	9.3%	3243	10.4%	1.1%
72	3661	13.7%	6797	21.8%	8.0%
80	8910	33.4%	7696	24.6%	-8.8%
88	980	3.7%	147	0.5%	-3.2%
96	4	0.0%	3	0.0%	0.0%
104	1	0.0%	0	0.0%	0.0%
112	0	0.0%	0	0.0%	0.0%
120	0	0.0%	0	0.0%	0.0%
Average =	59.9 kips		58.0 kips		-1.9 kips

As shown in the table, the number of unloaded class 9 trucks in the 32 to 40 kips range decreased by 1.1 percent while the number of loaded class 9 trucks in the 72 to 80 kips range decreased by 8.8 percent. During this time period the number 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 3.2 percent, from 59.9 kips to 58.0 kips kips. This may indicate a drift in the WIM system calibration.

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 September 2011 and the Comparison Data Set from January 2011.



	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0
Data	5.1%	6.9%	12.3%	30.6%	21.1%	13.4%	5.3%	1.8%	0.2%
CDS	3.8%	5.0%	8.9%	23.7%	20.8%	18.2%	11.1%	5.6%	

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

It can be seen in the figure that the greatest percentage of trucks have front axle weights measuring between 10.5 and 11.0 kips. The percentage of trucks in this range has decreased between the January 2011 Comparison Data Set (CDS) and the September 2011 dataset (Data). The percentage of light single axles (10.0 to 10.5 kips) has increased during this time while the percent of heavy single axle (11.5 to 12.0 kips) has decreased, indicating a negative drift in the WIM system calibration.

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

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

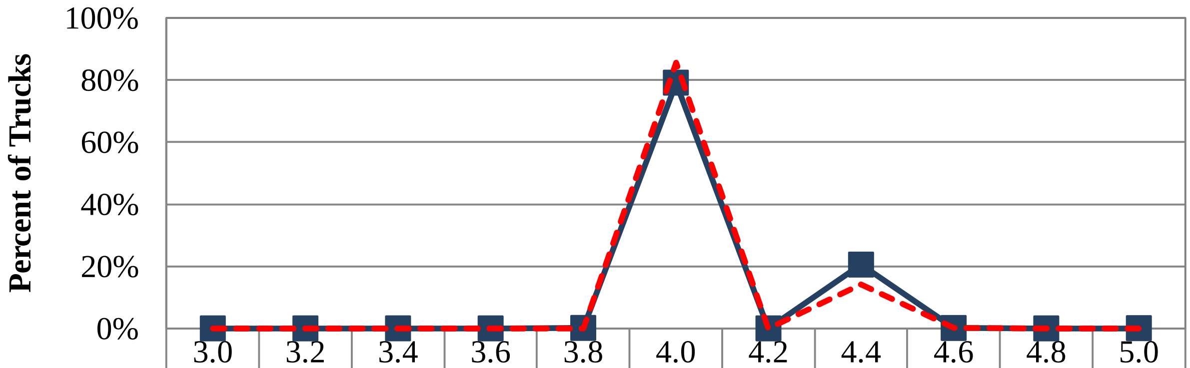
F/A weight bins (kips)	CDS		Data		Change
	Date				
	1/3/20011		9/19/2011		
9.0	580	2.2%	1011	3.2%	1.1%
9.5	1021	3.8%	1605	5.1%	1.3%
10.0	1316	5.0%	2144	6.9%	1.9%
10.5	2373	8.9%	3824	12.3%	3.3%
11.0	6281	23.7%	9558	30.6%	7.0%
11.5	5534	20.8%	6582	21.1%	0.3%
12.0	4831	18.2%	4194	13.4%	-4.8%
12.5	2936	11.1%	1669	5.3%	-5.7%
13.0	1478	5.6%	551	1.8%	-3.8%
13.5	200	0.8%	62	0.2%	-0.6%
Average =	11.2 kips		10.8 kips		-0.4 kips

The table shows that the average front axle weight for Class 9 trucks has decreased by 0.4 kips, or 3.6 percent. According to the values from the per vehicle records, the average front axle weight for Class 9 trucks is 10.8 kips.

2.6 Class 9 Tractor Tandem Spacing Data Analysis

The CDS data received from the Regional Support Contractor was analyzed to determine the expected average tractor tandem spacing. This will provide a basis for the evaluation of the accuracy of the equipment distance and speed measurements by comparing the observed average tractor tandem spacing from the sample data (Data) with the expected average tractor tandem spacing from the comparison data set (CDS).

The class 9 tractor tandem spacing plot in Figure 2-5 is provided to indicate possible shifts in WIM system distance and speed measurement accuracies.



	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0
Data	0.0%	0.0%	0.0%	0.0%	0.1%	79.1%	0.0%	20.5%	0.1%	0.0%	0.1%
CDS	0.0%	0.0%	0.0%	0.0%	0.0%	85.5%	0.0%	14.3%	0.1%	0.0%	0.0%

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

As seen in the figure, the Class 9 tractor tandem spacings for the January 2011 Comparison Data Set and the September 2011 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				
	1/3/20011		9/19/2011		
3.0	0	0.0%	0	0.0%	0.0%
3.2	0	0.0%	1	0.0%	0.0%
3.4	0	0.0%	4	0.0%	0.0%

Tandem 1 spacing bins (feet)	CDS		Data		Change
	Date				
	1/3/20011		9/19/2011		
3.6	0	0.0%	0	0.0%	0.0%
3.8	7	0.0%	45	0.1%	0.1%
4.0	22800	85.5%	24711	79.1%	-6.4%
4.2	0	0.0%	0	0.0%	0.0%
4.4	3805	14.3%	6414	20.5%	6.3%
4.6	37	0.1%	39	0.1%	0.0%
4.8	0	0.0%	0	0.0%	0.0%
5.0	4	0.0%	23	0.1%	0.1%
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 4.6 feet. Based on the average Class 9 drive tandem spacing values from the per vehicle records, the average tractor tandem spacing is 4.0 feet, which is identical to the expected average of 4.0 feet from the CDS per vehicle records. Further axle spacing analyses are performed during the validation and post-validation analysis.

2.7 Data Analysis Summary

Historical data analysis involved the comparison of the most recent Comparison Data Set (January 2011) based on the last calibration with the most recent two-week WIM data sample from the site (September 2011). Comparison of vehicle class distribution data indicates a 2.5 percent decrease in the number of Class 9 vehicles. Analysis of Class 9 weight data indicates that front axle weights have decreased by -0.4 kips and average Class 9 GVW has decreased by 3.2 percent for the September 2011 data, indicating a possible negative drift in the WIM system calibration. The data indicates an average truck tandem spacing of 4.0 feet, which is identical the expected average of 4.0 feet.

3 WIM Equipment Discussion

From a comparison between the report of the most recent validation of this equipment on December 08, 2010 and this validation visit, it appears that no changes have occurred during this time to the basic operating condition of the equipment.

3.1 Description

This site was installed on July 27, 2005 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.

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, significant cracking was noted at a location 396 feet prior to scales. There is a transition from asphalt to concrete 421 feet prior to scales that indicates faulting. Photos 4-1 and 4-2 show the distressed areas of the pavement.

Photo 4-1 - Transition and Cracking prior to WIM scales

Photo 4-2 - Cracking at 396 feet prior to scales

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..

4.2 Profile and Vehicle Interaction

Profile data was collected on April 26, 2011 by the North Central Regional Support Contractor using a high-speed profiler, where the operator measures the pavement profile over the entire one-thousand foot long WIM Section, beginning 900 feet prior to WIM scales and ending 100 feet after the WIM scales. Each pass collects International Roughness Index (IRI) values in both the left and right wheel paths. For this site, 11 profile passes were made, 5 in the center of the travel lane and 6 that were shifted to the left and to the right of the center of the travel lane.

From a pre-visit review of the IRI values for the center, right, and left profile runs, the highest IRI value within the 1000 foot WIM section and within the 400 foot approach section was 514 in/mi and is located approximately 394 feet prior to the WIM scale. These areas of the pavement were closely investigated during the validation visit, and truck dynamics in this area were closely observed. Although trucks appear to bounce in the area of the transition, the truck dynamics created by these distresses appeared to diminish prior to the trucks crossing over the WIM scales. A visual observation of the trucks as they approach, traverse and leave the sensor area did not indicate any visible motion of the trucks that would affect the performance of the WIM scales. Trucks appear to track down the center of the lane.

4.3 LTPP Pavement Profile Data Analysis

The IRI data files are processed using the WIM Smoothness Index software. The indices produced by the software provide an indication of whether or not the pavement roughness may affect the operation of the WIM equipment. The recommended thresholds for WIM Site pavement smoothness are provided in Table 4-1.

Table 4-1 – Recommended WIM Smoothness Index Thresholds

Index	Lower Threshold (m/km)	Upper Threshold (m/km)
Long Range Index (LRI)	0.50	2.1
Short Range Index (SRI)	0.50	2.1
Peak LRI	0.50	2.1
Peak SRI	0.75	2.9

When all values are less than the lower threshold shown in Table 4-1, it is unlikely that pavement conditions will significantly influence sensor output. Values between the threshold values may or may not influence the accuracy of the sensor output and values above the upper threshold would lead to sensor output that would preclude achieving the research quality loading data.

The profile analysis was based on four different indices: Long Range Index (LRI), which represents the pavement roughness starting 25.8 m prior to the scale and ending 3.2 m after the scale in the direction of travel; Short Range Index (SRI), which represents the pavement roughness beginning 2.74 m prior to the WIM scale and ending 0.46 m after the scale; Peak LRI – the highest value of LRI within 30 m prior to the scale; and Peak SRI – the highest value of SRI between 2.45 m prior to the scale and 1.5 m after the scale. The results from the analysis for each of the indices for the right wheel path (RWP) and left wheel path (LWP) values for the 3 left, 3 right and 5 center profiler runs are presented in Table 4-2.

Table 4-2 – WIM Index Values

Profiler Passes			**Pass 1**	**Pass 2**	**Pass 3**	**Pass 4**	**Pass 5**	**Avg**
Left	LWP	LRI (m/km)	0.561	0.644	0.636			0.614
		SRI (m/km)	0.434	0.431	0.402			0.422
		Peak LRI (m/km)	0.612	0.716	0.690			0.673
		Peak SRI (m/km)	0.496	0.491	0.423			0.470
	RWP	LRI (m/km)	0.562	0.478	0.550			0.530
		SRI (m/km)	0.440	0.285	0.433			0.386
		Peak LRI (m/km)	0.569	0.581	0.641			0.597
		Peak SRI (m/km)	*0.533*	*0.528*	*0.533*			*0.531*
Center	LWP	LRI (m/km)	0.450	0.467	0.456	0.449	0.502	0.456
		SRI (m/km)	0.275	0.289	0.307	0.279	0.319	0.288
		Peak LRI (m/km)	0.591	0.538	0.565	0.563	0.556	0.564
		Peak SRI (m/km)	*0.428*	*0.460*	*0.521*	*0.459*	*0.504*	*0.467*
	RWP	LRI (m/km)	0.636	0.522	0.558	0.605	0.619	0.580
		SRI (m/km)	0.477	0.281	0.478	0.378	0.306	0.404
		Peak LRI (m/km)	0.642	0.627	0.595	0.669	0.623	0.633
		Peak SRI (m/km)	*0.645*	*0.613*	*0.574*	*0.488*	*0.418*	*0.580*
Right	LWP	LRI (m/km)	0.564	0.613	0.655			0.611
		SRI (m/km)	0.509	0.481	0.506			0.499
		Peak LRI (m/km)	0.634	0.661	0.659			0.651
		Peak SRI (m/km)	*0.565*	*0.531*	*0.538*			*0.545*
	RWP	LRI (m/km)	0.729	0.699	0.838			0.755
		SRI (m/km)	2.057	1.475	1.922			1.818
		Peak LRI (m/km)	0.729	0.710	0.841			0.760
		Peak SRI (m/km)	**2.171**	**1.511**	**2.050**			**1.911**

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 (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).

4.4 Recommended Pavement Remediation

Pavement repair and remediation is recommended for the distressed areas of the pavement described above.

5 Statistical Reliability of the WIM Equipment

The following section provides summaries of data collected during the pre-validation, the calibration, and the post-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 Pre-Validation

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

The 41 pre-validation test truck runs were conducted on November 1, 2011, beginning at approximately 10:08 AM and continuing until 5:13 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with stone, and equipped with air suspension on truck and trailer tandems and with standard tandem spacings on both the tractor and trailer.
- A Class 9, 5-axle truck, loaded with stone, and equipped with air suspension on the tractor, steel spring suspension on the trailer, with standard tandem spacing on the tractor and standard tandem spacing on the trailer.

The test trucks were weighed prior to the pre-validation and were re-weighed at the conclusion of the pre-validation. The average test truck weights and measurements are provided in Table 5-1.

