WIM System Field Calibration and Validation Summary Report

Arizona SPS-2
SHRP ID – 040200

Validation Date: January 23, 2013
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1 Executive Summary

A WIM validation was performed on January 23 and 24, 2013 at the Arizona SPS-2 site located on route I-10, milepost 108.6, 1.1 miles west of S. Palo Verde Road interchange.

This site was installed on November 28, 2006. The in-road sensors are installed in the eastbound, 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 September 14, 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. There is a section of epoxy that has broken free from the conduit run adjacent to the trailing WIM sensor that has been temporarily repaired with asphalt patching material. Further equipment discussion is provided in Section 3.

During the on-site pavement evaluation, a previous WIM site installation was noted approximately 500 feet upstream of the WIM scales that may affect the accuracies of the WIM system. A visual observation of the trucks as they approach, traverse, and leave the old WIM sensor area indicated adverse dynamics that may 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 – 23-Jan-13

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-1.7 ± 8.6%	Pass
Tandem Axles	±15 percent	0.9 ± 8.1%	Pass
GVW	±10 percent	-0.6 ± 6.9%	Pass
Vehicle Length	±3.0 percent (1.9 ft)	0.2 ± 1.0 ft	Pass
Axle Length	± 0.5 ft [150mm]	-0.3 ± 0.2 ft	Pass

Truck speeds were manually collected for each test run by a radar gun and compared with the speed reported by the WIM equipment. For this site, the error in speed measurement was -0.4 ± 2.0 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 -0.3 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 3.4% from the 117 vehicle sample (Class 4 – 13) was due to the 4 misclassifications of Class 5 vehicles.

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

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

- 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 residential trash.

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

Table 1-2 – Post-Validation Test Truck Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	77.2	11.3	16.5	16.5	16.5	16.5	14.5	4.3	33.5	4.1	56.4	63.5
2	67.4	10.9	14.0	14.0	14.3	14.3	14.5	4.3	33.5	4.1	56.4	63.5

The posted speed limit at the site is 75 mph. During the testing, the speed of the test trucks ranged from to 53 to 73 mph, a variance of 20 mph.

During test truck runs, pavement temperature was collected using a hand-held infrared temperature device. The post-validation pavement surface temperatures varied from 55.8 to 65.6 degrees Fahrenheit, a range of 9.8 degrees Fahrenheit. The cloudy weather conditions pevented the desired 30 degree range in temperatures.

A review of the LTPP Standard Release Database 25 shows that there are 4 years of level "E" WIM data for this site. This site requires 1 year of data to meet the minimum of five years of research quality data.

2 WIM System Data Availability and Pre-Visit Data Analysis

To assess the quality of the current traffic data, a pre-visit analysis was conducted by comparing a two-week data sample from October 29, 2012 (Data) to the most recent Comparison Data Set (CDS) from September 15, 2010. 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 25 shows that there are 4 years of level "E" WIM data for this site. Table 2-1 provides a breakdown of the available data for years 2007 to 2011.

Table 2-1 – LTPP Data Availability

Year	Total Number of Days in Year	Number of Months
2007	100	4
2008	358	12
2009	333	12
2010	347	12
2011	253	9

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

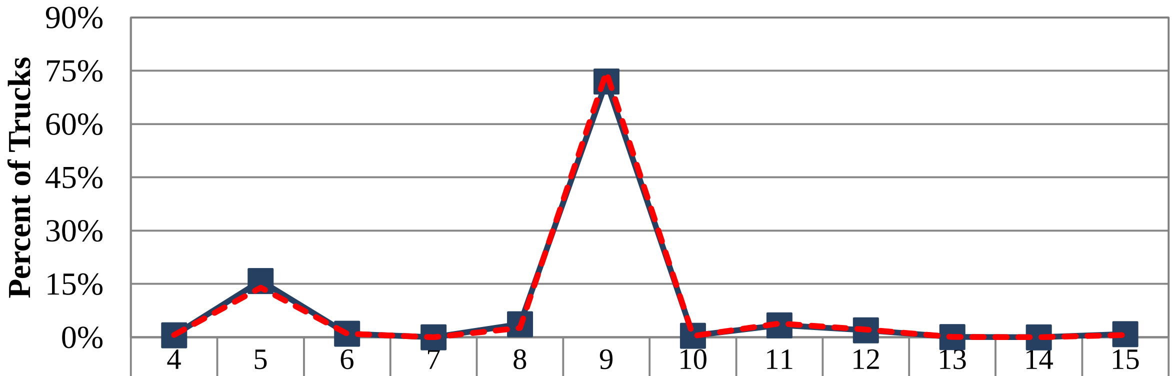
Table 2-2 provides a monthly breakdown of the available data for years 2007 through 2011.

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	
2007					30	30					25	15	4
2008	31	29	31	30	31	22	31	31	30	31	30	31	12
2009	31	28	31	30	31	30	31	31	30	31	28	1	12
2010	20	28	31	30	31	30	31	31	30	24	30	31	12
2011	31	28	30	30	31	23	31	31	18				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 between the sample dataset from October 29, 2012 (Data) and the most recent comparison Data Set (CDS) from September 15, 2010.



	4	5	6	7	8	9	10	11	12	13	14	15
Data	0.6%	15.9%	1.0%	0.0%	3.7%	72.0%	0.4%	3.4%	2.0%	0.1%	0.0%	0.9%
CDS	0.7%	14.0%	1.0%	0.0%	2.6%	74.6%	0.3%	3.9%	2.2%	0.1%	0.0%	0.6%

Truck Classification

Figure 2-1 – Comparison of Truck Distribution

Table 2-3 provides statistics for the truck distributions at the site for the two periods represented by the two datasets. The table shows that according to the most recent data, the two most frequent truck types crossing the WIM scale are Class 9 (72.0%) and Class 5 (15.9%) 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 0.9 percent of the vehicles at this site are unclassified.

Table 2-3 – Truck Distribution from W-Card

Vehicle Classification	CDS		Data		Change
	Date				
	9/15/2010		10/29/2012		
4	427	0.7%	360	0.6%	-0.1%
5	8813	14.0%	9749	15.9%	1.9%
6	626	1.0%	633	1.0%	0.0%
7	14	0.0%	13	0.0%	0.0%
8	1636	2.6%	2270	3.7%	1.1%
9	47118	74.6%	44267	72.0%	-2.6%
10	218	0.3%	276	0.4%	0.1%
11	2472	3.9%	2080	3.4%	-0.5%
12	1388	2.2%	1218	2.0%	-0.2%
13	58	0.1%	54	0.1%	0.0%
14	0	0.0%	0	0.0%	0.0%
15	403	0.6%	557	0.9%	0.3%

From the table it can be seen that the percentage of Class 9 vehicles has decreased by 2.6 percent between September 2010 and October 2012. 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 increased by 1.9 percent. These differences may be attributed to 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.

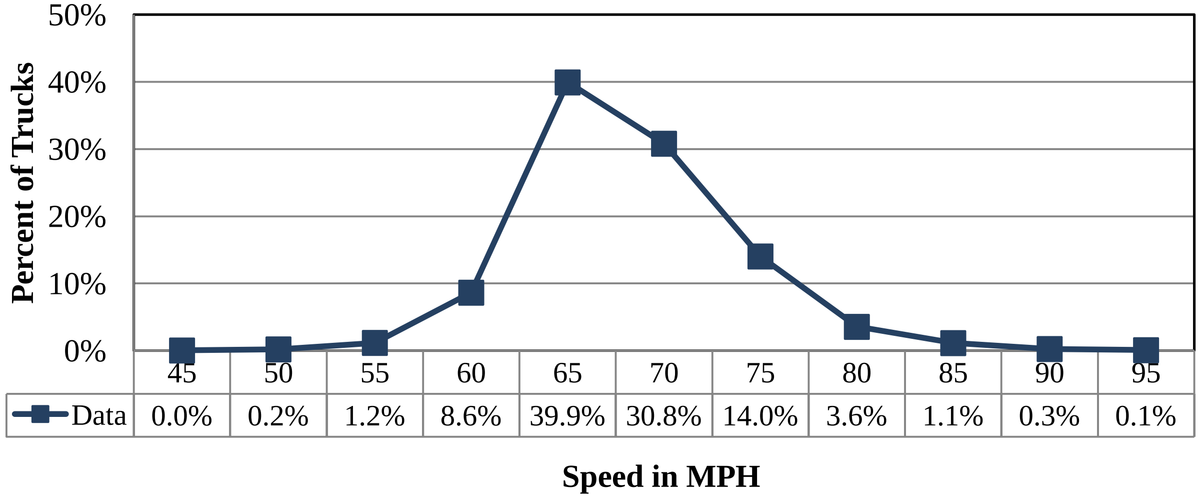


Figure 2-2 – Truck Speed Distribution – 22-Oct-12

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 75 and the 85th percentile speed for trucks at this site is 71 mph. The range of truck speeds for the validation will be 55 to 75 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 October 2012 and the Comparison Data Set from September 2010.

As shown in Figure 2-3, there is a slight shift to the left for the loaded peak between the September 2010 Comparison Data Set (CDS) and the October 2012 two-week sample W-card dataset (Data). The results indicate that there may have been a small change in the type of commodity being transported by trucks traveling over the WIM system or a small negative bias (underestimation of loads) possibly due to pavement condition or sensor deterioration.

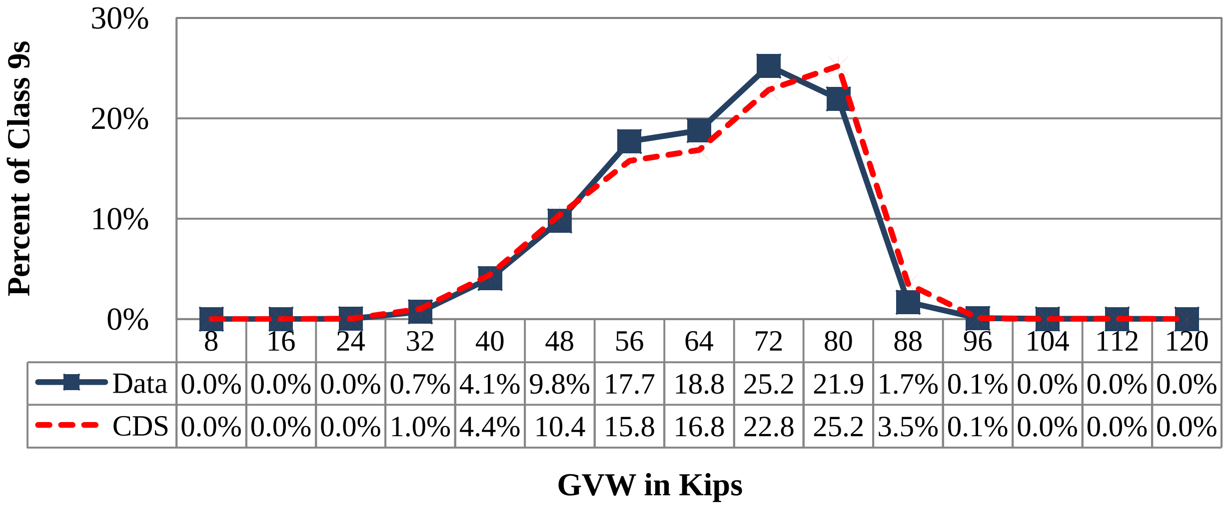


Figure 2-3 – Comparison of Class 9 GVW Distribution

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

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

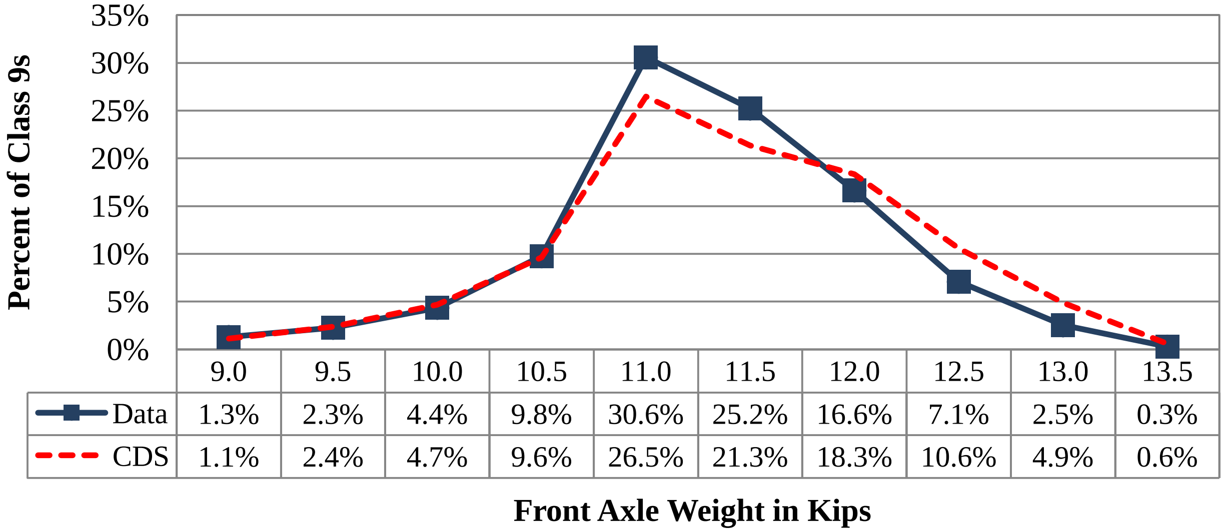
GVW weight bins (kips)	CDS		Data		Change
	Date				
	9/15/2010		10/29/2012		
8	0	0.0%	0	0.0%	0.0%
16	0	0.0%	0	0.0%	0.0%
24	15	0.0%	14	0.0%	0.0%
32	467	1.0%	322	0.7%	-0.3%
40	2077	4.4%	1785	4.1%	-0.4%
48	4859	10.4%	4306	9.8%	-0.6%
56	7393	15.8%	7788	17.7%	1.9%
64	7898	16.8%	8267	18.8%	2.0%
72	10703	22.8%	11095	25.2%	2.4%
80	11829	25.2%	9655	21.9%	-3.3%
88	1634	3.5%	739	1.7%	-1.8%
96	45	0.1%	31	0.1%	0.0%
104	1	0.0%	5	0.0%	0.0%
112	9	0.0%	4	0.0%	0.0%
120	0	0.0%	0	0.0%	0.0%
Average =	62.5 kips		61.8 kips		-0.7 kips

As shown in the table, the percentage of unloaded class 9 trucks in the 32 to 40 kips range decreased by 0.4 percent while the percentage of loaded class 9 trucks in the 72 to 80 kips range decreased by 3.3 percent. During this time period the percentage of overweight trucks decreased by 1.8 percent. Based on the average Class 9 GVW values from the per vehicle records, the GVW average for this site decreased by 1.1 percent, from 62.5 to 61.8 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 will provide a basis for the evaluation of the quality of the data by comparing the average front axle weight from the current data sample set with the expected average front axle weight 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 October 2012 and the Comparison Data Set from September 2010. The percentage of light axles (9.5 to 10.5 kips) decreased by approximately 0.2 percent and the percentage of heavy axles (11.5 to 12.5 kips) decreased by approximately 5.2%, indicating possible negative bias (underestimation of loads) in front axle measurement.