Table 5-1 - Pre-Validation Test Truck Weights and Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	75.7	10.1	14.0	14.0	18.8	18.8	14.3	4.3	24.8	4.1	47.5	54.5
2	65.9	9.2	12.8	12.8	15.5	15.5	14.3	4.3	15.9	4.1	38.6	45.5

Test truck speeds varied by 11 mph, from 55 to 66 mph. The measured pre-validation pavement temperatures varied 32.9 degrees Fahrenheit, from 36.7 to 69.6. The sunny weather conditions provided for meeting the desired 30 degree temperature range. Table 5-2 provides a summary of the pre-validation results.

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

Table 5-2 – Pre-Validation Overall Results – 01-Nov-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-3.6 ± 6.7%	Pass
Tandem Axles	±15 percent	-2.3 ± 5.0%	Pass
GVW	±10 percent	-2.4 ± 3.9%	Pass
Vehicle Length	±1.5 ft	1.4 ± 0.6 ft	FAIL
Axle Length	± 0.5 ft [150mm]	0.2 ± 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 over all speeds was 1.2 ± 2.4 mph, which is greater than the ±1.0 mph tolerance established by the LTPP Field Guide. However, since the site is measuring axle spacing length with a mean error of 0.2 feet, and the speed and axle spacing measurements are based on the distance between the axle detector sensors, it can be concluded that the distance factor is set correctly and that the speeds being reported by the WIM equipment are within acceptable ranges.

5.1.1 Statistical Speed Analysis

Statistical analysis was conducted on the test truck run data to investigate whether a relationship exists between speed and WIM equipment weight and distance measurement accuracy. The posted speed limit at this site is 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 – Pre-Validation Results by Speed – 01-Nov-11

Parameter	95% Confidence Limit of Error	Low 55.0 to 58.7 mph	Medium 58.8 to 62.4 mph	High 62.5 to 66.0 mph
Steering Axles	±20 percent	-1.9 ± 6.5%	-2.9 ± 3.8%	-6.0 ± 7.3%
Tandem Axles	±15 percent	-0.6 ± 4.6%	-3.1 ± 4.0%	-3.2 ± 5.4%
GVW	±10 percent	-0.7 ± 2.7%	-3.0 ± 2.6%	-3.6 ± 4.2%
Vehicle Length	±1.5 ft	1.4 ± 0.8 ft	1.4 ± 0.6 ft	1.4 ± 0.6 ft
Vehicle Speed	± 1.0 mph	1.4 ± 2.0 mph	1.2 ± 3.1 mph	1.0 ± 2.7 mph
Axle Length	± 0.5 ft [150mm]	0.2 ± 0.1 ft	0.2 ± 0.1 ft	0.2 ± 0.1 ft

From the table, it can be seen that, on average, the WIM equipment underestimates all weights at all speeds. The range in error appears to be greater at the lower and upper ends of the speed range.

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

5.1.1.1 GVW Errors by Speed

As shown in Figure 5-1, the equipment generally underestimated GVW at all speeds. The extent of underestimation appears to increase with increase in speed. The range in error is higher at high speeds when compared to low and medium speeds.

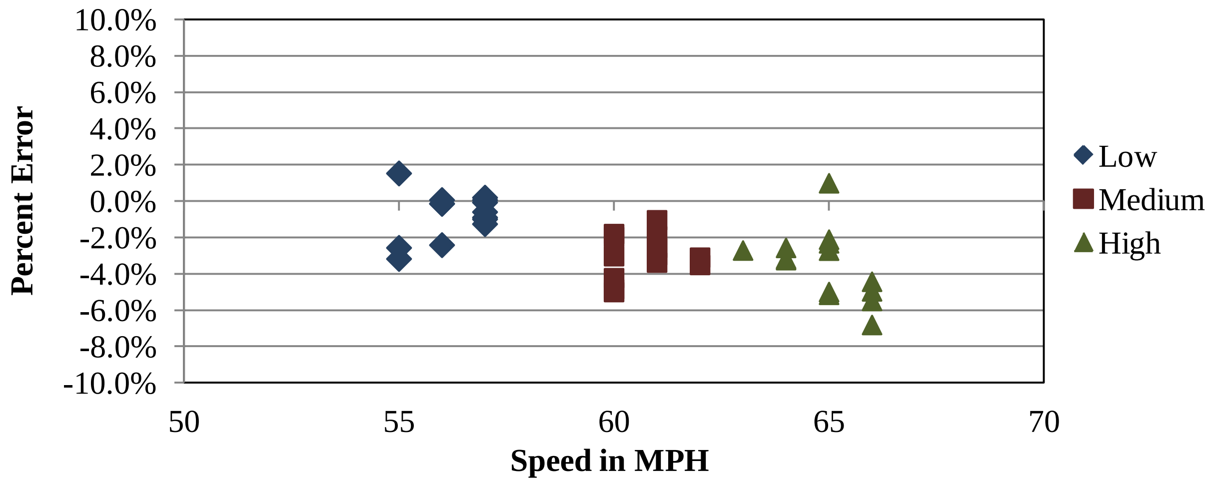


Figure 5-1 – Pre-Validation GVW Error by Speed – 01-Nov-11

5.1.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-2, the equipment underestimates steering axle weights with fairly similar bias at the low and medium speeds. The bias appears to be more negative at the higher speeds. The range in error is lower at medium speeds when compared to low and high speeds.

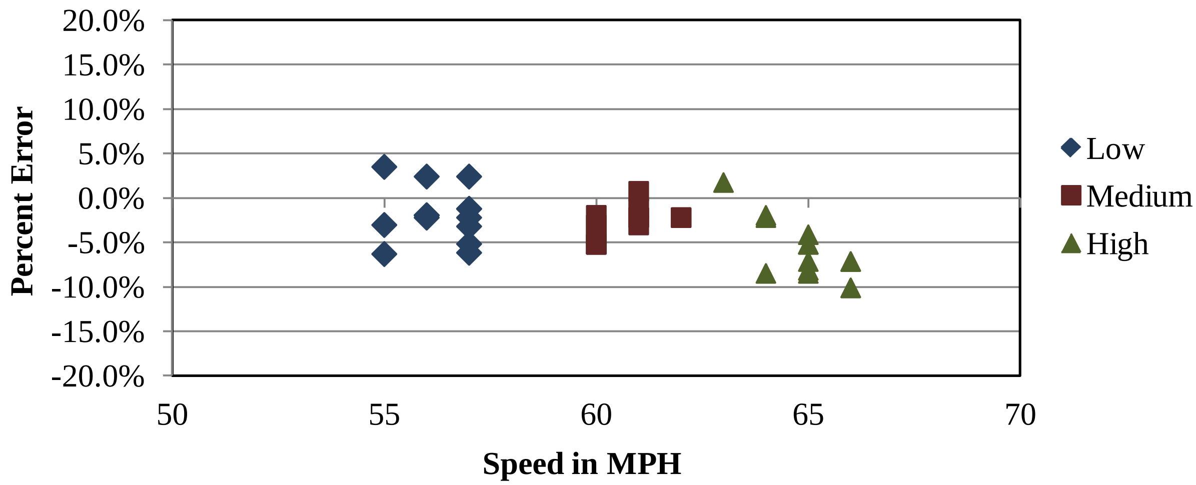


Figure 5-2 – Pre-Validation Steering Axle Weight Errors by Speed – 01-Nov-11

5.1.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 5-3, the equipment estimates tandem axle weights with reasonable accuracy at the lower speeds and underestimates tandem axle weights at the medium and high speeds. The range in error is similar throughout the entire speed range.

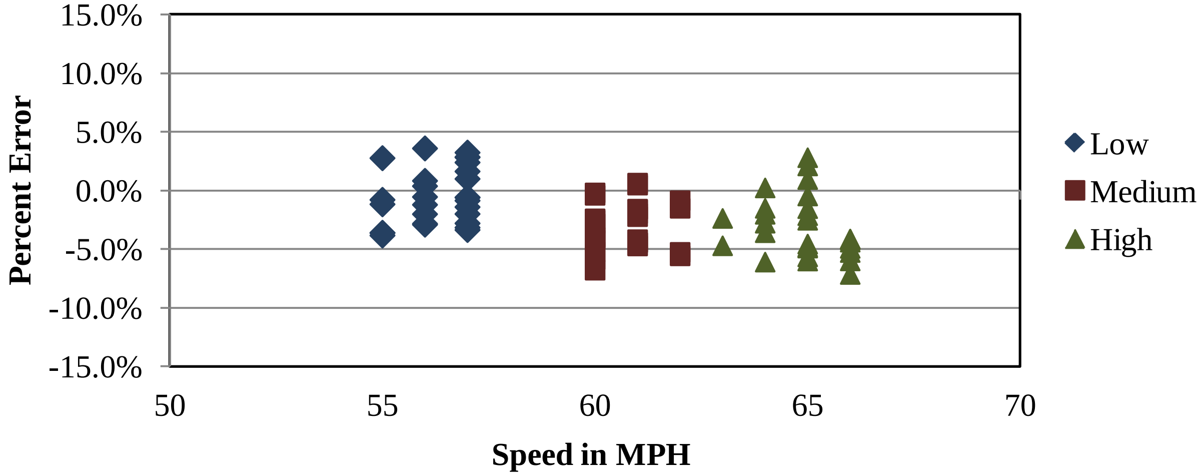


Figure 5-3 – Pre-Validation Tandem Axle Weight Errors by Speed – 01-Nov-11

5.1.1.4 GVW Errors by Speed and Truck Type

When the GVW error for each truck is analyzed as a function of speed, it can be seen that the WIM equipment precision and bias is similar for both the heavily loaded (Primary) truck and the partially loaded (Secondary) truck. Distribution of errors is shown graphically in Figure 5-4.

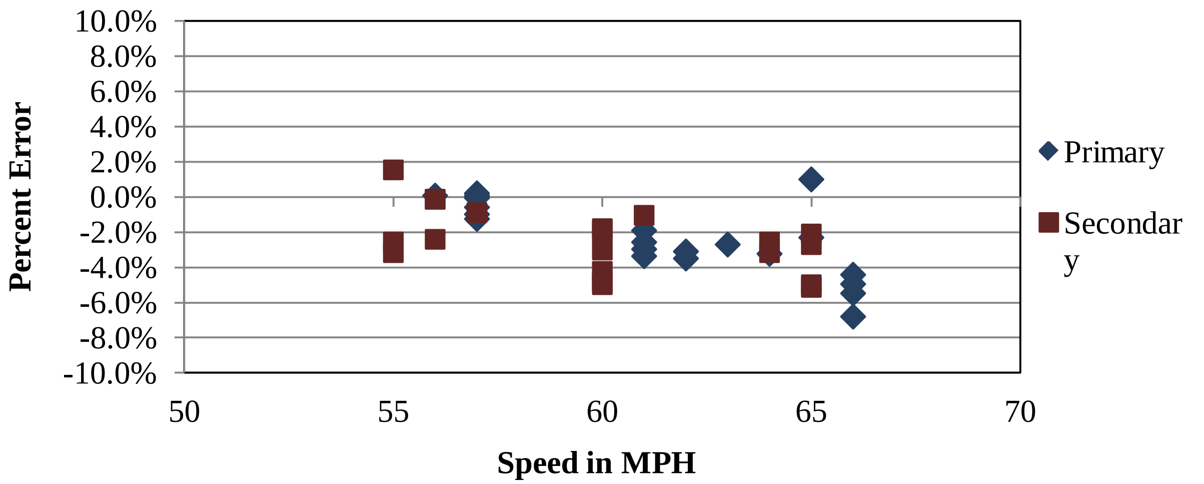


Figure 5-4 – Pre-Validation GVW Errors by Truck and Speed – 01-Nov-11

5.1.1.5 Axle Length Errors by Speed

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

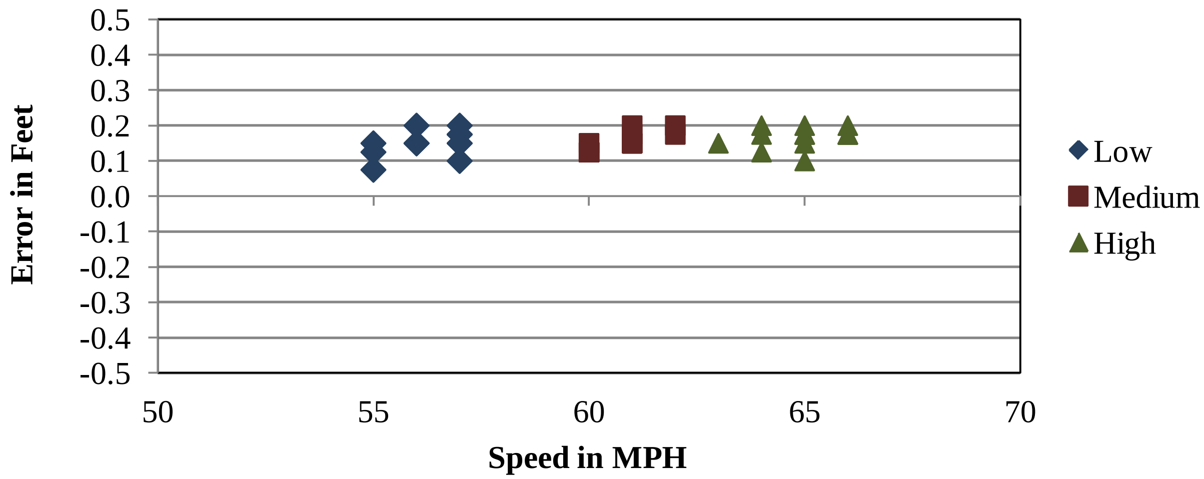


Figure 5-5 – Pre-Validation Axle Length Errors by Speed – 01-Nov-11

5.1.1.6 Overall Length Errors by Speed

For this system, the WIM equipment overestimated overall vehicle length consistently over the entire range of speeds, with an error range of 0.5 to 1.5 feet. Distribution of errors is shown graphically in Figure 5-6.