	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5
Data	1.3%	2.3%	4.4%	9.8%	30.6%	25.2%	16.6%	7.1%	2.5%	0.3%
CDS	1.1%	2.4%	4.7%	9.6%	26.5%	21.3%	18.3%	10.6%	4.9%	0.6%

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 11.0 and 12.0 kips. The percentage of trucks in this range has decreased between the September 2010 Comparison Data Set (CDS) and the October 2012 dataset (Data).

Table 2-5 provides the Class 9 front axle weight distribution data for the September 2010 Comparison Data Set (CDS) and the October 2012 dataset (Data).

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

F/A weight bins (kips)	CDS		Data		Change
	Date				
	9/15/2010		10/29/2012		
9.0	534	1.1%	574	1.3%	0.2%
9.5	1106	2.4%	991	2.3%	-0.1%
10.0	2191	4.7%	1909	4.4%	-0.3%
10.5	4500	9.6%	4278	9.8%	0.1%
11.0	12379	26.5%	13412	30.6%	4.1%
11.5	9982	21.3%	11062	25.2%	3.9%
12.0	8578	18.3%	7301	16.6%	-1.7%
12.5	4947	10.6%	3106	7.1%	-3.5%
13.0	2277	4.9%	1107	2.5%	-2.3%
13.5	271	0.6%	131	0.3%	-0.3%
Average =	11.2 kips		11.1 kips		-0.1 kips

The table shows that the average front axle weight for Class 9 trucks has decreased by 0.1 kips, or 0.9 percent. 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.

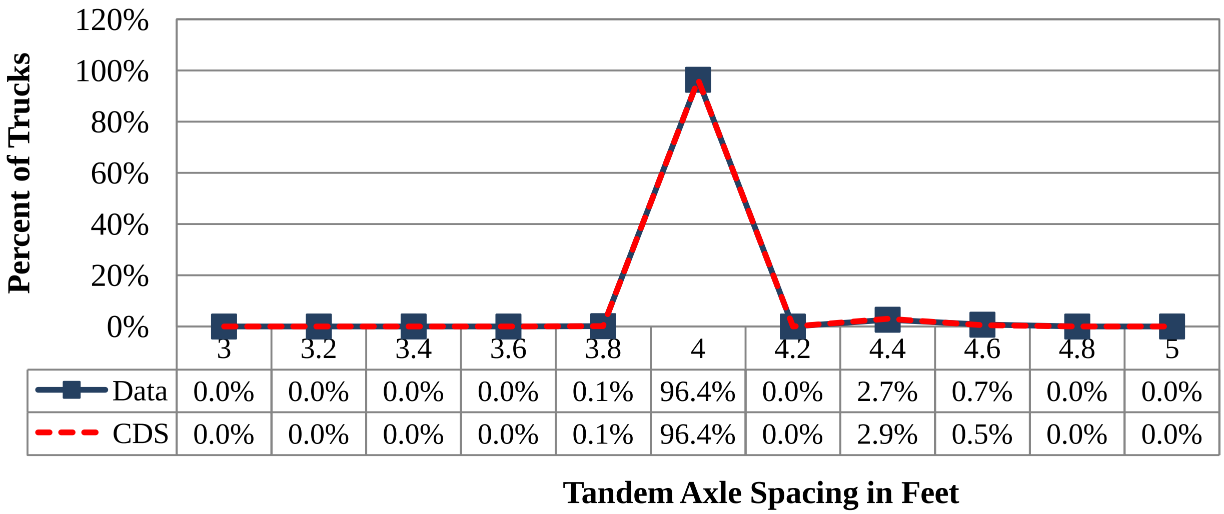


Figure 2-5 – Comparison of Class 9 Tractor Tandem Spacing

As seen in the figure, the Class 9 tractor tandem spacings for the September 2010 Comparison Data Set and the October 2012 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				
	9/15/2010		10/29/2012		
3.0	0	0.0%	0	0.0%	0.0%
3.2	1	0.0%	2	0.0%	0.0%
3.4	4	0.0%	11	0.0%	0.0%
3.6	0	0.0%	0	0.0%	0.0%
3.8	49	0.1%	64	0.1%	0.0%
4.0	45258	96.4%	42437	96.4%	0.0%
4.2	0	0.0%	0	0.0%	0.0%
4.4	1375	2.9%	1170	2.7%	-0.3%
4.6	240	0.5%	318	0.7%	0.2%
4.8	0	0.0%	0	0.0%	0.0%
5.0	3	0.0%	9	0.0%	0.0%
Average =	4.0 feet		4.0 feet		0.0 feet

From the table it can be seen that the drive tandem spacing of Class 9 trucks at this site is between 4.0 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, which is identical to to the expected average of 4.0 from the CDS per vehicle records. Further axle spacing analyses are performed during the validation and post-validation analysis.

2.7 Data Analysis Summary

Historical data analysis involved the comparison of the most recent Comparison Data Set (September 2010) based on the last calibration with the most recent two-week WIM data sample from the site (October 2012). Comparison of vehicle class distribution data indicates a 2.6 percent decrease in the percentage of Class 9 vehicles. Analysis of Class 9 weight data indicates that front axle weights have decreased by 0.9 percent and average Class 9 GVW has decreased by 1.1 percent for the October 2012 data. The data indicates an average truck tandem spacing of 4.0 feet, which is identical to the expected average of 4.0 feet.

3 Pavement Discussion

3.1 Pavement Condition Survey

The distress shown in Photo 3-1 was noted at the WIM site location. A section of the epoxy covering the metal electrical and drain conduits has broken free and has been temporarily patched. Although adverse truck dynamics were not indicated in this area, the distress may affect the accuracy of the WIM sensors.

Photo 3-1 – Pavement Distress at WIM Scale Location

3.2 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 3-1.

Table 3-1 – 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 3-1, 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, 2 right and 4 center profiler runs are presented in Table 3-2.

Table 3-2 – WIM Index Values

Profiler Passes			**Pass 1**	**Pass 2**	**Pass 3**	**Pass 4**	**Pass 5**	**Avg**
Left	LWP	LRI (m/km)	1.351	1.362	1.321			1.345
		SRI (m/km)	0.858	0.828	1.194			0.960
		Peak LRI (m/km)	1.537	1.528	1.418			1.494
		Peak SRI (m/km)	0.910	0.848	1.685			1.148
	RWP	LRI (m/km)	0.926	0.938	1.010			0.958
		SRI (m/km)	0.846	0.894	0.880			0.873
		Peak LRI (m/km)	0.940	0.944	1.010			0.965
		Peak SRI (m/km)	1.033	1.012	1.023			1.023
Center	LWP	LRI (m/km)	0.845	0.935	0.963	0.874		0.904
		SRI (m/km)	0.622	0.733	0.547	*0.490*		0.598
		Peak LRI (m/km)	0.850	0.935	0.963	0.874		0.906
		Peak SRI (m/km)	0.896	0.883	0.882	0.861		0.881
	RWP	LRI (m/km)	0.951	1.247	1.120	1.052		1.093
		SRI (m/km)	0.829	2.100	1.104	0.968		1.250
		Peak LRI (m/km)	0.951	1.247	1.120	1.052		1.093
		Peak SRI (m/km)	1.068	2.415	1.230	1.039		1.438
Right	LWP	LRI (m/km)	0.934	0.986				0.960
		SRI (m/km)	0.794	0.501				0.648
		Peak LRI (m/km)	0.942	0.986				0.964
		Peak SRI (m/km)	0.845	0.857				0.851
	RWP	LRI (m/km)	1.227	1.097				1.162
		SRI (m/km)	1.818	2.858				2.338
		Peak LRI (m/km)	1.229	1.106				1.168
		Peak SRI (m/km)	1.819	**2.861**				**2.340**

From Table 3-2 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).

3.3 Profile and Vehicle Interaction

Profile data was collected on December 8, 2011 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, 9 profile passes were made, 4 in the center of the travel lane and 5 that were shifted to the left and to the right of the center of the travel lane.

From a pre-visit review of the IRI values for the center, right, and left profile runs, the highest IRI value within the 1000 foot WIM section and the 400 foot approach section is 583 in/mi and is located approximately 331 feet prior to the WIM scale. This area of the pavement section was closely investigated during the validation visit, and truck dynamics in this area were closely observed. The distress shown in Figure 3-1 is a patched WIM scale from a previously installed and abandoned WIM site. The distress may influence truck dynamics in the WIM scale area.

Figure 3-1 – Pavement Distress Upstream of LTPP WIM Scales

Additionally, a visual observation of the trucks as they approach, traverse and leave the distressed area did indicate visible motion of the trucks that may affect the performance of the WIM scales. Trucks appear to track down the center of the lane.

3.4 Recommended Pavement Remediation

To improve the accuracy of the WIM system, it is recommended that the damage at the LTPP WIM scale location be repaired with permanent materials such as epoxy and that the abandoned WIM scales be removed and the pavement permanently repaired.

4 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.

4.1 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 40 pre-validation test truck runs were conducted on January 23, 2013, beginning at approximately 8:40 AM and continuing until 2:05 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with residential trash, 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 residential trash, and equipped with air suspension on the tractor, air suspension on the trailer, with standard tandem spacing on the tractor and trailer.

The test trucks were weighed prior to the pre-validation and were re-weighed at the conclusion of the pre-validation. The average test truck weights and measurements are provided in Table 4-1.

Table 4-1 – 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	77.5	11.3	16.6	16.6	16.6	16.6	14.5	4.3	33.5	4.1	56.4	63.5
2	67.8	10.9	14.1	14.1	14.3	14.3	14.5	4.3	33.5	4.1	56.4	63.5

Test truck speeds varied by 21 mph, from 52 to 73 mph. The measured pre-validation pavement temperatures varied 32.2 degrees Fahrenheit, from 44.6 to 76.8. The sunny weather conditions provided the desired 30 degree temperature range. Table 4-2 provides a summary of the pre-validation results.

As shown in Table 4-2, the site did not meet any of the LTPP requirements for loading and distance measurement as a result of the pre-validation test truck runs. This is due to non-calibrated coarse changes to the system compensation values as a result of recent repairs to the system.

Table 4-2 – Pre-Validation Overall Results – 23-Jan-13

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	5.0 ± 15.7%	FAIL
Tandem Axles	±15 percent	4.3 ± 17.3%	FAIL
GVW	±10 percent	6.5 ± 16.2%	FAIL
Vehicle Length	±3.0 percent (1.9 ft)	-2.6 ± 0.6 ft	FAIL
Axle Length	± 0.5 ft [150mm]	-0.3 ± 0.2 ft	FAIL

Truck speed was manually collected for each test run using a radar gun and compared with the speed reported by the WIM equipment. For this site, the average error in speed measurement over all speeds was -0.4 ± 2.0 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 -0.3 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.

4.1.1 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 75 mph. The test runs were divided into three speed groups - low, medium and high speeds, as shown in Table 4-3.

Table 4-3 – Pre-Validation Results by Speed – 23-Jan-13

Parameter	95% Confidence Limit of Error	Low	Medium	High
		52.0 to 59.0 mph	59.1 to 66.1 mph	66.2 to 73.0 mph
Steering Axles	±20 percent	13.0 ± 12.3%	5.9 ± 9.6%	-2.7 ± 7.4%
Tandem Axles	±15 percent	16.2 ± 11.3%	7.5 ± 9.1%	-1.3 ± 10.7%
GVW	±10 percent	15.3 ± 10.4%	7.1 ± 8.1%	-1.5 ± 9.3%
Vehicle Length	±3.0 percent (1.9 ft)	-2.5 ± 0.0 ft	-2.6 ± 0.8 ft	-2.6 ± 0.8 ft
Vehicle Speed	± 1.0 mph	-0.3 ± 1.7 mph	-0.4 ± 2.0 mph	-0.5 ± 2.6 mph
Axle Length	± 0.5 ft [150mm]	-0.3 ± 0.3 ft	-0.4 ± 0.2 ft	-0.4 ± 0.3 ft

From the table, it can be seen that, on average, the WIM equipment transitions from an overestimation of weights at the low speeds to an underestimation at the high speeds. The variability in error appears to be greater at the lower end 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.

4.1.1.1 GVW Errors by Speed

As shown in Figure 4-1, the WIM equipment transitions from an overestimation of GVW at the low speeds to an underestimation at the high speeds. The range in error appears to be similar at all speeds.