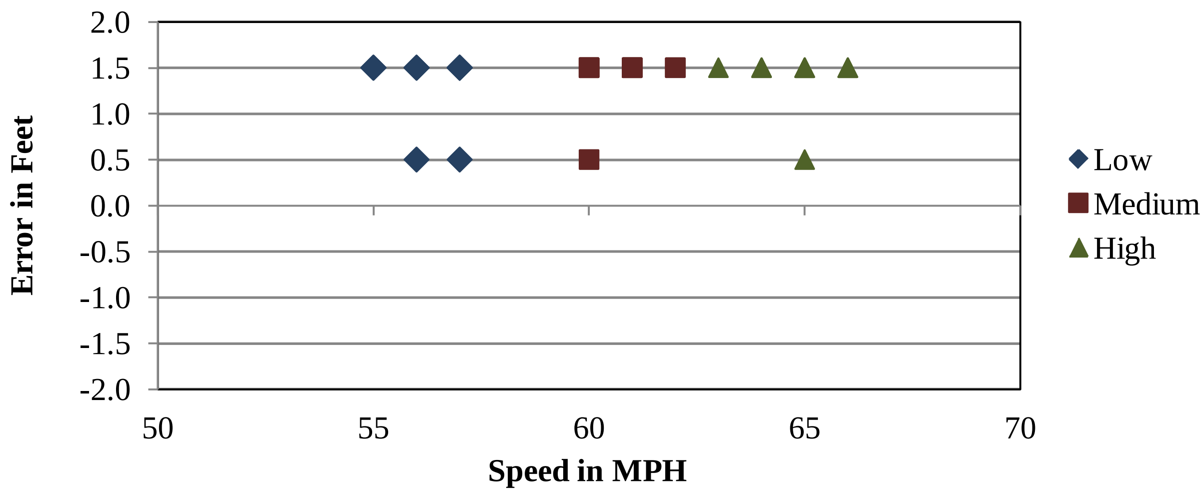


Figure 5-6 – Pre-Validation Overall Length Error by Speed – 01-Nov-11

5.1.2 Statistical Temperature Analysis

Statistical analysis was performed for the test truck run data to investigate whether a relationship exists between pavement temperature and WIM equipment weight and distance measurement accuracy. The range of pavement temperatures varied 32.9 degrees, from 36.7 to 69.6 degrees Fahrenheit. Although the desired 30 degree temperature range was met, the pre-validation test runs are being reported under two temperature groups – low and high, as shown in Table 5-4.

Table 5-4 – Pre-Validation Results by Temperature – 01-Nov-11

Parameter	95% Confidence Limit of Error	Low	High
		36.7 to 53.1 degF	53.2 to 69.6 degF
Steering Axles	±20 percent	-0.8 ± 7.0%	-4.5 ± 5.8%
Tandem Axles	±15 percent	-1.6 ± 4.9%	-2.5 ± 5.1%
GVW	±10 percent	-1.4 ± 3.9%	-2.7 ± 3.9%
Vehicle Length	±1.5 ft	1.4 ± 0.7 ft	1.4 ± 0.6 ft
Vehicle Speed	± 1.0 mph	0.8 ± 1.8 mph	1.3 ± 2.6 mph
Axle Length	± 0.5 ft [150mm]	0.1 ± 0.1 ft	0.2 ± 0.1 ft

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

5.1.2.1 GVW Errors by Temperature

From Figure 5-7, it can be seen that the equipment generally underestimates GVW across the range of temperatures observed in the field. The range in error is similar for different temperature groups.

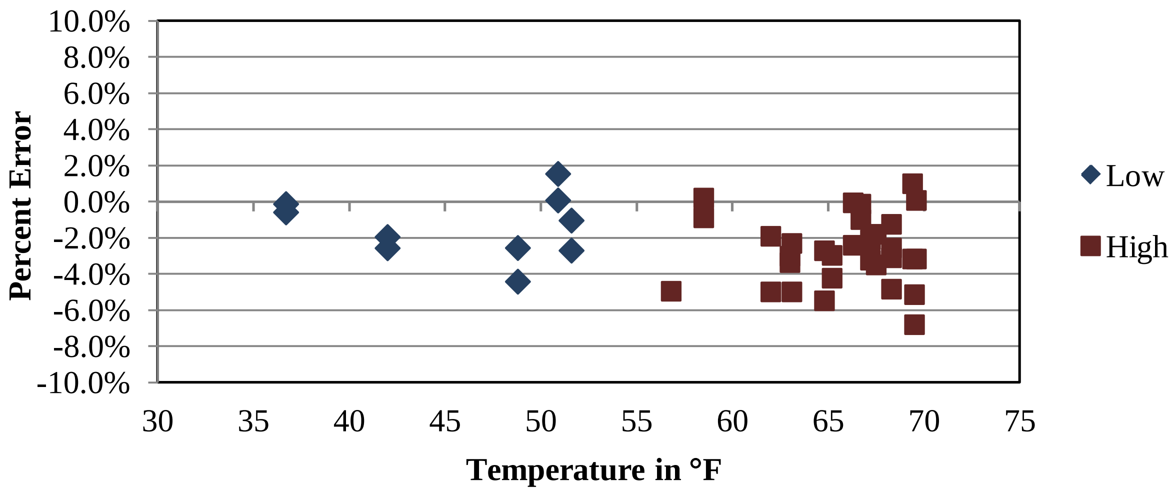


Figure 5-7 – Pre-Validation GVW Errors by Temperature – 01-Nov-11

5.1.2.2 Steering Axle Weight Errors by Temperature

Figure 5-8 illustrates that for steering axles, the WIM equipment increasingly underestimates weights as temperature increases. The range in error is similar for different temperature groups.

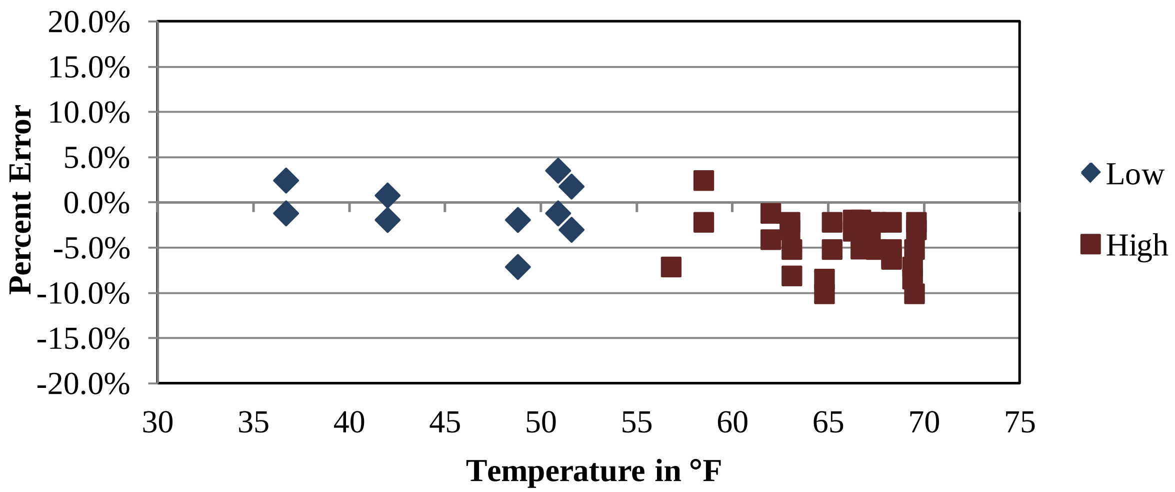


Figure 5-8 – Pre-Validation Steering Axle Weight Errors by Temperature – 01-Nov-11

5.1.2.3 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-9, the WIM equipment generally underestimates tandem axle weights across the range of temperatures observed in the field. The range in tandem axle errors is slightly higher for high temperature group.

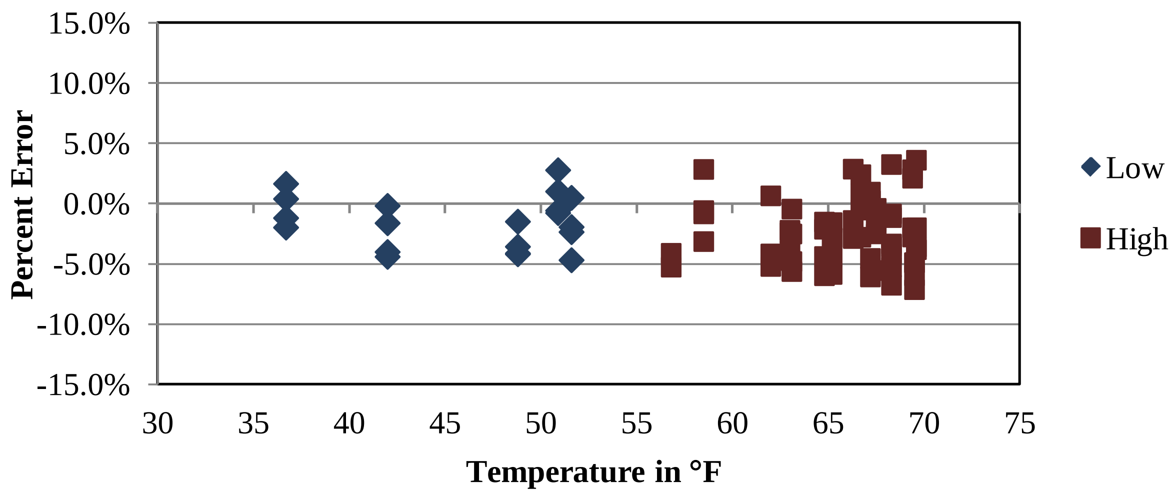


Figure 5-9 – Pre-Validation Tandem Axle Weight Errors by Temperature – 01-Nov-11

5.1.2.4 GVW Errors by Temperature and Truck Type

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

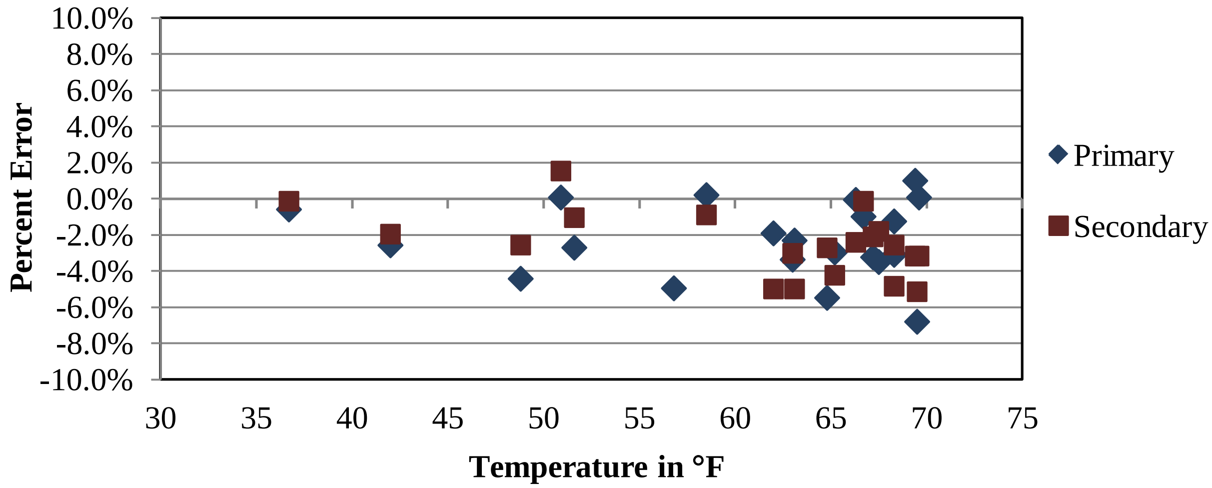


Figure 5-10 – Pre-Validation GVW Error by Truck and Temperature – 01-Nov-11

5.1.3 Classification and Speed Evaluation

The pre-validation classification and speed study involved the comparison of vehicle classification and speed data collected manually with the information for the same vehicles reported by the WIM equipment.

For the pre-validation classification study at this site, a manual sample of 109 vehicles including 100 trucks (Class 4 through 13) was collected. Video was collected during the study to provide a means for further analysis of misclassifications and vehicles whose classifications could not be determined with a high degree of certainty in the field.

Table 5-5 illustrates the breakdown of vehicles observed and identified by the WIM equipment for the manual classification study. Misclassified vehicles are defined as those vehicles that are manually classified by observation as one class of vehicle but identified by the WIM equipment as another class of vehicle. As shown in Table 5-6, one class 3 vehicle was misclassified as a Class 5 vehicle, and one Class 5 vehicle was misclassified as a Class 8 vehicle by the equipment. The combined results produced an undercount of one Class 3 and one overcount of a Class 8 vehicle, as shown in Table 5-5. The two incidents involving Class 5s canceled one another out. The cause of the misclassifications was not investigated in the field. There were no unclassified vehicles reported by the equipment.

Table 5-5 – Pre-Validation Classification Study Results – 01-Nov-11

Class	3	4	5	6	7	8	9	10	11	12	13
Observed Count	9	0	8	3	0	0	85	0	4	0	0
WIM Count	8	0	8	3	0	1	85	0	4	0	0
Observed Percent	8.3	0.0	7.3	2.8	0.0	0.0	78.0	0.0	3.7	0.0	0.0
WIM Percent	7.3	0.0	7.3	2.8	0.0	0.9	78.0	0.0	3.7	0.0	0.0
Misclassified Count	1	0	1	0	0	0	0	0	0	0	0
Misclassified Percent	11.1	0.0	12.5	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

The misclassified percentage represents the percentage of the misclassified vehicles in the manual sample. The misclassifications by pair are provided in Table 5-6.

Table 5-6 – Pre-Validation Misclassifications by Pair – 01-Nov-11

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

As shown in the table, a total of 2 vehicles, including 0 heavy trucks (6 – 13) were misclassified by the equipment. Based on the vehicles observed during the pre-validation study, the misclassification percentage is 0.0% for heavy trucks (6 – 13), which is within the 2.0% acceptability criteria for LTPP SPS WIM sites. The overall misclassification rate for all vehicles (3 – 15) is 1.8%.

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 – Pre-Validation Unclassified Trucks by Pair – 01-Nov-11

Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs
3/15	0	7/15	0	11/15	0
4/15	0	8/15	0	12/15	0
5/15	0	9/15	0	13/15	0
6/15	0	10/15	0		

Based on the manually collected sample of the 100 trucks, 0.0% of the vehicles at this site were reported as unclassified during the study. This is within the established criteria of 2.0% for LTTP SPS WIM sites.

For speed, the mean error for WIM equipment speed measurement was 0.9 mph; the range of errors was 2.1 mph.

5.2 Calibration

The WIM equipment required one calibration iteration between the pre- and post-validations. Information regarding the basis for changing equipment compensation factors, supporting data for the changes, and the resulting WIM accuracies from the calibrations are provided in this section.

The operating system weight compensation parameters that were in place prior to the pre-validation are shown in Table 5-8.

Table 5-8 – Initial System Parameters – 02-Nov-11

Speed Points (kph)	MPH	Right	Left
		1	2
80	50	3092	3478
88	55	3269	3678
96	60	3180	3578
104	65	3172	3567
112	70	3004	3377
Axle Distance (cm)		310	
Dynamic Comp (%)		104	
Loop Width (cm)		250	

5.2.1 Calibration Iteration 1

5.2.1.1 Equipment Adjustments

For GVW, the pre-validation test truck runs produced an overall error of -2.4% and errors of -0.7%, -3.0%, and -3.6% at the 55, 60 and 65 mph speed points respectively. The errors for the 55 mph and 65 mph speed points were extrapolated to derive new compensation factors for the 50 mph and 70 mph speed points. To compensate for these errors, the changes given in Table 5-9 were made to the compensation factors.

Table 5-9 – Calibration 1 Equipment Factor Changes – 02-Nov-11

Speed Points (kph)	Old Factors		Error	New Factors	
	Right	Left		Right	Left
	1	2		1	2
80	3092	3478	-0.62%	3111	3500
88	3269	3678	-0.62%	3289	3700
96	3180	3578	-2.90%	3275	3685
104	3172	3567	-3.42%	3284	3693
112	3004	3377	-3.42%	3111	3497
Axle Distance (cm)	310		-1.25%	306	
Dynamic Comp (%)	104		-3.60%	105	
Loop Width (cm)	250		1.4 ft	277	

5.2.1.2 Calibration 1 Results

The results of the 12 first calibration verification runs are provided in Table 5-10 and Figure 5-11. As can be seen in the table, the mean error of all weight estimates was reduced as a result of the first calibration iteration.

Table 5-10 – Calibration 1 Results – 02-Nov-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-0.7 ± 5.7%	Pass
Tandem Axles	±15 percent	0.7 ± 5.5%	Pass
GVW	±10 percent	0.6 ± 3.6%	Pass
Vehicle Length	±1.5 ft	-0.3 ± 1.0 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.1 ft	Pass

Figure 5-11 shows that the WIM equipment is estimating GVW with reasonable accuracy at all speeds.

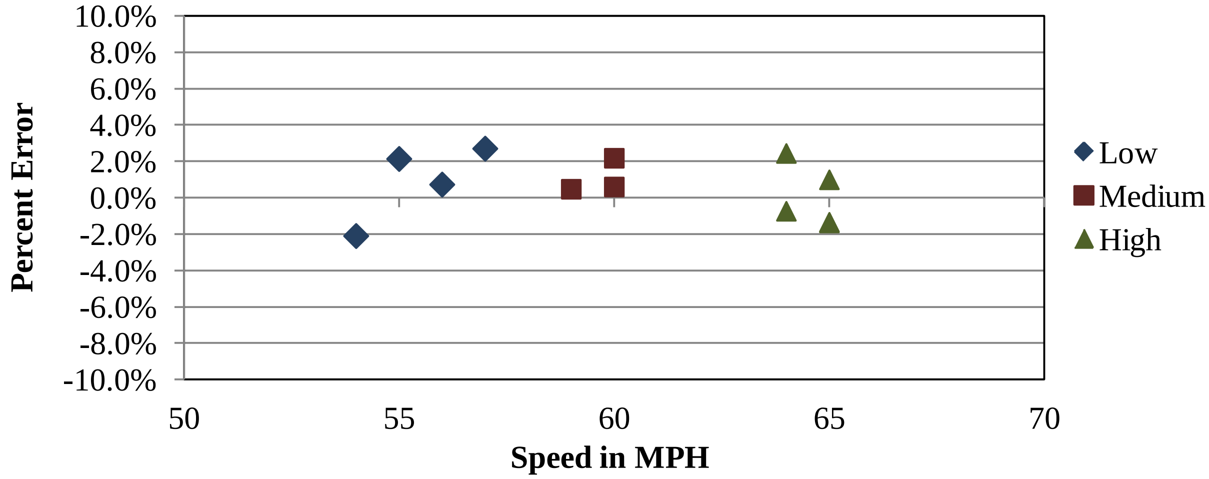


Figure 5-11 – Calibration 1 GVW Error by Speed – 02-Nov-11

Based on the results of the first calibration, where GVW estimate bias decreased to 0.6 percent, a second calibration was not considered to be necessary. The 12 calibration runs were combined with 28 additional post-validation runs to complete the WIM system validation.

5.3 Post-Validation

The 40 post-validation test truck runs were conducted on November 2, 2011, beginning at approximately 8:51 AM and continuing until 4:45 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with stone, and equipped with air suspension on truck and trailer tandems and with standard tandem spacings on both the tractor and trailer.
- A Class 9, 5-axle truck, loaded with stone, and equipped with air suspension on the tractor, steel spring suspension on the trailer, with standard tandem spacing on the tractor and standard tandem spacing on the trailer.

The test trucks were weighed prior to the post-validation and re-weighed at the conclusion of the post-validation. The average test truck weights and measurements are provided in Table 5-11.

Table 5-11 - Post-Validation Test Truck Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	75.6	10.2	14.0	14.0	18.7	18.7	14.3	4.3	24.8	4.1	47.5	54.5
2	65.7	9.2	12.7	12.7	15.5	15.5	14.3	4.3	15.9	4.1	38.6	45.5

Test truck speeds varied by 11 mph, from 54 to 65 mph. The measured post-validation pavement temperatures varied 33.4 degrees Fahrenheit, from 40.5 to 73.9. Despite the partly cloudy weather conditions the desired 30 degree temperature range was met. Table 5-12 is a summary of post validation results.

Table 5-12 – Post-Validation Overall Results – 02-Nov-11

Parameter	**95% Confidence Limit of Error**	**Site Values**	**Pass/Fail**
Steering Axles	±20 percent	0.8 ± 5.5%	Pass
Tandem Axles	±15 percent	1.1 ± 5.2%	Pass
GVW	±10 percent	1.0 ± 3.8%	Pass
Vehicle Length	±1.5 ft	-0.2 ± 1.0 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.0 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 0.1 ± 1.5 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 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 5-13.

Table 5-13 – Post-Validation Results by Speed – 02-Nov-11

Parameter	95% Confidence Limit of Error	Low	Medium	High
		54.0 to 57.7 mph	57.8 to 61.4 mph	61.5 to 65.0 mph
Steering Axles	±20 percent	0.3 ± 5.2%	1.2 ± 3.9%	1.0 ± 7.9%
Tandem Axles	±15 percent	0.8 ± 4.8%	1.1 ± 4.4%	1.4 ± 7.0%
GVW	±10 percent	0.6 ± 3.1%	1.1 ± 3.1%	1.4 ± 5.5%
Vehicle Length	±1.5 ft	-0.3 ± 0.9 ft	-0.1 ± 1.1 ft	-0.1 ± 1.1 ft
Vehicle Speed	± 1.0 mph	0.4 ± 1.4 mph	-0.3 ± 2.0 mph	0.3 ± 1.3 mph
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.1 ft	0.0 ± 0.0 ft	0.0 ± 0.1 ft

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

5.3.1.1 GVW Errors by Speed

As shown in Figure 5-12, the range in GVW error and bias error is slightly higher at high speeds.

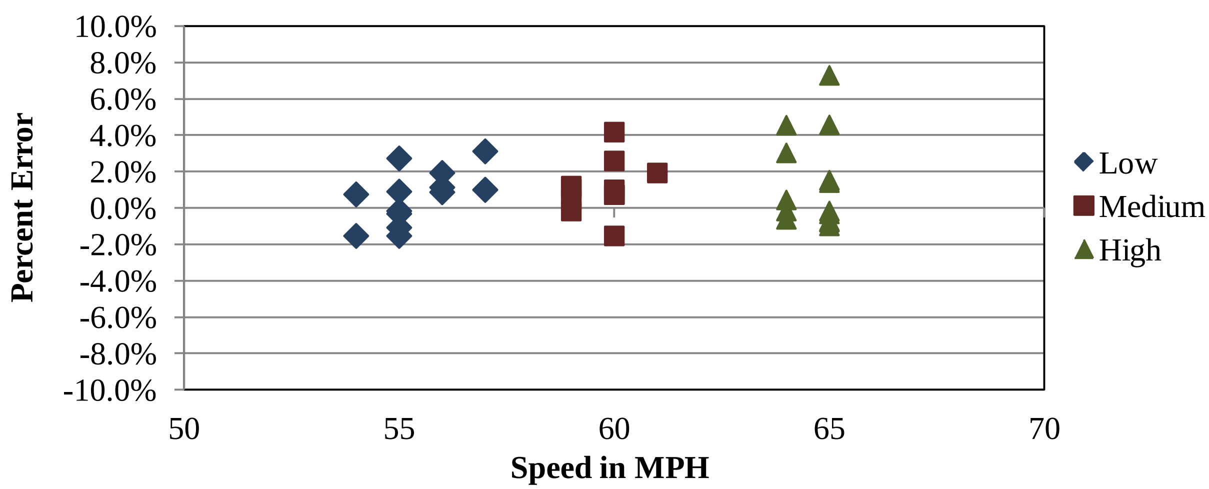


Figure 5-12 – Post-Validation GVW Errors by Speed – 02-Nov-11

5.3.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-13, 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 steering axle weight estimates at this site.

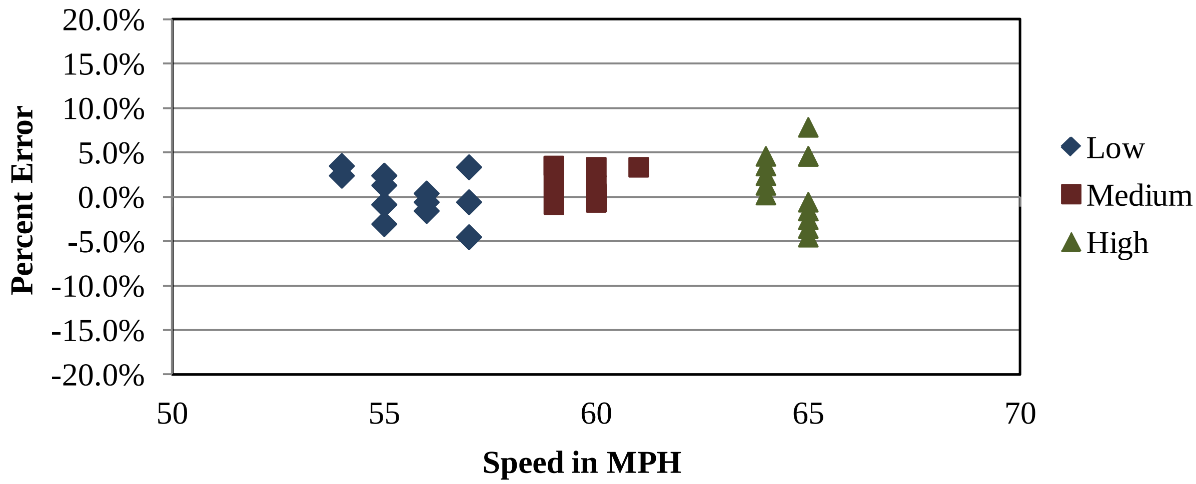


Figure 5-13 – Post-Validation Steering Axle Weight Errors by Speed – 02-Nov-11

5.3.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 5-14, the equipment estimated tandem axle weights with similar accuracy at all speeds. The range in tandem axle error and bias is slightly higher at high speeds.