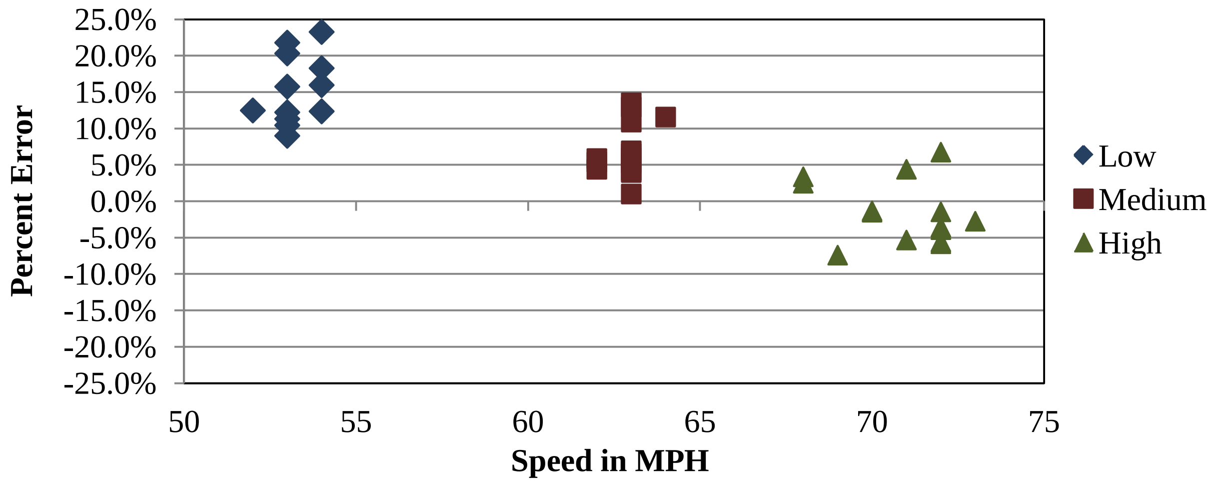


Figure 4-1 – Pre-Validation GVW Error by Speed – 23-Jan-13

4.1.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 4-2, the WIM equipment transitions from an overestimation of steering axle weights at the low speeds to an underestimation at the high speeds. The range in error appears to be similar at all speeds.

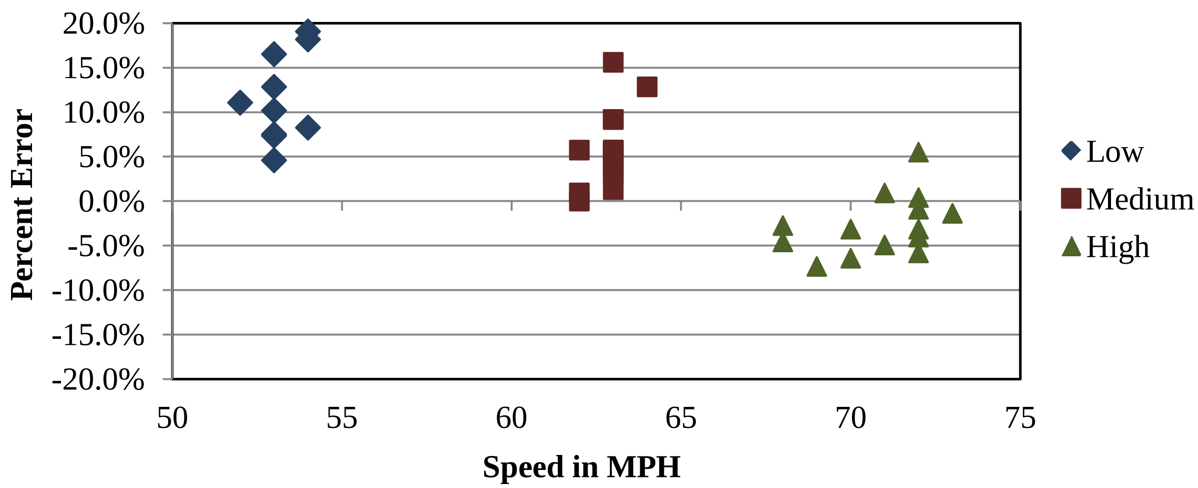


Figure 4-2 – Pre-Validation Steering Axle Weight Errors by Speed – 23-Jan-13

4.1.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 4-3, the WIM equipment transitions from an overestimation of tandem axle weights at the low speeds to an underestimation at the high speeds. The range in error appears to be similar at all speeds.

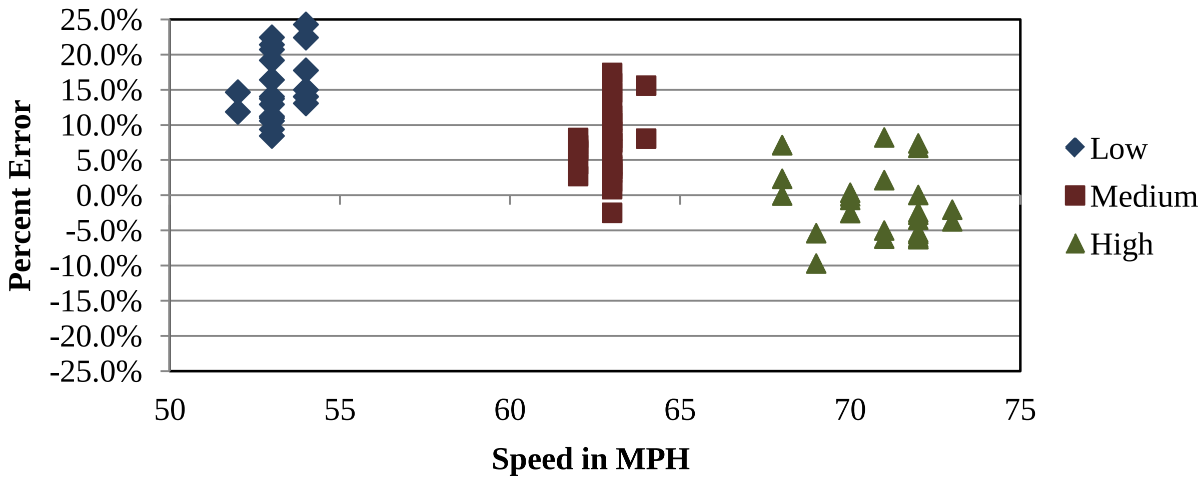


Figure 4-3 – Pre-Validation Tandem Axle Weight Errors by Speed – 23-Jan-13

4.1.1.4 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 4-4.

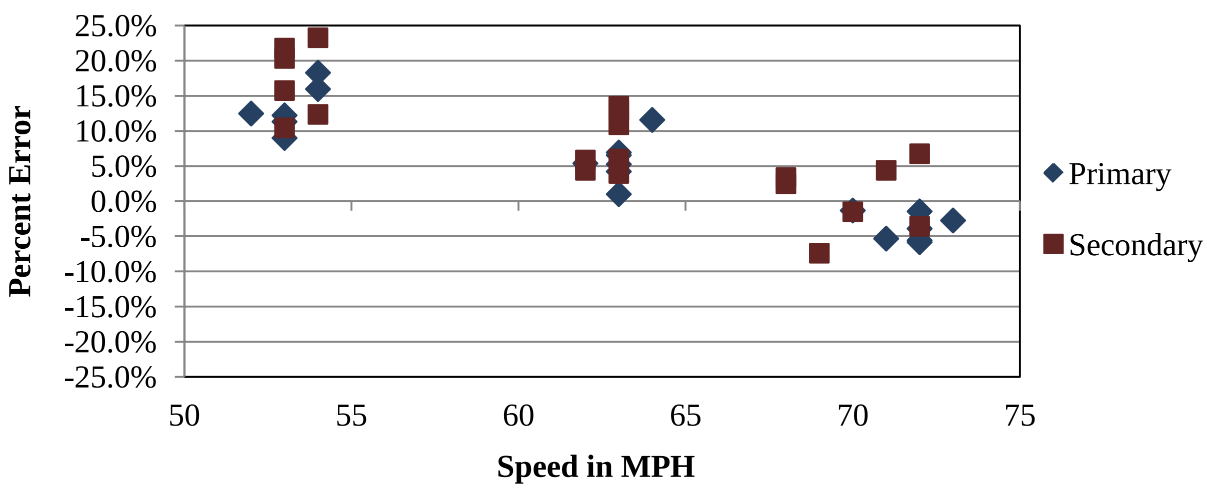


Figure 4-4 – Pre-Validation GVW Errors by Truck and Speed – 23-Jan-13

4.1.1.5 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 -0.6 feet. Distribution of errors is shown graphically in Figure 4-5.

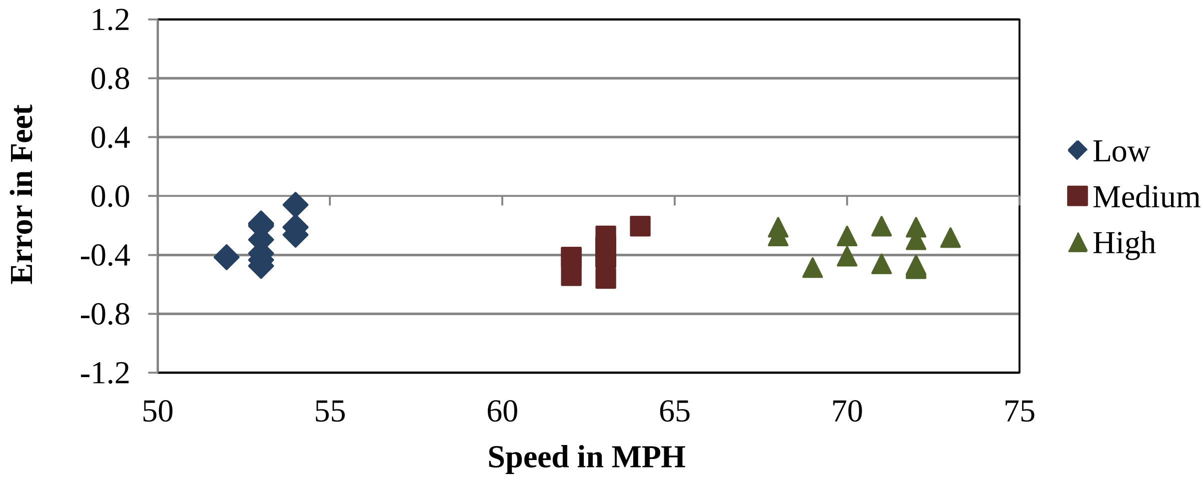


Figure 4-5 – Pre-Validation Axle Length Errors by Speed – 23-Jan-13

4.1.1.6 Overall Length Errors by Speed

For this system, the WIM equipment underestimated overall vehicle length consistently over the entire range of speeds, with an error range of -2.5 to -3.5 feet. Distribution of errors is shown graphically in Figure 4-6.

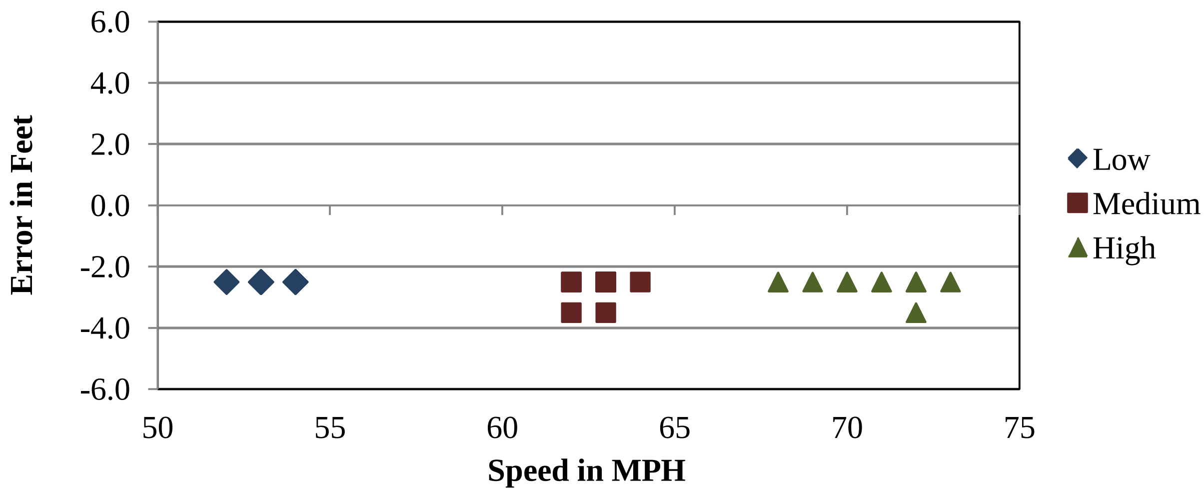


Figure 4-6 – Pre-Validation Overall Length Error by Speed – 23-Jan-13

4.1.2 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 32.2 degrees, from 44.6 to 76.8 degrees Fahrenheit. The desired 30 degree temperature range was met and the pre-validation test runs are being reported under three temperature groups – low, medium and high, as shown in Table 4-4.