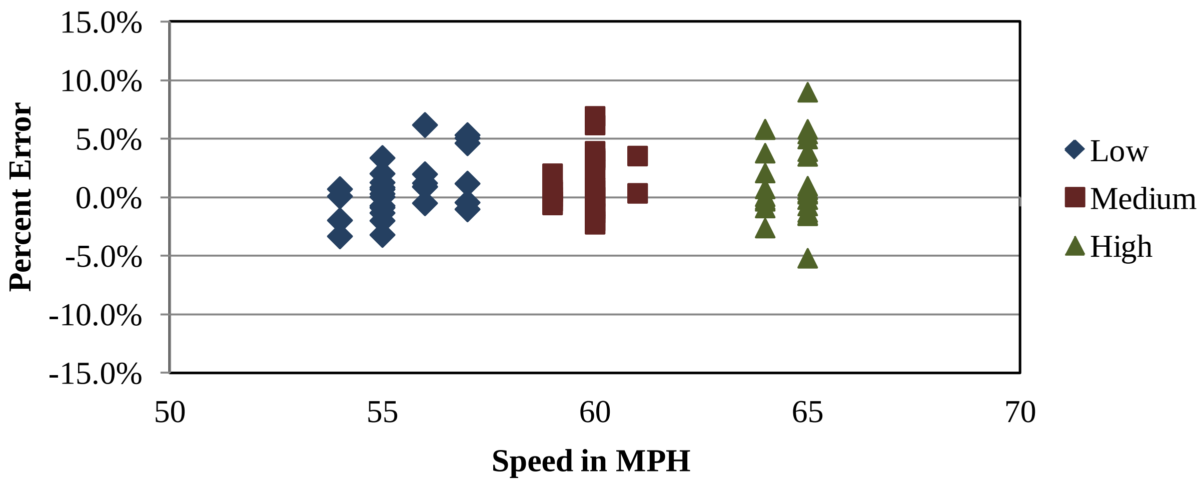


Figure 5-14 – Post-Validation Tandem Axle Weight Errors by Speed – 02-Nov-11

5.3.1.4 GVW Errors by Speed and Truck Type

It can be seen in Figure 5-15 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.

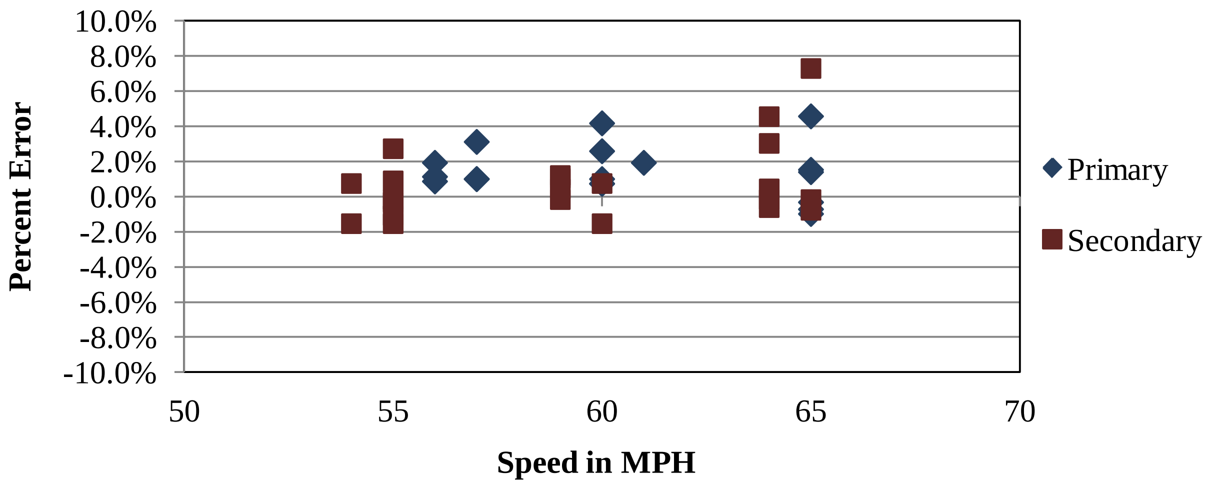


Figure 5-15 – Post-Validation GVW Error by Truck and Speed – 02-Nov-11

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 -0.1 feet to 0.1 feet. Distribution of errors is shown graphically in Figure 5-16.

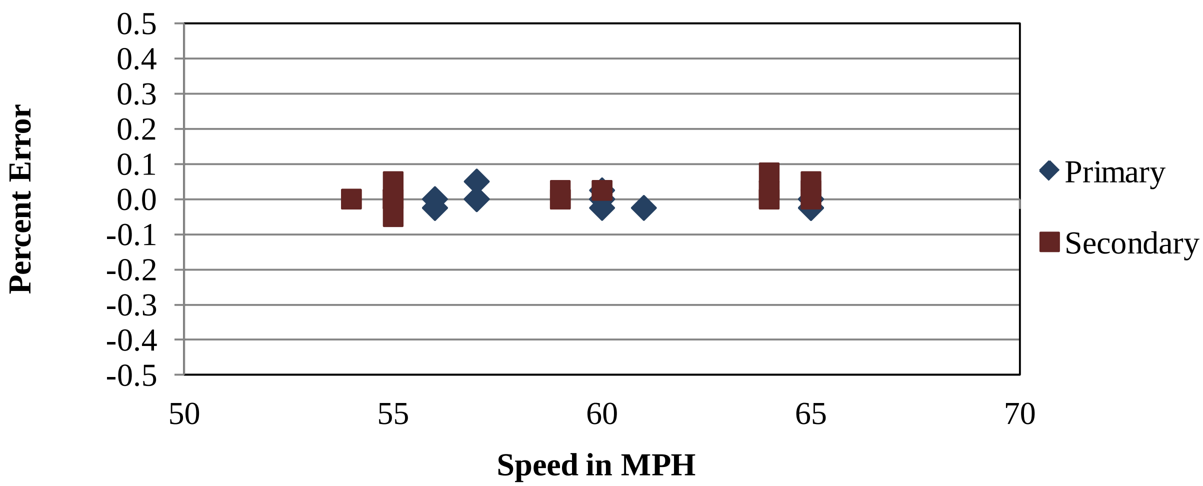


Figure 5-16 – Post-Validation Axle Length Error by Speed – 02-Nov-11

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 -0.5 to 0.5 feet. Distribution of errors is shown graphically in Figure 5-17.

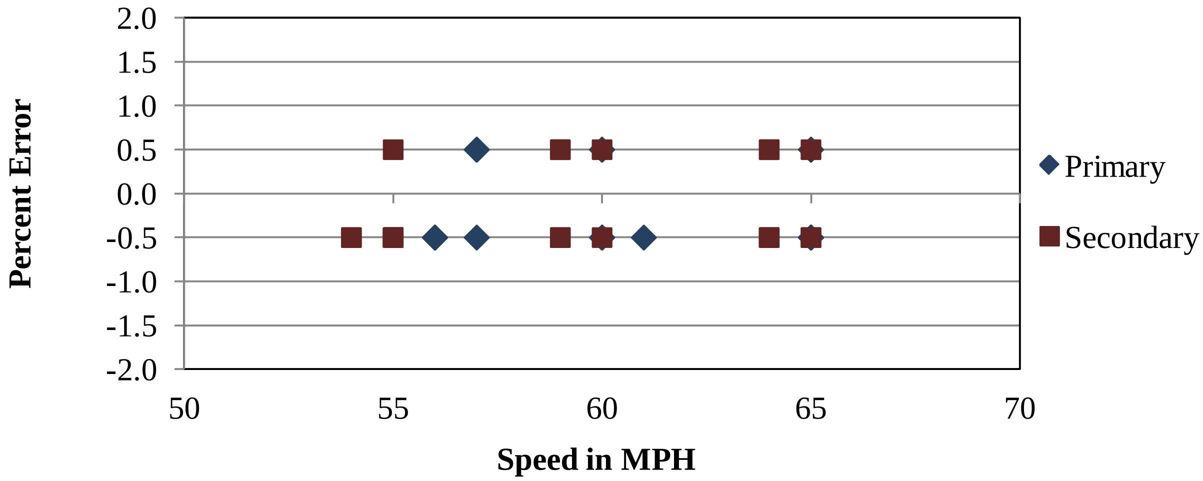


Figure 5-17 – Post-Validation Overall Length Error by Speed – 02-Nov-11

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 33.4 degrees, from 40.5 to 73.9 degrees Fahrenheit. The post-validation test runs are reported under three temperature groups – low, medium and high, as shown in Table 5-14 below.

Table 5-14 – Post-Validation Results by Temperature – 02-Nov-11

Parameter	95% Confidence Limit of Error	Low	Medium	High
		40.5 to 50 degF	50.1 to 60.0 degF	60.1 to 73.9 degF
Steering Axles	±20 percent	1.7 ± 6.3%	0.8 ± 6.2%	0.4 ± 5.7%
Tandem Axles	±15 percent	1.0 ± 6.0%	1.1 ± 3.5%	1.1 ± 6.1%
GVW	±10 percent	1.1 ± 3.9%	1.0 ± 1.7%	1.0 ± 4.9%
Vehicle Length	±1.5 ft	-0.2 ± 1.1 ft	-0.5 ± 0.0 ft	0.0 ± 1.1 ft
Vehicle Speed	± 1.0 mph	0.1 ± 2.0 mph	0.3 ± 1.1 mph	0.1 ± 1.7 mph
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.1 ft	0.0 ± 0.1 ft	0.0 ± 0.0 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 5-18, 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 strong correlation between temperature and weight estimates at this site. The range in error is the highest for the high temperature group.

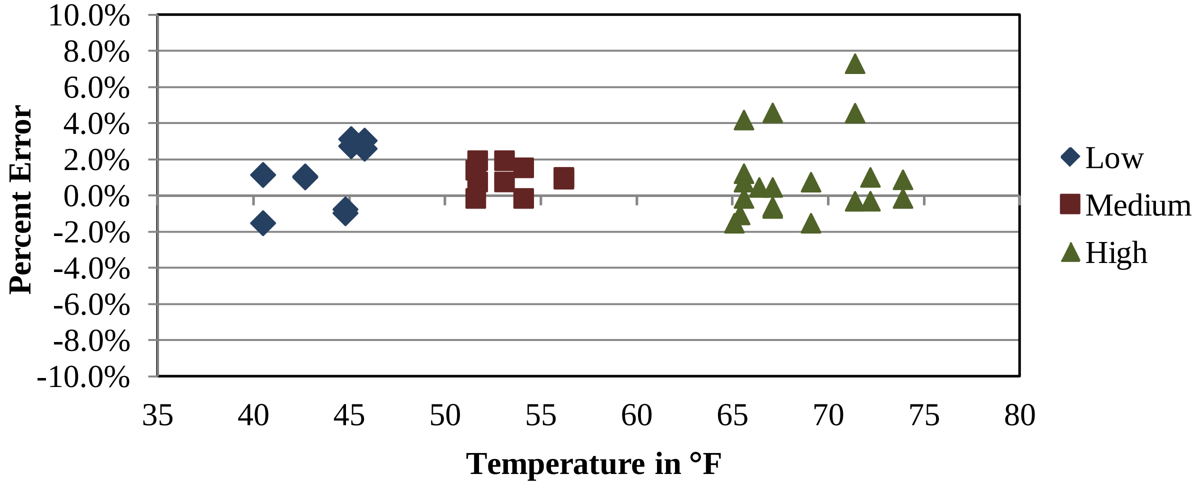


Figure 5-18 – Post-Validation GVW Errors by Temperature – 02-Nov-11

5.3.2.2 Steering Axle Weight Errors by Temperature

Figure 5-19 demonstrates that for steering axles, the WIM equipment appears to estimate weights with similar accuracy across the range of temperatures observed in the field. There does not appear to be a correlation between temperature and steering axle weight estimates at this site. The range in error is similar for different temperature groups.