Table 4-4 – Pre-Validation Results by Temperature – 23-Jan-13

Parameter	95% Confidence Limit of Error	Low	Medium	High
		44.6 to 55.3 degF	55.4 to 66.2 degF	66.3 to 76.8 degF
Steering Axles	±20 percent	4.3 ± 18.5%	3.1 ± 12.7%	6.5 ± 18.4%
Tandem Axles	±15 percent	6.8 ± 17.2%	4.7 ± 17.2%	8.5 ± 19.7%
GVW	±10 percent	6.2 ± 16.4%	4.4 ± 15.7%	7.9 ± 18.7%
Vehicle Length	±3.0 percent (1.9 ft)	-2.8 ± 1.1 ft	-2.6 ± 0.6 ft	-2.6 ± 0.5 ft
Vehicle Speed	± 1.0 mph	-1.0 ± 2.5 mph	0.0 ± 1.3 mph	-0.4 ± 2.2 mph
Axle Length	± 0.5 ft [150mm]	-0.4 ± 0.2 ft	-0.4 ± 0.2 ft	-0.3 ± 0.2 ft

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

4.1.2.1 GVW Errors by Temperature

From Figure 4-7, it can be seen that the equipment generally overestimates GVW across the range of temperatures observed in the field. The range in error, as well a positive bias (overestimation), is greater at the higher temperatures.

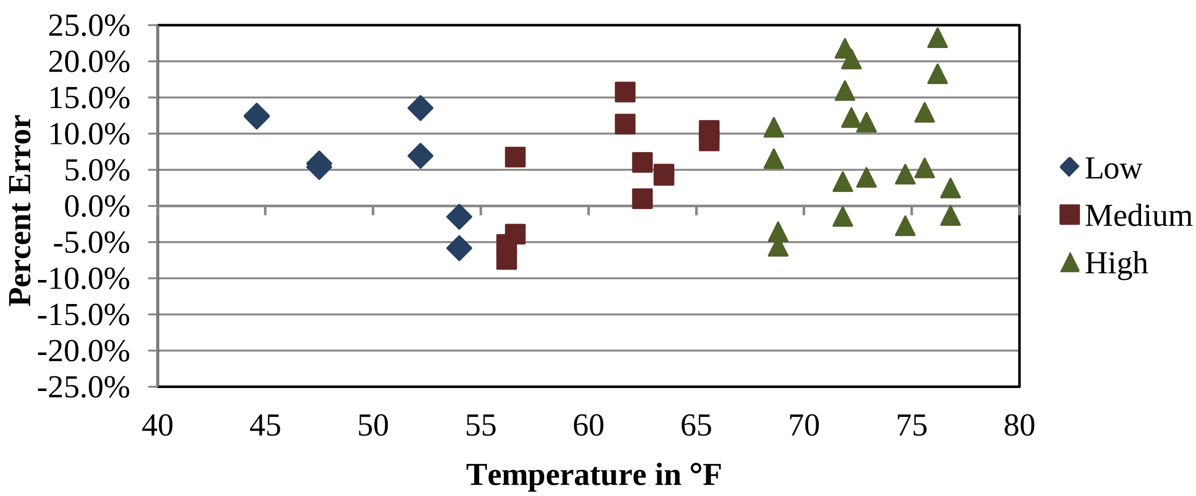


Figure 4-7 – Pre-Validation GVW Errors by Temperature – 23-Jan-13

4.1.2.2 Steering Axle Weight Errors by Temperature

Figure 4-8 illustrates that for steering axles, the WIM equipment overestimates weights at all temperature ranges equally. The range in error is greater at the lower and higher temperatures when compared with the median temperatures.

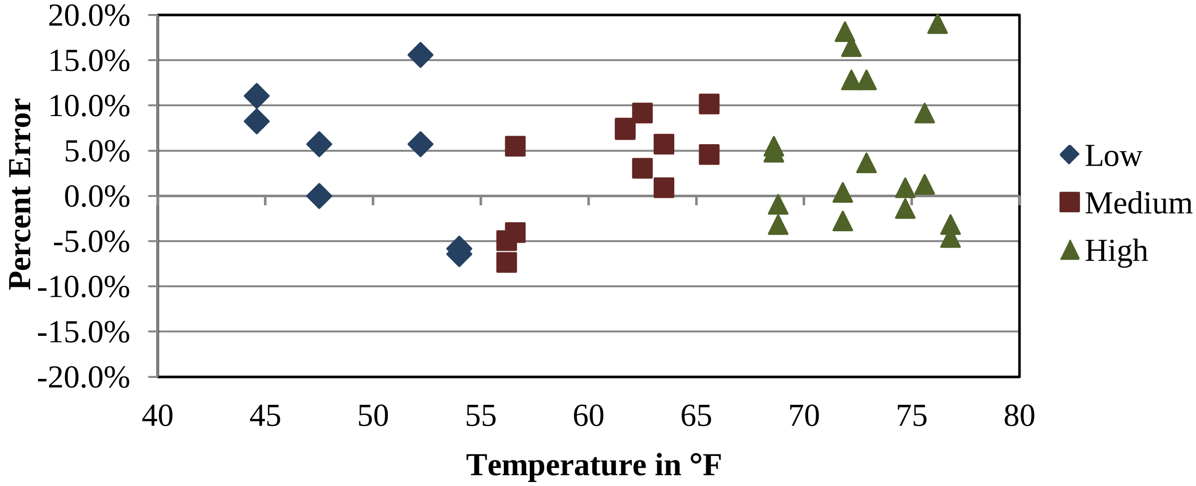


Figure 4-8 – Pre-Validation Steering Axle Weight Errors by Temperature – 23-Jan-13

4.1.2.3 Tandem Axle Weight Errors by Temperature

As shown in Figure 4-9, the WIM equipment, on average, overestimates tandem axle weights across the range of temperatures observed in the field. The range in tandem axle errors, as well a positive bias (overestimation), is slightly higher at high temperatures.

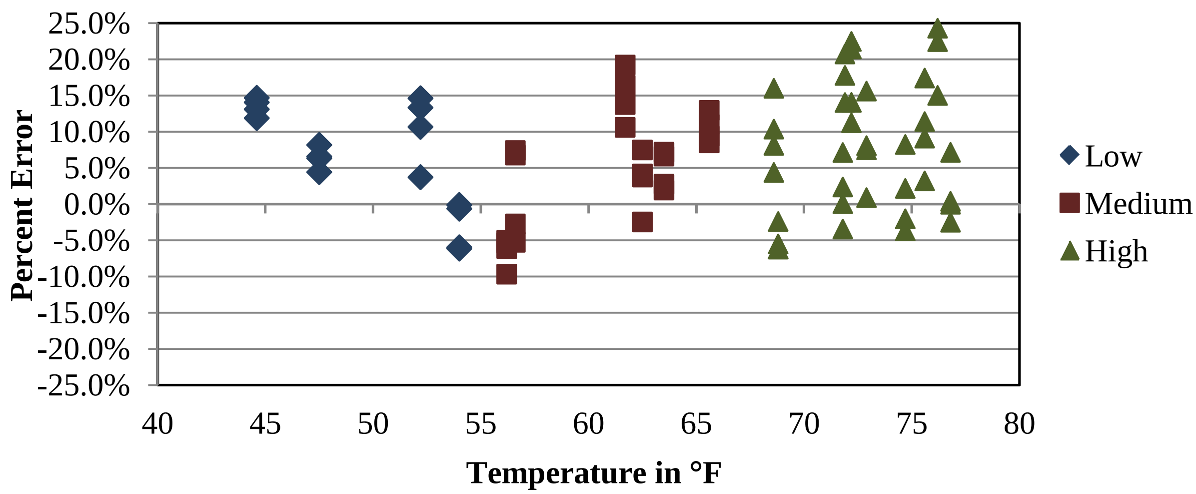


Figure 4-9 – Pre-Validation Tandem Axle Weight Errors by Temperature – 23-Jan-13

4.1.2.4 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 slightly higher at high temperatures. Distribution of errors is shown graphically in Figure 4-10.

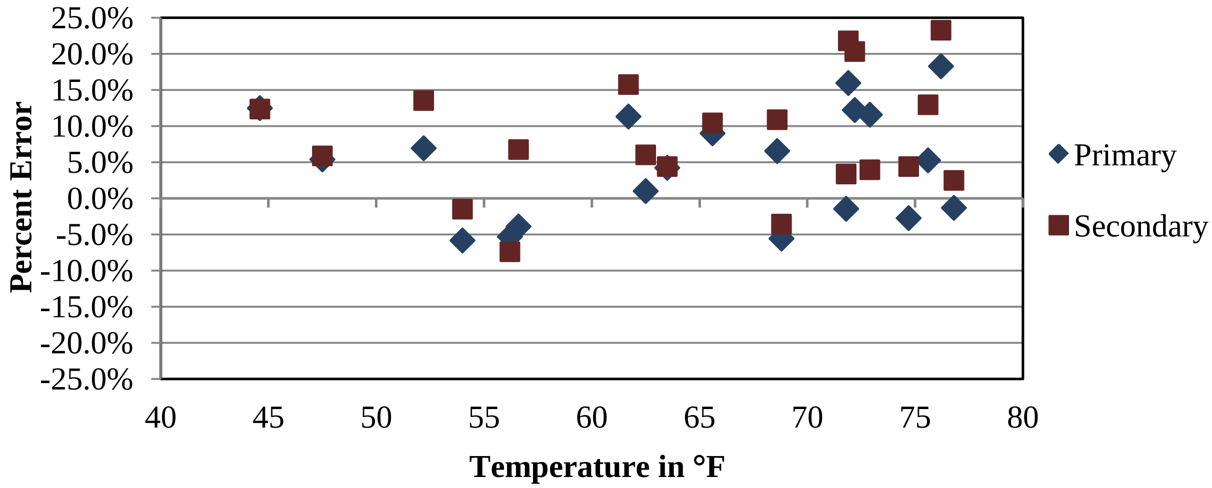


Figure 4-10 – Pre-Validation GVW Error by Truck and Temperature – 23-Jan-13

4.1.3 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 119 vehicles including 119 trucks (Class 4 through 13) was collected. Video was collected during the study to provide a means for further analysis of misclassifications and vehicles whose classifications could not be determined with a high degree of certainty in the field.

Misclassified vehicles are defined as those vehicles that are manually classified by observation as one class of vehicle but identified by the WIM equipment as another class of vehicle. The misclassifications by pair are provided in Table 4-5. The table illustrates the breakdown of vehicles observed and identified by the equipment for the manual classification study. As shown in Table 4-5, eight Class 5 vehicles were misclassified as Class 8 vehicles, one Class 5 vehicle was misclassified as a Class 9 vehicle, and one Class 6 vehicle was misclassified as a Class 9 vehicle by the equipment.

Table 4-5 – Pre-Validation Misclassifications by Pair – 23-Jan-13

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

As shown in the table, a total of 10 vehicles, including 1 heavy truck (vehicle classes 6 – 13) were misclassified by the equipment. Based on the vehicles observed during the pre-validation study, the misclassification percentage is 0.9% 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 8.4%, primarily due to misclassification of Class 5 vehicles as Class 8 vehicles. The causes for the misclassifications were not investigated in the field.

The combined results produced an undercount of 9 Class 5 and one Class 6 vehicle, and an overcount of 8 Class 8 and 2 Class 9 vehicles as shown in Table 4-6. The misclassified percentage represents the percentage of the misclassified vehicles in the manual sample.

Table 4-6 – Pre-Validation Classification Study Results – 23-Jan-13

Class	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Observed Count	0	0	13	5	0	1	90	0	5	4	1
WIM Count	0	0	4	4	0	9	92	0	5	4	1
Observed Percent	0.0	0.0	10.9	4.2	0.0	0.8	75.6	0.0	4.2	3.4	0.8
WIM Percent	0.0	0.0	3.4	3.4	0.0	7.6	77.3	0.0	4.2	3.4	0.8
Misclassified Count	0	0	9	1	0	0	0	0	0	0	0
Misclassified Percent	0.0	0.0	69.2	20.0	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 119 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 0.9 mph; the range of errors was 1.6 mph.

4.2 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 4-8.

Table 4-7 – Initial System Parameters – 24-Jan-13

Speed Point	MPH	Left	Right
		2	1
88	55	5001	4503
96	60	4916	4426
104	65	5027	4527
112	70	4795	4318
120	75	5177	4580
Axle Distance (cm)		372	
Dynamic Comp (%)		99	
Loop Width (cm)		200	

4.2.1 Calibration Iteration 1

4.2.1.1 Equipment Adjustments

For GVW, the pre-validation test truck runs produced an overall error of 6.5% and errors of 15.60%, 11.74%, and -7.87% at the 55, 65 and 75 mph speed points respectively. To compensate for these errors, the changes shown in Table 4-7 were made to the compensation factors.

Table 4-8 – Calibration 1 Equipment Factor Changes – 24-Jan-13

Speed Points	Old Factors		New Factors	
	Left	Right	Left	Right
	2	1	2	1
88	5001	4503	4300	3872
96	4916	4426	4463	4018
104	5027	4527	4789	4313
112	4795	4318	4783	4308
120	5177	4580	5441	4814
Axle Distance (cm)	372		374	
Dynamic Comp (%)	99		100	
Loop Width (cm)	200		121	

4.2.1.2 Calibration 1 Results

The results of the 12 calibration verification runs are provided in Table 4-9 and Figure 4-11. 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 4-9 – Calibration 1 Results – 24-Jan-13

Parameter	**95% Confidence Limit of Error**	**Site Values**	**Pass/Fail**
Steering Axles	±20 percent	-2.9 ± 10.0%	Pass
Tandem Axles	±15 percent	0.8 ± 8.4%	Pass
GVW	±10 percent	-1.1 ± 7.4%	Pass
Vehicle Length	±3.0 percent (1.9 ft)	0.1 ± 1.1 ft	Pass
Axle Length	± 0.5 ft [150mm]	-0.3 ± 0.2 ft	Pass

Figure 4-11 shows that the WIM equipment is estimating GVW with similar accuracy at all speeds.