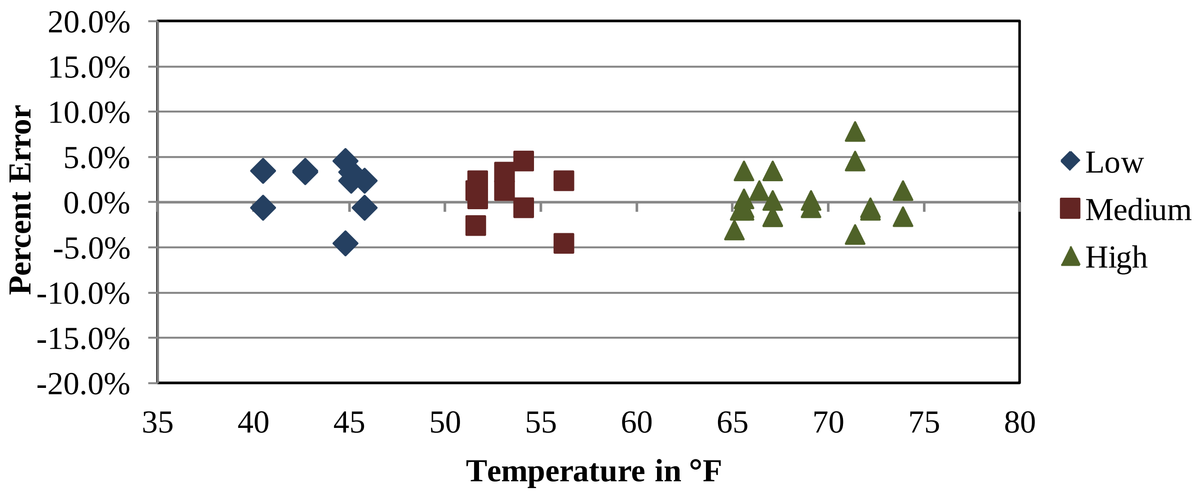


Figure 5-19 – Post-Validation Steering Axle Weight Errors by Temperature – 02-Nov-11

5.3.2.3 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-20, 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 similar for the three temperature groups.

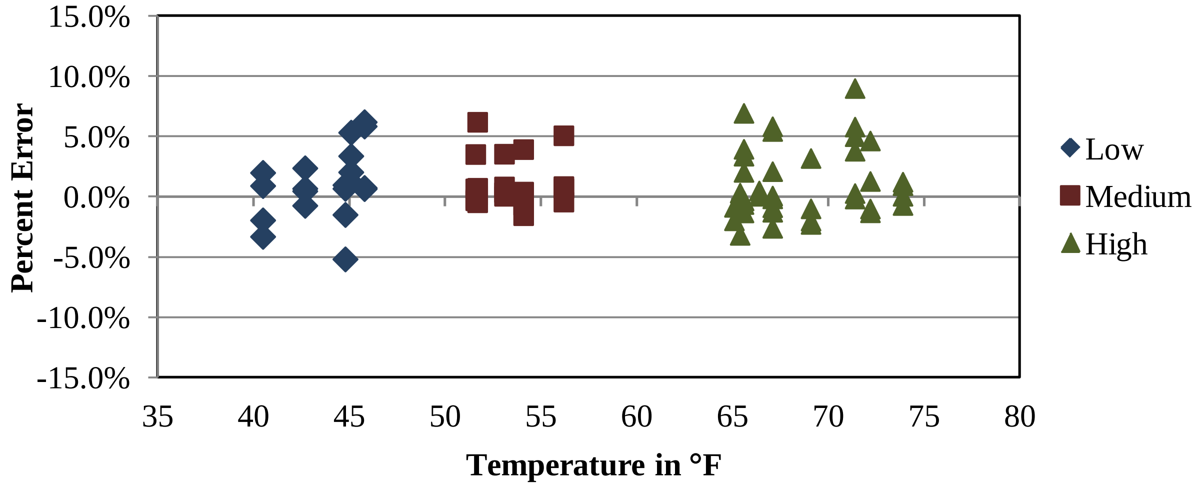


Figure 5-20 – Post-Validation Tandem Axle Weight Errors by Temperature – 02-Nov-11

5.3.2.4 GVW Errors by Temperature and Truck Type

As shown in Figure 5-21, 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.

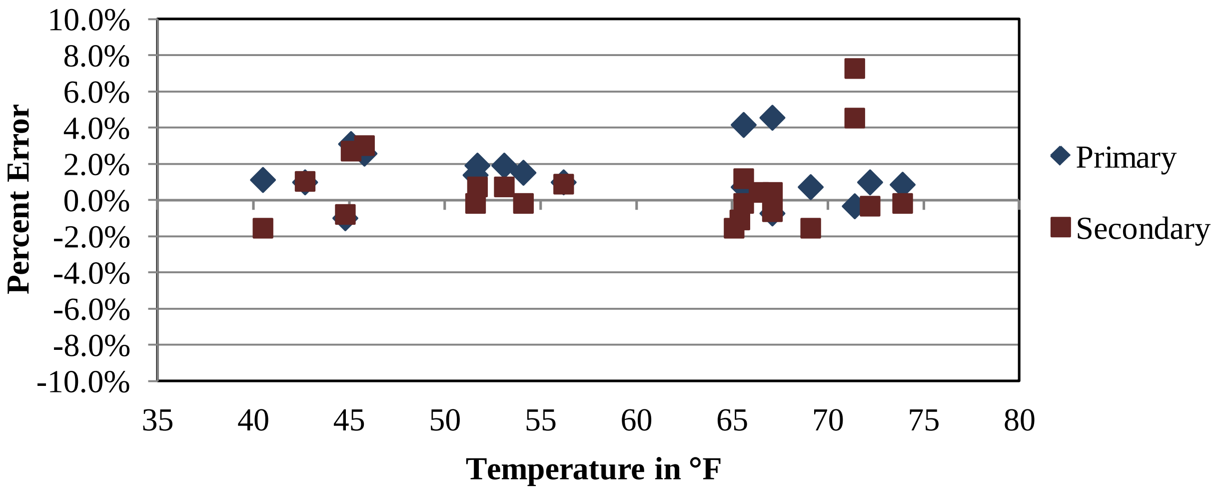


Figure 5-21 – Post-Validation GVW Error by Truck and Temperature – 02-Nov-11

5.3.3 GVW and Steering Axle Trends

Figure 5-22 is provided to illustrate the predicted GVW error with respect to the post-validation errors by speed.

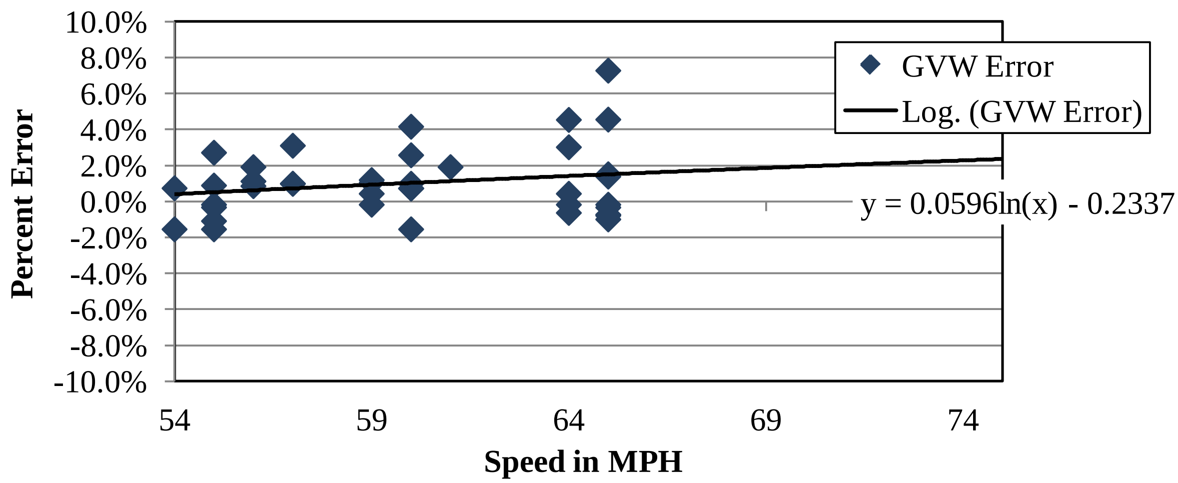


Figure 5-22 - GVW Error Trend by Speed

Figure 5-23 is provided to illustrate the predicted Steering Axle error with respect to the post-validation errors by speed.

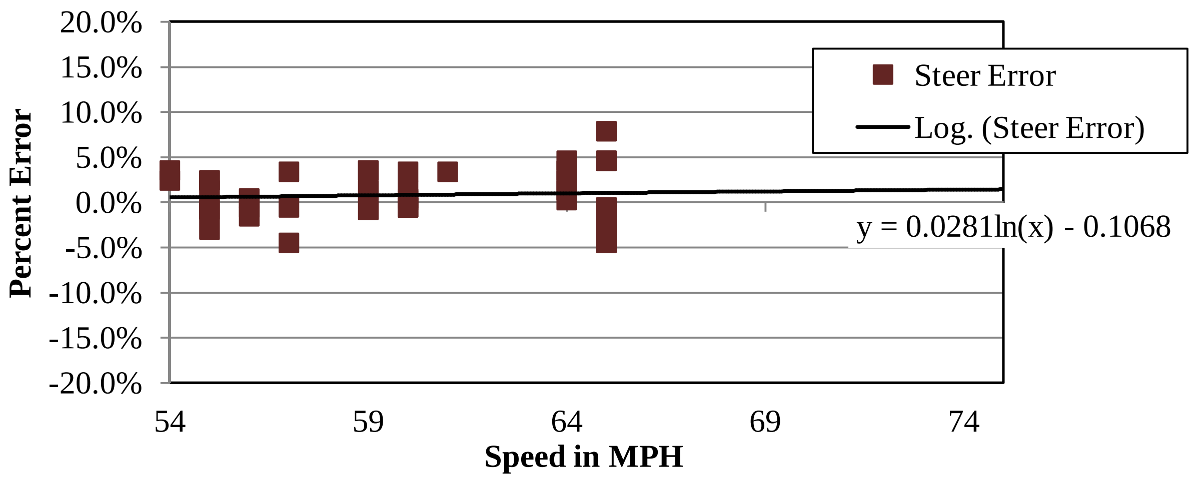


Figure 5-23 - Steering Axle Trend by Speed

5.3.4 Multivariable Analysis

This section provides additional analysis of post-validation results using a multivariable statistical technique of multiple linear regression. The same calibration data analyzed and discussed previously are analyzed again, but this time using a more sophisticated statistical methodology. The objective of the additional analysis is to investigate if the trends identified using previous analyses are statistically significant, and to quantify these trends.

Multivariable analyses provide additional insight on how speed, temperature, and truck type affect weight measurement errors for a specific site. It is expected that multivariable analyses done systematically for many sites will reveal overall trends.

5.3.4.1 Data

All errors from the weight measurement data collected by the equipment during the validation were analyzed. The percent error is defined as percentage difference between the weight measured by the WIM system and the static weight. Compared to analysis described previously, the weight of "axle group" was evaluated separately for tandem axles on tractors and on trailers. The separate evaluation was carried out because the tandem axles on trailers may have different dynamic response to loads than tandem axles on tractors.

The measurement errors were statistically attributed to the following variables or factors:

- Truck type. Primary truck and secondary truck.
- Truck test speed. Truck test speed ranged from 54 to 65 mph.
- Pavement temperature. Pavement temperature ranged from 40.5 to 73.9 degrees Fahrenheit.
- Interaction between the factors such as the interaction between speed and pavement temperature.

5.3.4.2 Results

For analysis of GVW weights, the value of regression coefficients and their statistical properties are summarized in Table 5-15. The value of regression coefficients defines the slope of the relationship between the % error in GVW and the predictor variables (speed, temperature, and truck type). The values of the t-distribution (for the regression coefficients) given in Table 5-15 are for the null hypothesis that assumes that the coefficients are equal to zero. None of the parameters were found to be statistically significant. For example, the probability that the effect of truck type on the observed GVW errors has not occurred by chance alone was only about 29 percent.

Table 5-15 – Table of Regression Coefficients for Measurement Error of GVW

Parameter	Regression coefficients	Standard error	Value of t-distribution	Probability value
Intercept	-4.0143	4.8618	-0.8257	0.4144
Speed	0.0862	0.0772	1.1164	0.2716
Temp	0.0038	0.0275	0.1376	0.8913
Truck	-0.6561	0.6057	-1.0833	0.2859

The relationship between speed and GVW measurement errors is shown in Figure 5-24. The figure includes trend line for the predicted percent error. Besides the visual assessment of the relationship, Figure 5-24 provides quantification and statistical assessment of the relationship.

The quantification is provided by the value of the regression coefficient, in this case 0.0826 (in Table 5-15). This means, for example, that for a 10 mph increase in speed, the % error is increased by 0.862 % (0.0826 x 10). The statistical assessment of the relationship is provided by the probability value of the regression coefficient.

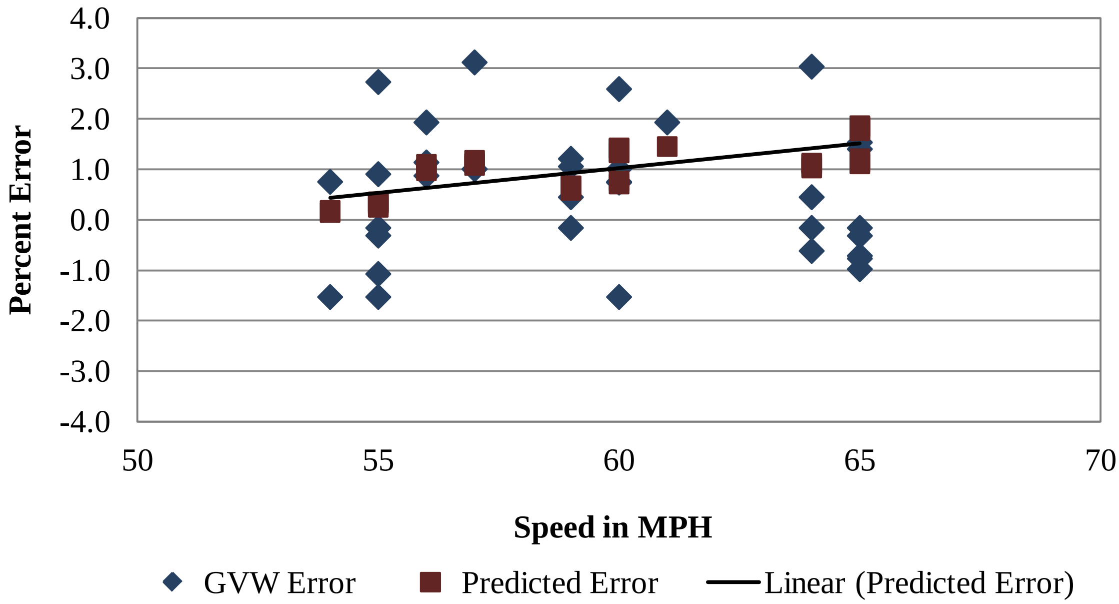


Figure 5-24 – Influence of Speed on the Measurement Error of GVW

The effect of speed on GVW was not statistically significant. The probability that the regression coefficient for speed (0.0862 in Table 5-15) is not different from zero was 0.2716. In other words, there is about 27 percent chance that the value of the regression coefficient is due to the chance alone.

The interaction between speed, temperature, and truck type was investigated by adding an interactive variable (or variables) such as the product of speed and temperature. No interactive variables were statistically significant. The intercept was not statistically significant and does not have practical meaning.

5.3.4.3 Summary Results

Table 5-16 lists regression coefficients and their probability values for all combinations of factors and % errors evaluated. Not listed in the table are factor interactions because the interactions were not statistically significant. Entries in the table are provided only if the probability value was smaller than 0.20. The dash in Table 5-16 indicates that the relationship was not statistically significant (the probability that the relationship can occur by chance alone was greater than 20 percent).

Table 5-16 – Summary of Regression Analysis

Weight, % error	**Factor**					
	Speed		**Temperature**		**Truck type**	
	Regression coefficient	Probability value	Regression coefficient	Probability value	Regression coefficient	Probability value
GVW	–	–	–	–	–	–
Steering axle	–	–	-0.0590	0.0915	2.963	0.0003
Tandem axle tractor	–	–	–	–	-3.147	0.0004
Tandem axle trailer	0.1421	0.1435	–	–	–	–

5.3.4.4 Conclusions

1. Speed had no statistically significant effect on measurement errors.

2. Temperature had possibly statistically significant effect on measurement error of steering axle weights only (p=0.0915).

3. Truck type had statistically significant effect on measurement errors of steering axle weights and weights of tandem axles on tractors. The regression coefficient for truck type in Table 5-16, represent the difference between the mean errors for the primary and secondary trucks. (Truck type is an indicator variable with values of 0 or 1.). For example, the mean error of steering axle weights for the Primary truck was about 3 percent larger than the error for the Secondary truck. However, the sign for the errors was

reversed for tandem axles on tractors (-3.147), and there was no statistically significant effect of truck type on GVW.

4. Even though the truck type had statistically significant effect on measurement errors, the practical significance of these errors is small and does not affect the validity of the calibration.

5.3.5 Classification and Speed Evaluation

The post-validation classification and speed study involved the comparison of vehicle classification and speed data collected manually with the information for the same vehicles reported by the WIM equipment.

For the post-validation classification study at this site, a manual sample of 112 vehicles including 100 trucks (Class 4 through 13) was collected. Video was collected during the study to provide a means for further analysis of misclassifications and vehicles whose classifications could not be determined with a high degree of certainty in the field.

Table 5-17 illustrates the breakdown of vehicles observed and identified by the WIM equipment for the manual classification study. 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. As shown in Table 5-18, one Class 5 vehicle was misclassified as a Class 4 vehicle and one Class 5 vehicle was misclassified as a Class 9 vehicle by the equipment. Additionally, seven Class 3 vehicles were misclassified as Class 5 vehicles. Combined, the misclassifications produced an overcount of one Class 4 vehicle, five Class 5 vehicles, and one Class 9 vehicle and produced an undercount of seven Class 3 vehicles. The cause of the misclassifications was not investigated in the field. There were no unclassified vehicles reported by the equipment.

Table 5-17 – Post-Validation Classification Study Results – 02-Nov-11

Class	3	4	5	6	7	8	9	10	11	12	13
Observed Count	12	0	12	2	0	2	78	1	3	1	1
WIM Count	5	1	17	2	0	2	79	1	3	1	1
Observed Percent	10.7	0.0	10.7	1.8	0.0	1.8	69.6	0.9	2.7	0.9	0.9
WIM Percent	4.5	0.9	15.2	1.8	0.0	1.8	70.5	0.9	2.7	0.9	0.9
Misclassified Count	7	0	2	0	0	0	0	0	0	0	0
Misclassified Percent	58.3	0.0	16.7	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

The misclassified percentage represents the percentage of the misclassified vehicles in the manual sample. The misclassifications by pair are provided in Table 5-18.

Table 5-18 – Post-Validation Misclassifications by Pair – 02-Nov-11

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

As shown in the table, a total of 9 vehicles, including 0 heavy trucks (6 – 13) were misclassified by the equipment. Based on the vehicles observed during the post-validation study, the misclassification percentage is 0.0% for heavy trucks (6 – 13), which is within the 2.0% acceptability criteria for LTPP SPS WIM sites. The overall misclassification rate for all vehicles (3 – 15) is 8.0%.

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 5-19.

Table 5-19 – Post-Validation Unclassified Trucks by Pair – 02-Nov-11

Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs
3/15	0	7/15	0	11/15	0
4/15	0	8/15	0	12/15	0
5/15	0	9/15	0	13/15	0
6/15	0	10/15	0		

Based on the manually collected sample of the 100 trucks, 0.0% of the vehicles at this site were reported as unclassified during the study. This is within the established criteria of 2.0% for LTTP SPS WIM sites.

For speed, the mean error for WIM equipment speed measurement was -0.1 mph; the range of errors was 2.5 mph.

6 Previous WIM Site Validation Information

The information reported in this section provides a summary of the performance of the WIM equipment since it was installed or since the first validation was performed on the equipment. The information includes historical data on weight and classification accuracies as well as a comparison of post-validation results.

6.1 Sheet 16s

This site has validation information from five previous visits as well as the current one as summarized in the tables below and provided on the Traffic Sheet 16. Table 6-1 data was extracted from previous validation reports and was updated to include the results of this validation.

Table 6-1 – Classification Validation History

Date	Misclassification Percentage by Class										Pct Unclass
	4	5	6	7	8	9	10	11	12	13	
7-Sep-05	75	67	0	0	0	0	0	0	0	0	0
8-Sep-05	67	25	25	0	0	0	0	0	0	0	0
20-Sep-06	67	20	0	0	0	0	0	0	0	0	0
21-Sep-06	50	44	0	0	0	0	0	0	0	0	0
28-Mar-07	0	0	0	0	0	0	0	0	0	0	0
29-Mar-07	0	0	0	0	0	0	0	0	0	0	0
9-Jul-08	0	13	0	0	33	0	0	0	0	0	0
10-Jul-08	100	13	0	0	0	1	100	0	0	100	2
7-Dec-10	0	0	0	0	0	0	100	0	0	0	0
8-Dec-10	0	0	0	0	0	0	0	0	0	0	1
1-Nov-11	11	0	13	0	0	0	0	0	0	0	0
2-Nov-11	58	0	17	0	0	0	0	0	0	0	0

Table 6-2 data was extracted from previous validation reports and was updated to include the results of this validation. The table provides the mean error and standard deviation for GVW, single axles and tandems for prior pre- and post-validations as reported on the LTPP Traffic Sheet 16s.

Table 6-2 – Weight Validation History

Date	Mean Error and SD		
	GVW	Single Axles	Tandem
7-Sep-05	1.6 ± 2.6	-3.5 ± 5.2	2.6 ± 3.6
8-Sep-05	1.5 ± 2.9	-3.0 ± 6.5	2.4 ± 3.5
20-Sep-06	-0.4 ± 2.5	-3.4 ± 4.4	0.1 ± 3.7
21-Sep-06	-0.7 ± 2.5	-4.8 ± 5.1	0.0 ± 3.5
28-Mar-07	1.6 ± 2.8	-6.6 ± 6.3	-0.3 ± 3.9
29-Mar-07	0.2 ± 2.4	-3.1 ± 5.6	1.0 ± 3.6
9-Jul-08	-0.8 ± 2.0	-2.7 ± 1.8	-0.5 ± 2.8
10-Jul-08	0.5 ± 1.6	-2.0 ± 2.5	0.9 ± 2.2
7-Dec-10	6.2 ± 2.6	1.8 ± 2.7	7.2 ± 3.1
8-Dec-10	-0.8 ± 2.9	-2.2 ± 2.7	-0.8 ± 2.9
1-Nov-11	-2.4 ± 1.9	-3.6 ± 3.3	-2.3 ± 2.5
2-Nov-11	1.0 ± 1.9	0.8 ± 2.7	1.1 ± 2.6

The variability of the GVW and Tandem weight errors appear to have remained reasonably consistent since the site was first validated. For steering axle weight error, the range of error was significantly reduced beginning with the validation conducted in July of 2008. From this information, it appears that the system demonstrates a tendency for the equipment accuracy to drift over time. The table also demonstrates the effectiveness of the validations in keeping the weight estimations within LTPP SPS WIM equipment tolerances.

6.2 Comparison of Past Validation Results

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

Table 6-3 – Comparison of Post-Validation Results

Parameter	95% Confidence Limit of Error	Site Values (Mean Error and 95% Confidence Interval)					
		8-Sep-05	21-Sep-06	29-Mar-07	10-Jul-08	8-Dec-10	2-Nov-11
Steering Axles	±20 percent	-3.0 ± 13.2	-4.8 ± 10.4	-3.1 ± 11.3	-2.0 ± 5.0	-2.2 ± 5.4	0.8 ± 5.5
Tandem Axles	±15 percent	2.4 ± 6.9	0.0 ± 6.9	1.0 ± 7.2	0.9 ± 4.4	-0.8 ± 5.9	1.1 ± 5.2
GVW	±10 percent	1.5 ± 5.8	-0.7 ± 5.0	0.2 ± 4.9	0.5 ± 3.2	-0.8 ± 4.9	1.0 ± 3.8

From Table 6-3, it appears that the mean error and the 95% confidence interval for GVW and tandem axle weight estimations have remained reasonably consistent since the equipment was installed. For single axles, the range in error was significantly reduced after the July, 2008 validation. This may coincide with an equipment or pavement maintenance activity.

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

Table 6-4 – Final Factors

Speed Points (kph)	Right	Left
	1	2
80	3111	3500
88	3289	3700
96	3275	3685
104	3284	3693
112	3111	3497
Axle Distance (cm)	306	
Dynamic Comp (%)	105	
Loop Width (cm)	277	

A review of the LTPP Standard Release Database 25 shows that there are 6 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.

7 Additional Information

The following information is provided in the attached appendix:

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

Illinois, SPS-6
SHRP ID: 170600

Validation Date: November 2, 2011

APPLIED RESEARCH ASSOCIATES, INC.