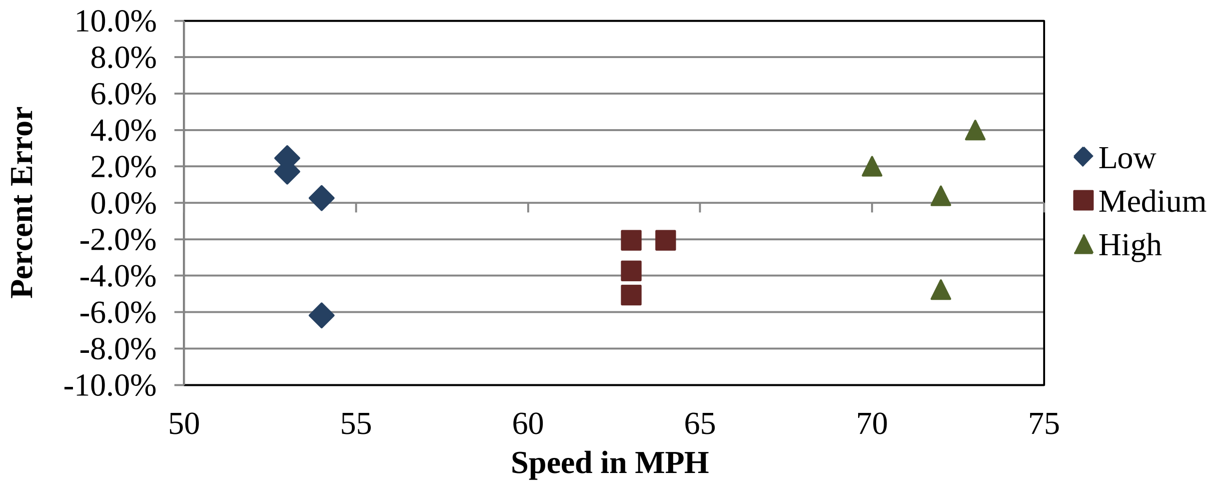


Figure 4-11 – Calibration 1 GVW Error by Speed – 24-Jan-13

Based on the results of the first calibration, where GVW estimate bias decreased to -1.1 percent, a second calibration was not considered to be necessary. The 12 calibration runs were combined with 29 additional post-validation runs to complete the WIM system validation.

4.3 Post-Validation

The 41 post-validation test truck runs were conducted on January 24, 2013, beginning at approximately 8:32 AM and continuing until 1:59 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with residential trash, 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 residential trash, and equipped with air suspension on the tractor, air suspension on the trailer, with standard tandem spacing on the tractor and trailer.

The test trucks were weighed prior to the post-validation and re-weighed at the conclusion of the post-validation. The average test truck weights and measurements are provided in Table 4-10.

Table 4-10 – Post-Validation Test Truck Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	77.2	11.3	16.5	16.5	16.5	16.5	14.5	4.3	33.5	4.1	56.4	63.5
2	67.4	10.9	14.0	14.0	14.3	14.3	14.5	4.3	33.5	4.1	56.4	63.5

Test truck speeds varied by 20 mph, from 53 to 73 mph. The measured post-validation pavement temperatures varied 9.8 degrees Fahrenheit, from 55.8 to 65.6. The mostly cloudy weather conditions prevented the desired minimum 30 degree temperature range. Table 4-11 is a summary of post validation results.

Table 4-11 – Post-Validation Overall Results – 24-Jan-13

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-1.7 ± 8.6%	Pass
Tandem Axles	±15 percent	0.9 ± 8.1%	Pass
GVW	±10 percent	-0.6 ± 6.9%	Pass
Vehicle Length	±3.0 percent (1.9 ft)	0.2 ± 1.0 ft	Pass
Axle Length	± 0.5 ft [150mm]	-0.3 ± 0.2 ft	Pass

Truck speed was manually collected for each test run using a radar gun and compared with the speed reported by the WIM equipment. For this site, the average error in speed measurement for all speeds was 0.6 ± 1.8 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 -0.3 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.

4.3.1 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 75 mph. The test runs were divided into three speed groups - low, medium and high speeds, as shown in Table 4-12.

Table 4-12 – Post-Validation Results by Speed – 24-Jan-13

Parameter	95% Confidence Limit of Error	Low	Medium	High
		53.0 to 59.7 mph	59.8 to 66.4 mph	66.5 to 73.0 mph
Steering Axles	±20 percent	-3.0 ± 9.3%	-1.1 ± 8.4%	-0.5 ± 10.4%
Tandem Axles	±15 percent	-0.6 ± 7.6%	-1.0 ± 9.0%	1.1 ± 8.7%
GVW	±10 percent	-1.0 ± 6.7%	-0.9 ± 7.9%	0.8 ± 7.8%
Vehicle Length	±3.0 percent (1.9 ft)	0.2 ± 1.0 ft	0.1 ± 1.0 ft	0.2 ± 1.2 ft
Vehicle Speed	± 1.0 mph	0.7 ± 2.1 mph	0.8 ± 1.9 mph	0.3 ± 2.0 mph
Axle Length	± 0.5 ft [150mm]	-0.3 ± 0.2 ft	-0.3 ± 0.2 ft	-0.3 ± 0.2 ft

From the table, it can be seen that the WIM equipment estimates all weights with similar precision at all speeds. There relationship between weight estimates and speed at this site seems to be insignificant.

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.

4.3.1.1 GVW Errors by Speed

As shown in Figure 4-12, the equipment estimated GVW with similar accuracy at all speeds. The range in error is greater at the medium speeds when compared with low and high speed error ranges.

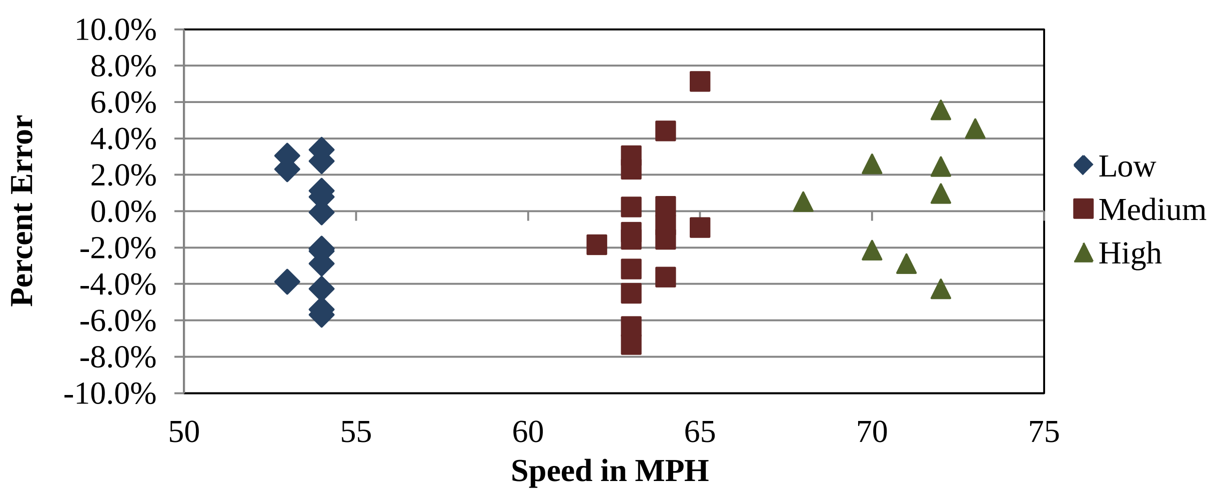


Figure 4-12 – Post-Validation GVW Errors by Speed – 24-Jan-13

4.3.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 4-13, 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.

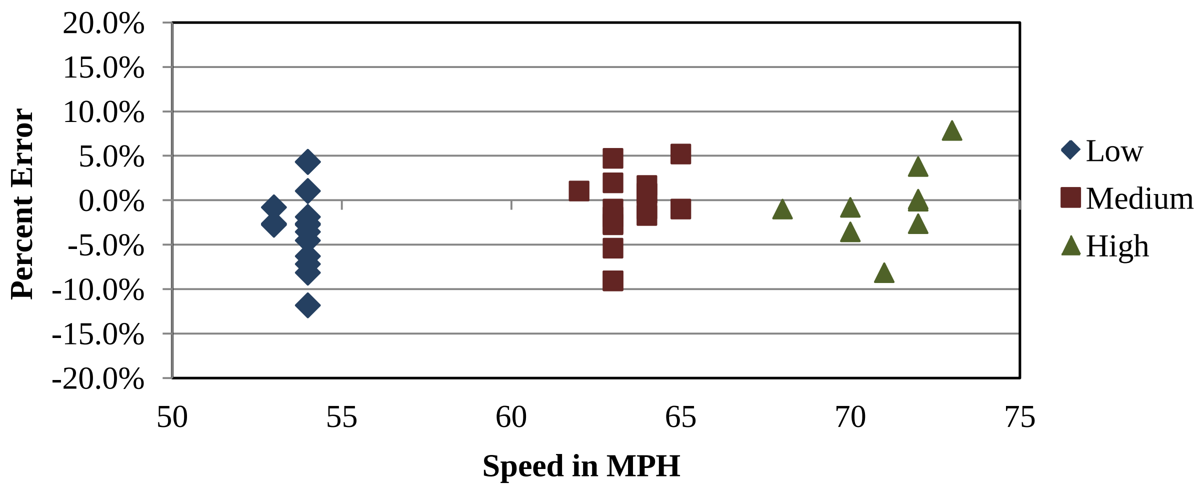


Figure 4-13 – Post-Validation Steering Axle Weight Errors by Speed – 24-Jan-13

4.3.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 4-14, the equipment estimated tandem axle weights with similar accuracy at all speeds. The range in error is greater at the medium speeds when compared with the error ranges at the low and high speeds.

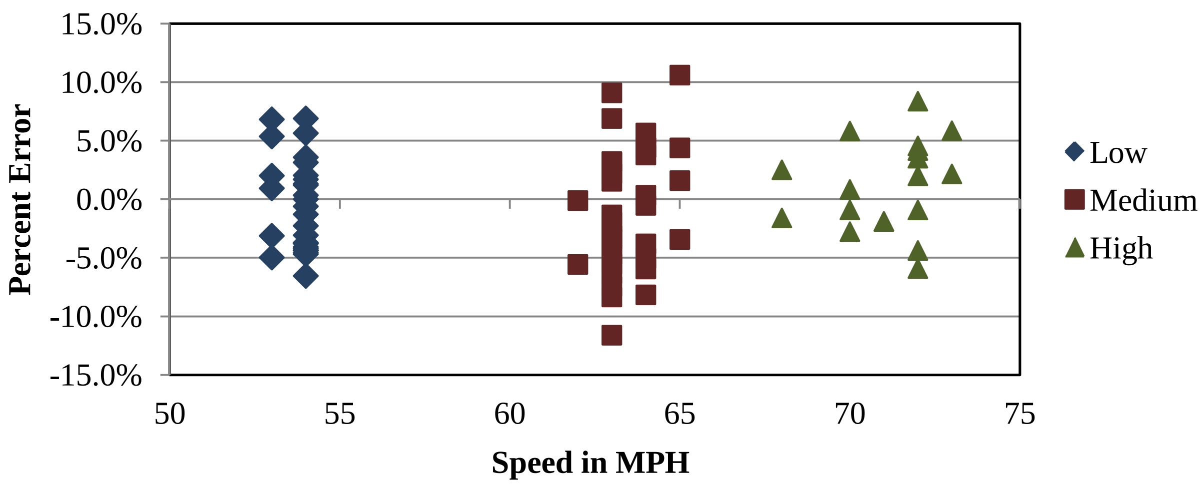


Figure 4-14 – Post-Validation Tandem Axle Weight Errors by Speed – 24-Jan-13

4.3.1.4 GVW Errors by Speed and Truck Type

It can be seen in Figure 4-15 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.

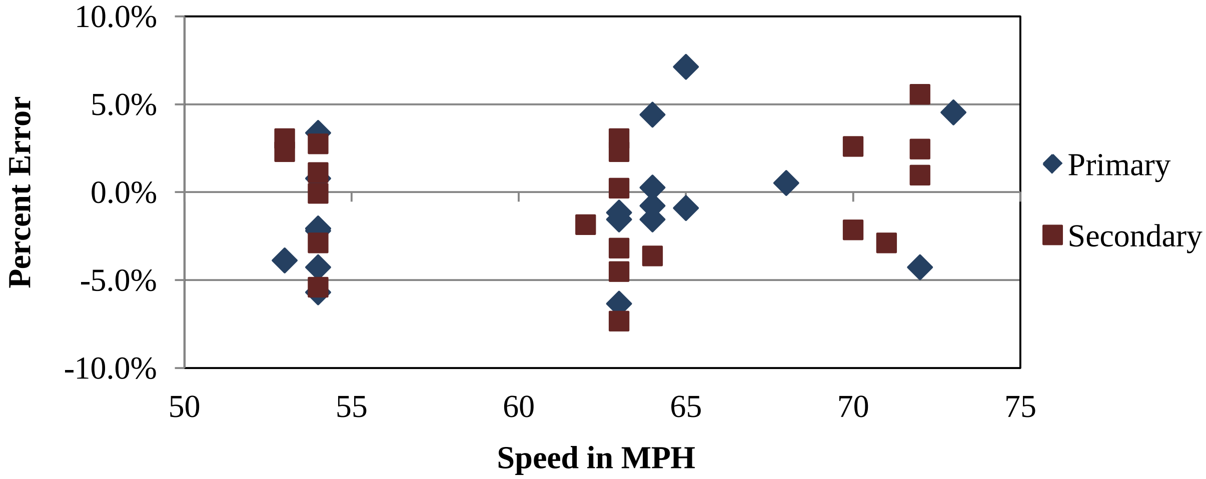


Figure 4-15 – Post-Validation GVW Error by Truck and Speed – 24-Jan-13

4.3.1.5 Axle Length Errors by Speed

For this site, the error in axle length measurement was consistent at all speeds. The range in axle length measurement error was from 0.0 to -0.4 feet. Distribution of errors is shown graphically in Figure 4-16.

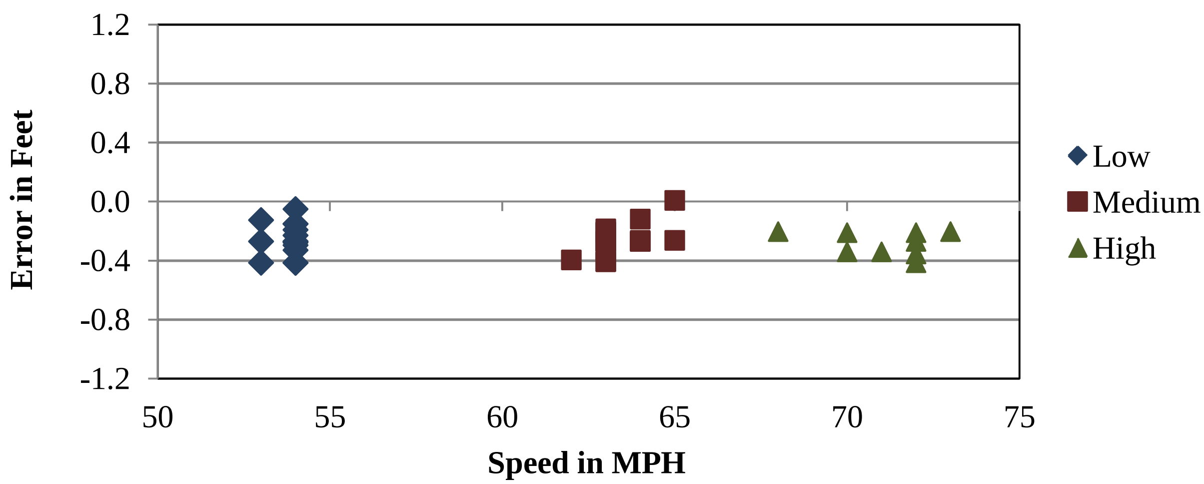


Figure 4-16 – Post-Validation Axle Length Error by Speed – 24-Jan-13

4.3.1.6 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 4-17.

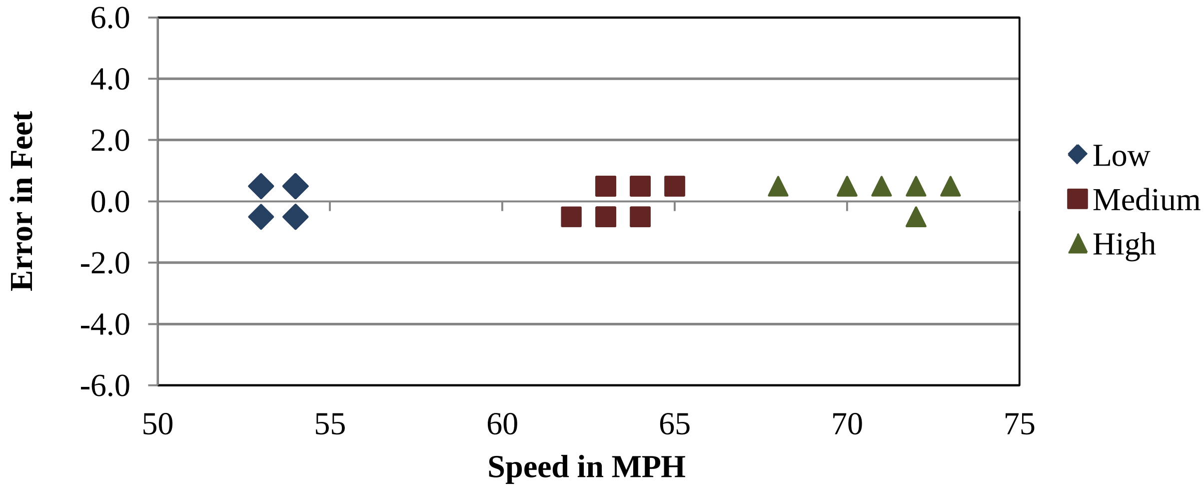


Figure 4-17 – Post-Validation Overall Length Error by Speed – 24-Jan-13

4.3.2 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 9.8 degrees, from 55.8 to 65.6 degrees Fahrenheit. The post-validation test runs are grouped and reported under one temperature group – medium, as shown in Table 4-13 below.

Table 4-13 – Post-Validation Results by Temperature – 24-Jan-13

Parameter	95% Confidence Limit of Error	Medium 55.8 to 65.6 degF
Steering Axles	±20 percent	-1.7 ± 8.6%
Tandem Axles	±15 percent	-0.4 ± 8.1%
GVW	±10 percent	-0.6 ± 6.9%
Vehicle Length	±3.0 percent (1.9 ft)	0.2 ± 1.0 ft
Vehicle Speed	± 1.0 mph	0.6 ± 1.8 mph
Axle Length	± 0.5 ft [150mm]	-0.3 ± 0.2 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.

4.3.2.1 GVW Errors by Temperature

From Figure 4-18, 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 correlation between temperature and weight estimates at this site.

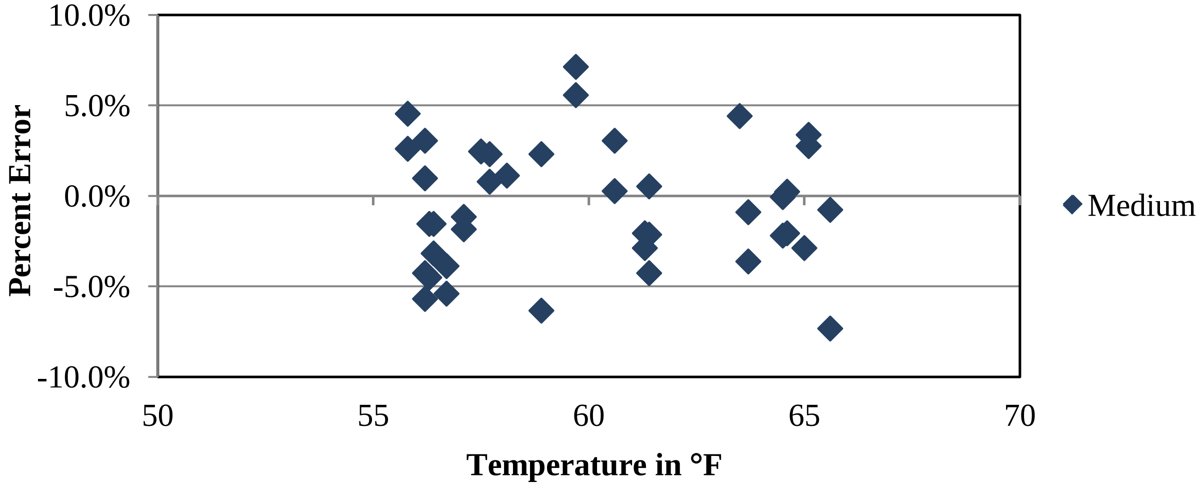


Figure 4-18 – Post-Validation GVW Errors by Temperature – 24-Jan-13

4.3.2.2 Steering Axle Weight Errors by Temperature

Figure 4-19 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.

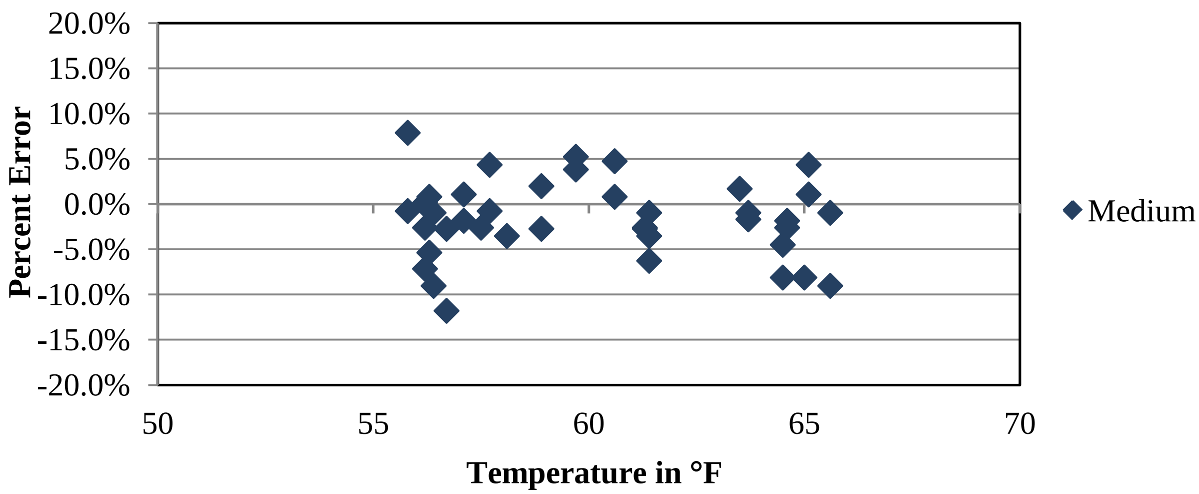


Figure 4-19 – Post-Validation Steering Axle Weight Errors by Temperature – 24-Jan-13

4.3.2.3 Tandem Axle Weight Errors by Temperature

As shown in Figure 4-20, 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.

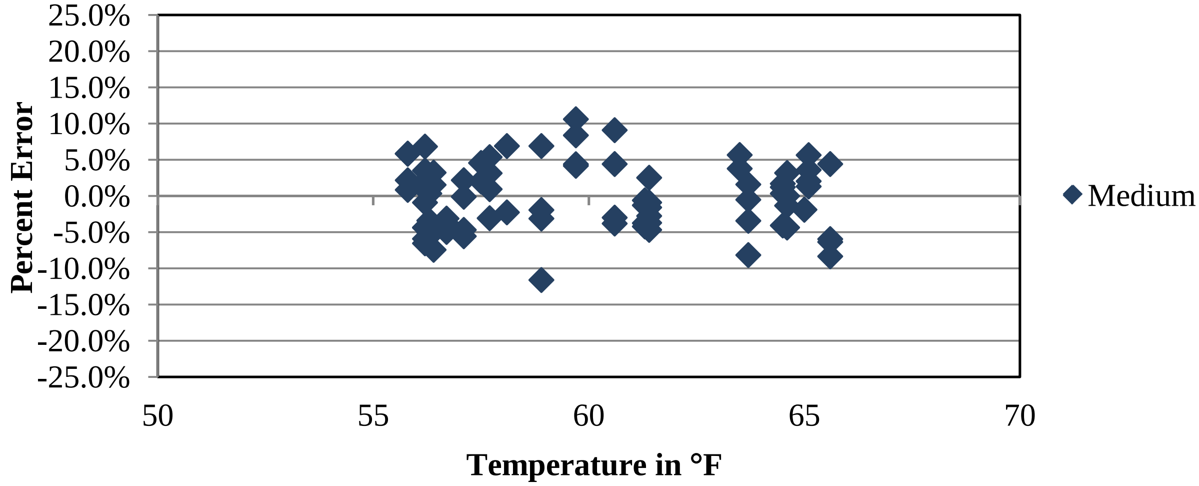


Figure 4-20 – Post-Validation Tandem Axle Weight Errors by Temperature – 24-Jan-13

4.3.2.4 GVW Errors by Temperature and Truck Type

As shown in Figure 4-21, 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.

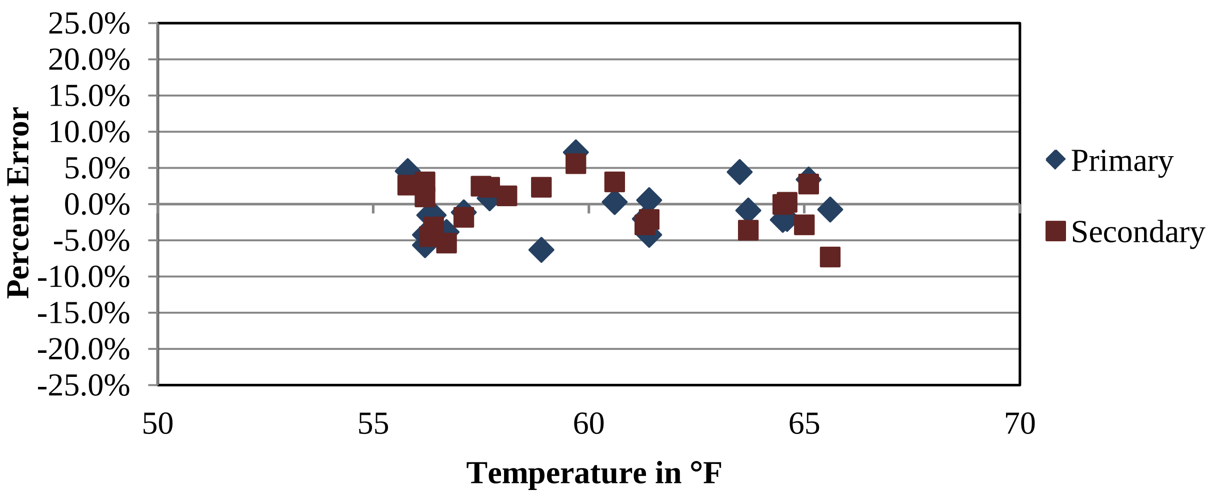


Figure 4-21 – Post-Validation GVW Error by Truck and Temperature – 24-Jan-13

4.3.3 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 117 vehicles including 117 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 4-14. The table illustrates the breakdown of vehicles observed and identified by the equipment for the manual classification study. As shown in Table 4-14, four Class 5 vehicles were misclassified as Class 8 vehicles.