Photo 1 – Cabinet Exterior

Photo 2 – Cabinet Interior (Front)

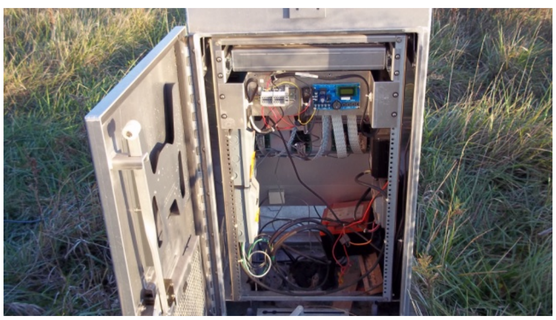


Photo 3 – Cabinet Interior (Back)

Photo 4 – Leading Loop

Photo 5 – Leading WIM Sensor

Photo 6 – Trailing WIM Sensor

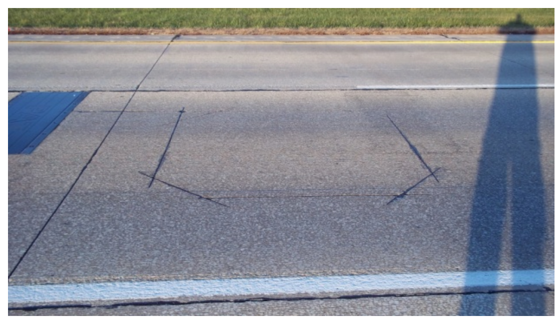


Photo 7 – Trailing Loop Sensor

Photo 8 – Power Service Box

Photo 9 – Telephone Service Box

Photo 10 – Downstream

Photo 11 – Upstream

Photo 12 – Truck 1

Photo 13 – Truck 1 Tractor

Photo 14 – Truck 1 Trailer and Load

Photo 15 – Truck 1 Suspension 1

Photo 16 – Truck 1 Suspension 2

Photo 17 – Truck 1 Suspension 3

Photo 18 – Truck 1 Suspension 4

Photo 19 – Truck 1 Suspension 5

Photo 20 – Truck 2

Photo 21 – Truck 2 Tractor

Photo 22 – Truck 2 Trailer and Load

Photo 23 – Truck 2 Suspension 1

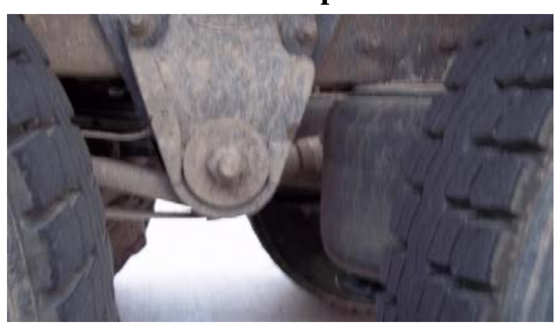


Photo 24 – Truck 2 Suspension 2

Photo 25 – Truck 2 Suspension 3

Photo 26 – Truck 2 Suspension 5

Photo 27 – Truck 2 Suspension 4

Traffic Sheet 16	STATE CODE:	17
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	170600
SITE CALIBRATION SUMMARY	DATE (mm/dd/yyyy)	11/1/2011

SITE CALIBRATION INFORMATION

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

2. TYPE OF EQUIPMENT CALIBRATED: Both

3. REASON FOR CALIBRATION: LTPP Validation

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

a. Inductance Loops
c. ______
b. 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: 21

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

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

Mean Difference Between -

	Mean		Standard Deviation
Dynamic and Static GVW:	-2.4%	Standard Deviation:	1.9%
Dynamic and Static Single Axle:	-3.6%	Standard Deviation:	3.3%
Dynamic and Static Double Axles:	-2.3%	Standard Deviation:	2.5%

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

9. DEFINE SPEED RANGES IN MPH:

			Low		High	Runs
a.	Low	-	55.0	to	58.7	14
b.	Medium	-	58.8	to	62.4	13
c.	High	-	62.5	to	66.0	14
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 17 SPS WIM ID: 170600 DATE (mm/dd/yyyy) 11/1/2011

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3275 | 3685

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		-	
FHWA Class 8:	Unk	FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 0.0%

Validation Test Truck Run Set - Pre

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

Contact Information: Phone: 717-975-3550

E-mail: dwolf@ara.com

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 17 SPS WIM ID: 170600 DATE (mm/dd/yyyy) 11/2/2011

SITE CALIBRATION INFORMATION

1. DATE OF CALIBRATION {mm/dd/yy} 11/2/11

2. TYPE OF EQUIPMENT CALIBRATED: Both

3. REASON FOR CALIBRATION: LTPP Validation

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

a. Inductance Loops c. ______
b. 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	steel spring
Truck 3:			

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

Mean Difference Between -

Dynamic and Static GVW:	1.0%	Standard Deviation:	1.9%
Dynamic and Static Single Axle:	0.8%	Standard Deviation:	2.7%
Dynamic and Static Double Axles:	1.1%	Standard Deviation:	2.6%

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

9. DEFINE SPEED RANGES IN MPH:

			Low		High	Runs
a.	Low	-	54.0	to	57.7	14
b.	Medium	-	57.8	to	61.4	12
c.	High	-	61.5	to	65.0	14
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 17 SPS WIM ID: 170600 DATE (mm/dd/yyyy) 11/2/2011

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3241 | 3646

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

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

CLASSIFIER TEST SPECIFICS

12. METHOD FOR COLLECTING INDEPENDENT VOLUME MEASUREMENT BY VEHICLE CLASS:

Manual

13. METHOD TO DETERMINE LENGTH OF COUNT: Number of Trucks

14. MEAN DIFFERENCE IN VOLUMES BY VEHICLES CLASSIFICATION:

FHWA Class 9:	1.0	FHWA Class	5	-	42.0
FHWA Class 8:	0.0	FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 0.0%

Validation Test Truck Run Set - Post

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

Contact Information: Phone: 717-975-3550

E-mail: dwolf@ara.com

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 17 SPS WIM ID: 170600 DATE (mm/dd/yyyy) 11/1/2011

Count - 109 Time = 1:02:30 Trucks (4-15) - 100 Class 3s - 9

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
67	9	43421	65	9	64	9	43563	64	9
62	8	43427	66	5	62	3	43566	60	3
62	9	43432	62	9	66	9	43569	66	9
59	9	43433	59	9	70	9	43570	66	9
67	9	43437	66	9	66	9	43573	66	9
68	9	43438	66	9	65	9	43579	64	9
65	9	43440	64	9	68	9	43581	66	9
67	9	43441	67	9	71	9	43582	68	9
65	3	43444	67	3	66	5	43587	62	5
63	9	43447	62	9	64	9	43589	68	9
68	9	43448	67	9	65	11	43592	63	11
67	9	43449	66	9	66	9	43593	65	9
66	9	43454	64	9	65	9	43595	65	9
64	9	43458	62	9	62	9	43599	62	9
64	9	43530	62	9	67	9	43605	68	9
65	9	43531	63	9	66	9	43607	61	9
70	9	43532	68	9	62	9	43608	60	9
63	9	43534	66	9	67	9	43613	63	9
67	9	43535	66	9	65	3	43615	63	3
72	3	43539	72	3	65	9	43642	64	9
67	9	43544	65	9	65	9	43643	65	9
69	3	43548	68	3	67	9	43645	68	9
67	9	43549	64	9	69	5	43647	64	3
65	9	43550	64	9	67	9	43648	65	9
66	9	43560	64	9	68	9	43671	68	9

Sheet 1 - 0 to 50 Start: 11:02:54 Stop: 11:36:50

Recorded By: djw Verified By: kt

Validation Test Truck Run Set - Pre

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 17 SPS WIM ID: 170600 DATE (mm/dd/yyyy) 11/1/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
65	9	43703	64	9	65	9	43771	65	9
65	9	43705	64	9	65	3	43772	65	3
65	9	43707	64	9	70	3	43774	66	3
67	5	43712	66	5	65	9	43775	66	9
65	9	43716	64	9	67	9	43780	67	9
69	9	43718	65	9	64	9	43781	67	9
65	9	43719	64	9	61	9	43784	62	9
66	9	43720	65	9	64	6	43785	63	6
67	9	43723	64	9	66	9	43792	64	9
68	9	43728	64	9	68	9	43793	65	9
66	9	43729	64	9	62	9	43794	61	9
65	9	43736	63	9	70	5	43796	71	5
65	9	43737	65	9	62	9	43799	62	9
64	6	43739	62	6	67	9	43800	66	9
65	11	43744	67	11	70	9	43804	72	9
65	9	43745	65	9	68	9	43805	70	9
69	9	43748	68	9	70	9	43806	69	9
65	9	43753	64	9	65	11	43838	64	11
65	5	43754	64	5	66	11	43839	64	11
65	9	43757	65	9	70	9	43840	69	9
67	9	43759	65	9	65	9	43849	68	9
65	9	43761	62	9	65	5	43852	67	5
68	9	43762	64	9	64	9	43853	64	9
64	9	43763	62	9	69	6	43854	60	6
67	9	43765	64	9	60	9	43855	61	9

Sheet 2 - 51 to 100 Start: 11:40:53 Stop: 12:00:46

Recorded By: djw Verified By: kt

Validation Test Truck Run Set - Pre

Traffic Sheet 20 **LTPP MONITORED TRAFFIC DATA** **SPEED AND CLASSIFICATION STUDIES**	STATE CODE: 17 SPS WIM ID: 170600 DATE (mm/dd/yyyy) 11/1/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
62	5	43868	63	5					
60	9	43873	64	9					
64	5	43874	64	5					
65	9	43878	64	9					
65	9	43883	65	9					
65	9	43884	64	9					
72	3	43885	66	3					
68	9	43886	67	9					
62	9	43888	68	9					

Sheet 3 - 101 - 150 Start: 12:02:21 Stop: 12:05:24

Recorded By: djw Verified By: kt

Validation Test Truck Run Set - Pre

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 17 SPS WIM ID: 170600 DATE (mm/dd/yyyy) 11/2/2011

Count - 112 Time = 1:11:41 Trucks (4-15) - 100 Class 3s - 12

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
70	**5**	**52257**	**70**	**3**	64	9	52318	67	9
60	9	52259	65	9	65	9	52320	67	9
68	9	52262	70	9	56	9	52321	55	9
67	5	52264	67	5	67	9	52325	68	9
68	9	52265	66	9	68	9	52328	68	9
62	9	52274	63	9	64	9	52330	64	9
70	9	52276	69	9	63	9	52331	61	9
63	9	52277	64	9	60	9	52332	60	9
66	9	52278	66	9	65	9	52333	64	9
58	9	52279	60	9	64	9	52334	64	9
66	9	52289	67	9	**63**	**9**	**52335**	**64**	**5**
64	9	52291	65	9	60	9	52340	56	9
63	9	52292	64	9	64	9	52342	61	9
64	9	52294	66	9	68	9	52348	68	9
62	6	52295	63	6	69	9	52350	64	9
66	9	52298	65	9	60	9	52351	61	9
62	9	52303	69	9	62	11	52352	62	11
73	9	52304	75	9	56	6	52386	62	6
70	9	52305	69	9	65	9	52387	68	9
70	10	52307	72	10	66	9	52391	67	9
67	9	52309	63	9	**67**	**5**	**52393**	**71**	**3**
62	9	52310	69	9	60	9	52396	59	9
64	9	52312	61	9	64	9	52401	65	9
65	9	52315	64	9	59	9	52404	62	9
62	9	52316	63	9	65	9	52407	66	9

Sheet 1 - 0 to 50 Start: 13:45:20 Stop: 14:05:15

Recorded By: djw Verified By: kt

Validation Test Truck Run Set - Post

Traffic Sheet 20 **LTPP MONITORED TRAFFIC DATA** **SPEED AND CLASSIFICATION STUDIES**	STATE CODE: 17 SPS WIM ID: 170600 DATE (mm/dd/yyyy) 11/2/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
70	5	52411	72	5	69	9	52580	65	9
64	9	52415	63	9	65	5	52584	65	5
70	**5**	**52416**	**68**	**3**	65	9	52609	66	9
60	9	52419	59	9	67	9	52611	61	9
60	9	52420	59	9	65	5	52615	66	5
64	5	52424	67	5	62	9	52619	61	9
71	12	52426	63	12	60	9	52626	58	9
72	3	52431	73	3	63	9	52627	58	9
65	9	52437	65	9	65	13	52631	64	13
60	9	52438	63	9	65	9	52639	64	9
63	3	52444	69	3	63	9	52640	65	9
64	**4**	**52445**	**64**	**5**	62	9	52646	64	9
60	**5**	**52447**	**61**	**3**	67	9	52685	67	9
64	9	52449	63	9	68	9	52687	66	9
61	**5**	**52457**	**65**	**3**	59	3	52689	60	3
64	9	52458	64	9	67	9	52694	64	9
67	**5**	**52459**	**76**	**3**	68	5	52700	67	5
62	9	52464	61	9	62	11	52713	62	11
64	9	52467	63	9	63	5	52715	64	5
62	8	52471	60	8	65	9	52734	66	9
65	9	52477	65	9	**68**	**5**	**52736**	**68**	**3**
65	11	52481	65	11	65	3	52737	64	3
64	9	52485	64	9	68	9	52741	65	9
64	5	52505	63	5	64	9	52742	62	9
68	9	52510	68	9	66	8	52744	65	8

Sheet 2 - 51 to 100   Start: 14:05:50   Stop: 14:52:00

Recorded By: djw   Verified By: kt

Validation Test Truck Run Set - Post

Traffic Sheet 20 **LTPP MONITORED TRAFFIC DATA** **SPEED AND CLASSIFICATION STUDIES**	STATE CODE: 17 SPS WIM ID: 170600 DATE (mm/dd/yyyy) 11/2/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
66	9	52756	66	9					
65	9	52757	65	9					
65	9	52758	65	9					
64	9	52768	63	9					
62	9	52769	62	9					
72	3	52773	72	3					
68	9	52776	68	9					
65	9	52777	63	9					
64	5	52779	64	5					
62	9	52780	60	9					
66	9	52783	66	9					
64	5	52784	64	5					

Sheet 3 - 101 - 150 Start: 14:53:40 Stop: 14:57:01

Recorded By: djw Verified By: kt

Validation Test Truck Run Set - Post