Table 4-14 – Post-Validation Misclassifications by Pair – 24-Jan-13

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

As shown in the table, a total of 4 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 (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 3.4 percent, due to misclassification of Class 5 vehicles as Class 8 vehicles.

The combined results of the misclassifications resulted in an undercount of four Class 5 vehicles and an overcount of four Class 8 vehicles, as shown in Table 4-15. The misclassified percentage represents the percentage of the misclassified vehicles in the manual sample.

Table 4-15 – Post-Validation Classification Study Results – 24-Jan-13

Class	3	4	5	6	7	8	9	10	11	12	13
Observed Count	0	1	13	2	0	7	86	1	3	3	1
WIM Count	0	1	9	2	0	11	86	1	3	3	1
Observed Percent	0.0	0.9	11.1	1.7	0.0	6.0	73.5	0.9	2.6	2.6	0.9
WIM Percent	0.0	0.9	7.7	1.7	0.0	9.4	73.5	0.9	2.6	2.6	0.9
Misclassified Count	0	0	4	0	0	0	0	0	0	0	0
Misclassified Percent	0.0	0.0	30.8	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 117 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 0.7 mph; the range of errors was 1.4 mph.

4.3.4 Final WIM System Compensation Factors

The final factors left in place at the conclusion of the validation are provided in Table 4-16.

Table 4-16 – Final Factors

Speed Point	MPH	Left	Right
		2	1
88	55	4300	3872
96	60	4463	4018
104	65	4789	4313
112	70	4783	4308
120	75	5441	4814
Axle Distance (cm)		374	
Dynamic Comp (%)		100	
Loop Width (cm)		121	

5 Post-Visit Data Analysis

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

5.1 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.

5.1.1 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 53 to 73 mph.
- Pavement temperature. Pavement temperature ranged from 55.8 to 65.6 degrees Fahrenheit.

5.1.2 Results

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

Table 5-1 – Table of Regression Coefficients for Measurement Error of GVW

Parameter	Regression coefficients	Standard error	Value of t-distribution	Probability value (p-value)
Intercept	-8.8327	11.9743	-0.7376	0.4655
Speed	0.1041	0.0848	1.2277	0.2275
Temp	0.0290	0.1659	0.1747	0.8623
Truck	0.2667	1.1249	0.2371	0.8139

The lowest probability value given in Table 5-1 was 0.2275 for speed. This means that there is about 22 percent chance that the value of regression coefficient for speed (0.1041) can occur by chance alone. Overall, speed has the most significant effect on the GVW measurement errors.

The relationship between speed and GVW measurement errors is shown in Figure 5-1. The figure includes a trend line for the predicted percent error. Besides the visual assessment of the relationship, Figure 5-1 provides quantification and statistical assessment of the relationship.

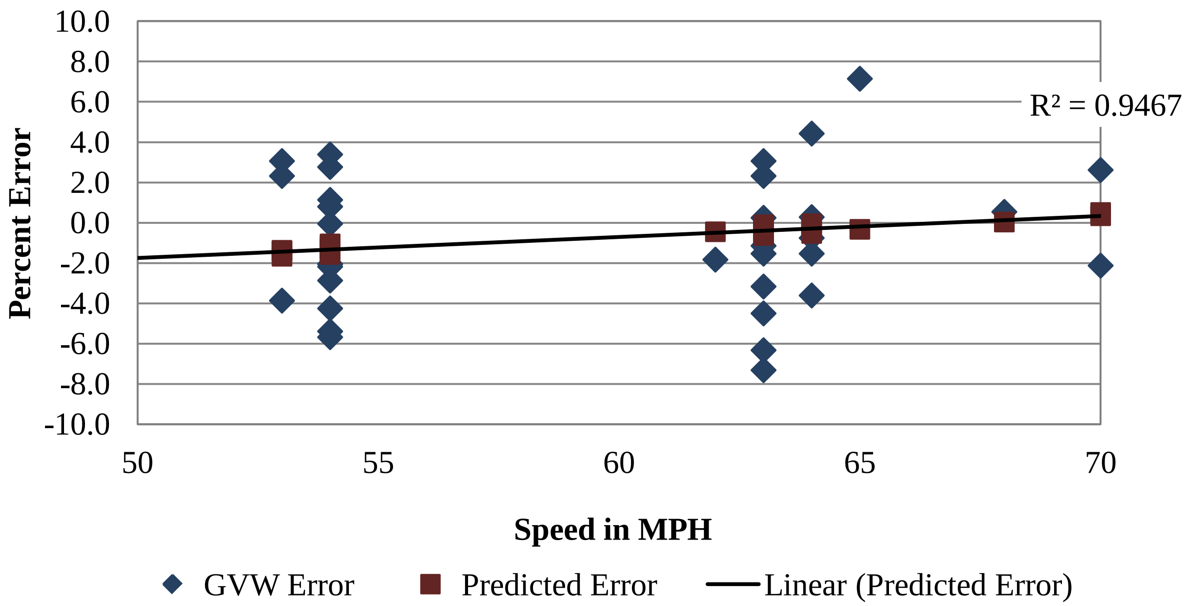


Figure 5-1 – Influence of Speed on the Measurement Error of GVW

The quantification of the relationship is provided by the value of the regression coefficient, in this case 0.1041 (in Table 5-1). This means, for example, that for a 10 mph increase in speed, the error is increased by about 1 percent (0.1041 x 10). The statistical assessment of the relationship is provided by the probability value of the regression coefficient (0.2275) and is not statistically significant (the probability that the relationship can occur by chance alone was greater than 20 percent).

5.1.3 Summary Results

Table 5-2 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 5-2 indicates that the relationship was not statistically significant (the probability that the relationship can occur by chance alone was greater than 20 percent).

Table 5-2 – 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	-	-	-	-	-	-
Steering axle	0.1901	0.0597	-	-	-2.7096	0.0438
Tandem axle tractor	-	-	-	-	-	-
Tandem axle trailer	-	-	-	-	-	-

5.1.4 Conclusions

1. Speed had statistically significant effect on the weight measurement errors of steering axles only. However, the value of the regression coefficient is very low indicating no practical significance.

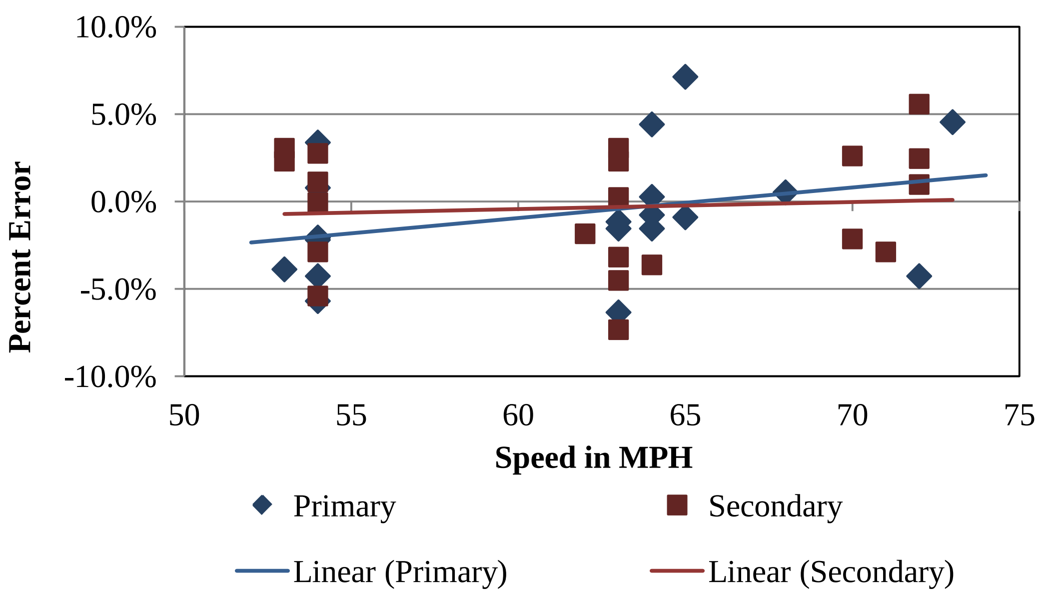
2. Temperature did not have statistically significant effect on the weight measurement errors. The range pavement temperatures during the post-validation testing was only 9.8 ºF. However, during pre-validation testing the range of pavement temperatures was 32.2 ºF and the effect of pavement temperatures was also statistically insignificant (Figure 4-7).

3. Truck type had statistically significant effect on the measurement error of the steering axles only. The regression coefficient for truck type in Table 5-2 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.). Thus, the mean measurement error of the steering axle weights for the Primary truck was about 2.7 % lower than the corresponding error for the Secondary truck.

4. The GVW measurement errors for the two test trucks are compared in Figure 5-2. The measurement errors for the two test trucks were similar; there was no statistically significant difference between the average errors and error variations for the two truck types. The average GVW error for the Primary truck was -0.8%, and for the Secondary truck -0.3%. The corresponding values for standard deviations of the GVW measurement errors for the two test trucks were 3.6% and 3.4%. Consequently, very similar calibration results would have been obtained by using either one of the two test trucks alone.

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



5.2 Misclassification Analysis

The misclassifications involving heavy trucks as recorded during the Classification Study are provided in Table 5-3.

Table 5-3 – Sheet 20 Misclassifications

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	Time
60	8	18903	59	5	14:52
60	8	19014	59	5	15:05
70	8	19085	69	5	15:13
63	8	19164	61	5	15:23

A post-visit analysis was conducted on the truck misclassifications identified during the post-validation conducted in the field. For this site, there were four misclassifications of Class 5 vehicles as Class 8 vehicles. The capture of the real-time record for each of these vehicles is provided in Figure 5-3.

(18903) Lane: #1 Class: 8 Speed: 61 mph Thu Jan 24 14:52:29.74 2013
Length: 55.4 ft 18-K ESAL: 1.0883 GVW: 32.8 kips Max GVW: 72.5 kips
Front Bumper to First Axle: 6.1 ft Last Axle to Rear Bumper: 2.8 ft

Axle	Spacing (ft)	Left Wt (kips)	Right Wt (kips)	Total Wt (kips)	Allowable w (kips)
1		4.9	5.2	10.1	20.0
2	19.7	8.1	10.2	18.3	20.0
3	18.2	1.2	1.4	2.6	20.0
4	8.7	0.7	1.2	1.8	20.0

(19014) Lane: #1 Class: 8 Speed: 60 mph Thu Jan 24 15:05:29.72 2013
Length: 52.1 ft 18-K ESAL: 0.5069 GVW: 25.3 kips Max GVW: 71.5 kips
Front Bumper to First Axle: 3.7 ft Last Axle to Rear Bumper: 3.3 ft

Axle	Spacing (ft)	Left Wt (kips)	Right Wt (kips)	Total Wt (kips)	Allowable w (kips)
1		3.9	3.5	7.4	20.0
2	18.7	6.9	7.6	14.5	20.0
3	18.0	1.1	1.0	2.1	20.0
4	8.3	0.7	0.6	1.3	20.0

(19085) Lane: #1 Class: 8 Speed: 71 mph Thu Jan 24 15:13:13.34 2013
Length: 57.3 ft 18-K ESAL: 0.7041 GVW: 32.7 kips Max GVW: 73.5 kips
Front Bumper to First Axle: 6.2 ft Last Axle to Rear Bumper: 3.7 ft

Axle	Spacing (ft)	Left Wt (kips)	Right Wt (kips)	Total Wt (kips)	Allowable w (kips)
1		5.5	4.7	10.2	20.0
2	20.5	6.9	8.8	15.7	20.0
3	17.6	1.6	1.9	3.5	20.0
4	9.4	1.6	1.7	3.3	20.0

(19164) Lane: #1 Class: 8 Speed: 63 mph Thu Jan 24 15:23:29.53 2013
Length: 62.7 ft 18-K ESAL: 0.9457 GVW: 34.4 kips Max GVW: 76.0 kips
Front Bumper to First Axle: 7.9 ft Last Axle to Rear Bumper: 3.6 ft

Axle	Spacing (ft)	Left Wt (kips)	Right Wt (kips)	Total Wt (kips)	Allowable w (kips)
1		6.2	4.7	11.0	20.0
2	21.1	7.8	9.1	16.9	20.0
3	19.1	1.9	1.5	3.4	20.0
4	11.1	1.6	1.6	3.2	20.0

Figure 5-2 – Vehicle Records Capture Text

In looking at the axle spacings in Figure 5-3, it is apparent that each of these vehicles was a Class 5 pulling a Class 2, typically an RV or rental moving truck (U-Haul) pulling a car.

5.3 Traffic Data Analysis

5.3.1 Imbalance

Due to the circumstances created by the WIM sensor channel assignments, the results of the pre-visit data analysis for determining the presence of imbalanced weights could not be used for the validation. Additionally, left-to-right imbalance percentage cannot be developed from test trucks runs due to the limited sample. Consequently, free flow truck traffic must be used.

A post-visit data analysis was conducted using the data immediately following the date of the validation. The results of the post-visit imbalance analysis are presented in Table 5-4.

Table 5-4 – Front Axle Weight Imbalance

Data Set	**Date**	**Left**	**Right**	**Imbalance**	**PCT**
Pre-Visit Sample	November 31, 2012	5.83	5.19	Left	11.0%
Post-Visit Sample	February 5, 2013	5.58	5.73	Right	2.6%

As shown in the table, the right weights are 2.6 percent greater than the left side weights. An adjustment of the compensation factors to correct this is not recommended.

5.3.2 WIM System Factor Adjustments

Since the average GVW and steering axle weights provided during the Post-Visit data analysis are reasonably similar to those provided by the Comparison Data Set, and the front axle does not demonstrate a significant imbalance, no adjustments to the WIM system factors are recommended.

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 Classification

The information in Table 6-1 data was extracted from the most recent previous validation and was updated to include the results of this validation.

Table 6-1 – Classification Validation History

Date	Misclassification Percentage by Class											Pct Unclass
	3	4	5	6	7	8	9	10	11	12	13	
30-Apr-07	-	-	0	-	-	0	0	0	0	0	-	0
1-May-07	-	-	0	0	-	0	0	0	0	0	-	0
11-Feb-08	-	100	27	0	-	27	0	-	0	-	-	0
12-Feb-08	-	100	43	0	-	20	0	0	0	-	-	0
13-Sep-10	-	100	27	0	-	0	0	-	0	0	-	0
14-Sep-10	-	-	9	50	-	0	1	100	0	0	-	0
23-Jan-13	0	0	69	20	0	0	0	0	0	0	0	0
24-Jan-13	0	0	31	0	0	0	0	0	0	0	0	0

6.2 Weight

Table 6-2 data was extracted from the previous validation and was updated to include the results of this validation. The table provides the mean error and 95% confidence level for GVW, steering and single axles and tandems for prior pre- and post-validations.

Table 6-2 – Weight Validation History

Date	Mean Error and 2SD		
	GVW	Single Axles	Tandem
30-Apr-07	1.5 ± 6.1	1.4 ± 8.7	1.6 ± 8.1
1-May-07	-0.2 ± 7.3	1.1 ± 9.9	-0.3 ± 10.9
11-Feb-08	2.2 ± 6.5	5.0 ± 6.3	1.7 ± 8.1
12-Feb-08	2.4 ± 5.9	3.8 ± 5.9	2.2 ± 8.3
13-Sep-10	-5.2 ± 5.3	-3.2 ± 6.2	-5.7 ± 6.7
14-Sep-10	-0.6 ± 6.5	-0.5 ± 7.5	-0.6 ± 8.1
23-Jan-13	6.5 ± 16.2	5.0 ± 15.7	4.3 ± 17.3
24-Jan-13	-0.6 ± 6.9	-1.7 ± 8.6	0.8 ± 8.1

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

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 – Site Photograph Logs
- Updated Handout Guide

WIM System Field Calibration and Validation - Photos

Arizona, SPS-2
SHRP ID: 040200

Validation Date: January 23, 2013

Photo 1 – Cabinet Exterior

Photo 4 – Leading Loop

Photo 2 – Cabinet Interior (Front)

Photo 5 – Leading WIM Sensor

Photo 3 – Cabinet Interior (Back)

Photo 6 – Trailing WIM Sensor

Photo 7 – Trailing Loop Sensor

Photo 8 – Solar Panel

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 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 04 SPS WIM ID: 040200 DATE (mm/dd/yyyy) 1/23/2013

SITE CALIBRATION INFORMATION

1. DATE OF CALIBRATION {mm/dd/yy} 1/23/13

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	steel spring	air
Truck 2:	9	steel spring	air
Truck 3:			

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

Mean Difference Between -

Dynamic and Static GVW:	6.5%	Standard Deviation:	8.0%
Dynamic and Static Single Axle:	5.0%	Standard Deviation:	7.8%
Dynamic and Static Double Axles:	4.3%	Standard Deviation:	8.6%

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

9. DEFINE SPEED RANGES IN MPH:

			Low		High	Runs
a.	Low	-	52.0	to	59.0	12
b.	Medium	-	59.1	to	66.1	14
c.	High	-	66.2	to	73.0	14
d.		-		to		
e.		-		to		

Traffic Sheet 16	STATE CODE:	04
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	040200
SITE CALIBRATION SUMMARY	DATE (mm/dd/yyyy)	1/23/2013

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 4795 | 4318

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:	2.0	FHWA Class	5	-	-69.0
FHWA Class 8:	800.0	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: 04 SPS WIM ID: 040200 DATE (mm/dd/yyyy) 1/24/2013

SITE CALIBRATION INFORMATION

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

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: 21

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

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

Mean Difference Between -

Dynamic and Static GVW:	-0.6%	Standard Deviation:	3.4%
Dynamic and Static Single Axle:	-1.7%	Standard Deviation:	4.3%
Dynamic and Static Double Axles:	0.9%	Standard Deviation:	4.0%

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

9. DEFINE SPEED RANGES IN MPH:

			Low		High	Runs
a.	Low	-	53.0	to	59.7	15
b.	Medium	-	59.8	to	66.4	17
c.	High	-	66.5	to	73.0	9
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: SPS WIM ID: DATE (mm/dd/yyyy)	04 040200 1/24/2013

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 4783 | 4308

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: ____________

13. METHOD TO DETERMINE LENGTH OF COUNT: ____________

14. MEAN DIFFERENCE IN VOLUMES BY VEHICLES CLASSIFICATION:

FHWA Class 9:	0.0	FHWA Class	5	-	-31.0
FHWA Class 8:	57.0	FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 0.0%

Validation Test Truck Run Set - Post

Person Leading Calibration Effort: **Dean 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: 04 SPS WIM ID: 040200 DATE (mm/dd/yyyy) 1/23/2013

Count - 119 Time = 1:01:20 Trucks (4-15) - 119 Class 3s - 0

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
67	9	11133	67	9	67	9	11313	67	9
58	9	11166	59	9	64	9	11314	64	9
60	**8**	**11168**	**60**	**5**	55	9	11326	54	9
57	9	11177	56	9	70	9	11340	72	9
64	9	11184	65	9	64	9	11344	65	9
64	9	11196	64	9	67	9	11345	67	9
62	9	11202	61	9	68	9	11346	68	9
63	9	11205	59	9	64	9	11349	64	9
63	11	11208	61	11	73	9	11350	71	9
65	9	11210	66	9	69	9	11352	68	9
70	8	11220	69	8	70	9	11364	68	9
68	12	11221	69	12	57	9	11366	56	9
63	9	11229	64	9	62	6	11367	61	6
59	**8**	**11232**	**58**	**5**	63	9	11368	63	9
63	9	11237	62	9	62	9	11375	55	9
59	9	11238	59	9	64	9	11376	64	9
64	9	11240	63	9	68	9	11382	68	9
59	**8**	**11243**	**58**	**5**	67	6	11383	66	6
64	9	11247	63	9	74	12	11391	72	12
62	9	11256	62	9	67	9	11392	65	9
64	9	11260	62	9	59	9	11394	59	9
61	13	11265	60	13	64	9	11407	63	9
68	9	11275	66	9	65	9	11411	65	9
61	9	11279	63	9	64	12	11412	64	12
68	9	11285	68	9	57	9	11416	56	9

Sheet 1 - 0 to 50 Start: 15:10:26 Stop: 15:41:17

Recorded By: gh Verified By: djw

Validation Test Truck Run Set - Pre

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 04 SPS WIM ID: 040200 DATE (mm/dd/yyyy) 1/23/2013

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
62	5	11423	63	5	62	9	11518	65	9
67	9	11429	66	9	57	6	11529	56	6
64	9	11431	64	9	66	9	11530	65	9
60	9	11432	60	9	63	9	11531	62	9
60	9	11433	59	9	67	9	11536	66	9
61	**8**	**11436**	**61**	**5**	66	9	11547	63	9
64	9	11442	63	9	68	9	11555	68	9
64	9	11444	61	9	**55**	**8**	**11559**	**51**	**5**
69	9	11448	65	9	72	12	11566	73	12
70	9	11449	66	9	62	11	11570	63	11
72	9	11450	71	9	64	9	11572	64	9
61	5	11455	58	5	63	9	11578	62	9
60	**8**	**11456**	**56**	**5**	65	9	11585	65	9
66	9	11457	61	9	**68**	**9**	**11589**	**68**	**6**
64	9	11463	62	9	67	9	11594	67	9
59	6	11464	57	6	65	9	11598	64	9
65	9	11465	63	9	58	9	11600	57	9
63	11	11471	59	11	59	9	11602	58	9
60	11	11474	55	11	63	9	11603	62	9
64	9	11481	64	9	71	9	11609	69	9
71	9	11490	68	9	64	9	11614	65	9
62	9	11491	58	9	68	9	11624	69	9
66	9	11507	66	9	62	9	11631	61	9
68	9	11511	67	9	73	9	11636	75	9
59	**8**	**11517**	**57**	**5**	68	9	11640	68	9

Sheet 2 - 51 to 100 Start: 15:41:50 Stop: 16:02:29

Recorded By: gh Verified By: djw

Validation Test Truck Run Set - Pre

Traffic Sheet 20 **LTPP MONITORED TRAFFIC DATA** **SPEED AND CLASSIFICATION STUDIES**	STATE CODE: 04 SPS WIM ID: 040200 DATE (mm/dd/yyyy) 1/23/2013

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
69	9	11642	68	9					
66	9	11644	65	9					
64	11	11645	62	11					
65	9	11653	65	9					
60	**8**	**11657**	**61**	**5**					
68	5	11661	67	5					
68	9	11663	67	9					
67	9	11665	65	9					
68	9	11672	67	9					
63	9	11673	62	9					
65	9	11676	65	9					
63	9	11679	63	9					
70	9	11680	69	9					
67	9	11684	68	9					
59	9	11688	59	9					
59	5	11689	54	5					
73	**9**	**11700**	**71**	**5**					
63	9	11703	62	9					
67	9	11713	64	9					

Sheet 3 - 101 - 150 Start: 16:02:42 Stop: 16:11:46

Recorded By: gh Verified By: djw

Validation Test Truck Run Set - Pre

Traffic Sheet 20 **LTPP MONITORED TRAFFIC DATA** **SPEED AND CLASSIFICATION STUDIES**	STATE CODE: 04 SPS WIM ID: 040200 DATE (mm/dd/yyyy) 1/24/2013

Count - 117 Time = 1:00:40 Trucks (4-15) - 117 Class 3s - 0

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
64	9	18859	62	9	64	9	18967	63	9
69	9	18867	72	9	73	5	18972	72	5
63	11	18878	61	11	70	9	18977	70	9
64	12	18880	63	12	63	9	18978	62	9
64	10	18884	63	10	62	9	18979	62	9
64	9	18898	63	9	62	8	18980	61	8
64	9	18898	68	9	64	9	18983	63	9
65	9	18902	64	9	64	5	18989	61	5
60	**8**	**18903**	**59**	**5**	61	9	18990	60	9
68	9	18906	67	9	65	8	18995	65	8
70	9	18911	70	9	68	9	19000	71	9
65	9	18916	65	9	68	9	19003	69	9
63	6	18918	63	6	69	9	19005	69	9
67	9	18921	68	9	63	11	19007	62	11
67	9	18923	66	9	62	9	19011	61	9
67	9	18924	67	9	59	9	19012	58	9
67	9	18937	67	9	**60**	**8**	**19014**	**59**	**5**
67	9	18938	66	9	61	9	19016	61	9
62	9	18940	61	9	59	5	19019	57	5
64	9	18941	63	9	63	9	19025	63	9
60	9	18948	59	9	70	9	19030	67	9
68	9	18956	70	9	66	9	19032	65	9
65	9	18960	65	9	64	9	19034	65	9
62	9	18962	60	9	61	9	19036	60	9
62	13	18964	62	13	73	9	19038	75	9

Sheet 1 - 0 to 50 Start: 14:47:02 Stop: 15:08:31

Recorded By: gah Verified By: djw

Validation Test Truck Run Set - Post

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 04 SPS WIM ID: 040200 DATE (mm/dd/yyyy) 1/24/2013

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
55	5	19041	56	5	75	9	19167	75	9
71	9	19063	70	9	63	9	19171	64	9
68	9	19065	67	9	65	8	19175	63	8
67	5	19073	69	5	65	9	19182	64	9
64	9	19083	63	9	64	9	19183	64	9
70	**8**	**19085**	**69**	**5**	66	9	19209	66	9
62	8	19090	62	8	64	9	19210	63	9
67	9	19094	65	9	56	12	19218	54	12
67	8	19095	66	8	64	9	19227	63	9
65	9	19099	63	9	60	11	19229	58	11
69	9	19106	69	9	52	9	19237	52	9
73	9	19107	71	9	64	8	19239	64	8
62	9	19120	61	9	61	9	19250	60	9
63	9	19121	63	9	67	9	19259	66	9
69	9	19131	68	9	64	9	19261	63	9
62	5	19132	61	5	67	12	19268	68	12
63	5	19137	61	5	62	9	19270	61	9
67	9	19139	66	9	67	9	19275	67	9
61	9	19143	61	9	60	9	19279	59	9
69	4	19144	66	4	68	9	19286	68	9
70	9	19150	69	9	70	6	19292	68	6
59	9	19151	58	9	59	9	19293	55	9
67	9	19154	66	9	64	9	19298	63	9
63	5	19159	62	5	64	9	19299	63	9
63	**8**	**19164**	**61**	**5**	59	9	19303	57	9

Sheet 2 - 51 to 100 Start: 15:08:42 Stop: 15:38:13

Recorded By: gah Verified By: djw

Validation Test Truck Run Set - Post

Traffic Sheet 20	STATE CODE:	04
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	040200
SPEED AND CLASSIFICATION STUDIES	DATE (mm/dd/yyyy)	1/24/2013

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
64	8	19314	61	8					
71	9	19326	70	9					
65	9	19328	65	9					
65	9	19329	68	9					
60	9	19337	58	9					
62	9	19343	60	9					
70	9	19347	69	9					
67	9	19351	67	9					
70	9	19356	66	9					
64	9	19363	65	9					
64	9	19373	64	9					
63	9	19377	62	9					
64	9	19380	63	9					
65	9	19382	64	9					
65	9	19386	66	9					
61	9	19389	60	9					
67	5	19406	62	5					

Sheet 3 - 101 - 150 Start: 15:39:10 Stop: 15:47:42

Recorded By: gah Verified By: djw

Validation Test Truck Run Set - Post