WIM System Field Calibration and Validation Summary Report

California SPS-2
SHRP ID – 060200

Validation Date: August 18, 2010
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1 Executive Summary

A WIM validation was performed on August 17 and 18, 2010 at the California SPS-2 site located on route SR-99 at milepost 32.5, .6 miles north of Collier Road exit.

This site was installed on November 30, 2007. The in-road sensors are installed in the northbound lane. The site is equipped with bending plate WIM sensors and 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 March 26, 2008 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 all WIM components determined that the equipment was operating within tolerances. Damage to the solar panel was noted during the physical inspection of the equipment. Further equipment discussion is provided in Section 3.

During the on-site pavement evaluation, no distresses that would affect the performance of the WIM scales were noted. Observations of trucks passing over the site did not detect any motions by the trucks that would affect WIM system accuracies. 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 – 18-Aug-10

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-1.1 ± 4.3%	Pass
Single Axles	±20 percent	-1.1 ± 4.3%	Pass
Tandem Axles	±15 percent	0.2 ± 3.7%	Pass
GVW	±10 percent	-0.1 ± 2.5%	Pass
Vehicle Length	±3 percent (1.9 ft)	2.1 ± 0.7 ft	FAIL
Axle Spacing Length	± 0.5 ft [150mm]	0.1 ± 0.5 ft	FAIL

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 ± 1.6 mph, which is greater than the ±1.0 mph tolerance for variance 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 0.1 feet, and the spacing and speed 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 2.5% from the 120 truck sample (Class 4 – 13) was due to the three 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. The Primary truck was loaded with scrap metal loaded on pallets, in bales, and in bins loaded on the trailer.

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

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. 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	79.8	12.2	17.4	16.8	16.6	16.7	15.6	4.4	31.9	4.1	56.0	61.0
2	66.2	11.8	14.5	14.3	12.8	12.8	19.9	4.4	30.0	4.1	58.4	66.0

The posted speed limit at the site is 55 mph. During the testing, the speed of the test trucks ranged from to 49 to 62 mph, a range of 13 mph.

During test truck runs, pavement temperature was collected using a hand-held infrared temperature device. The post-validation pavement surface temperatures varied from 84.2 to 113.9 degrees Fahrenheit, a range of 29.7 degrees Fahrenheit. The sunny weather conditions nearly provided for a greater than 30 degree range in temperatures.

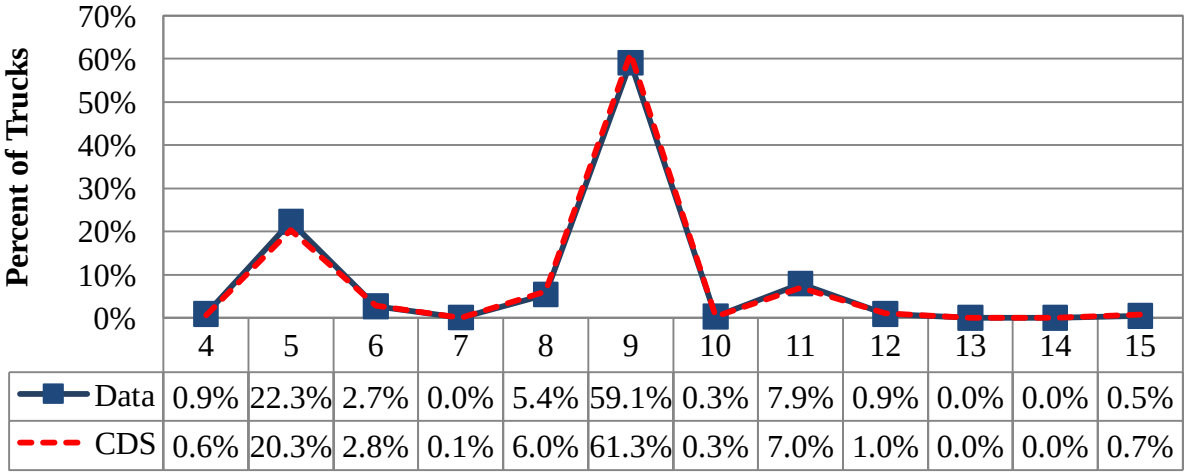
A review of the LTPP Standard Release Database 24 shows that there are 19 consecutive months of level "E" WIM data for this site. This site requires at least 3 additional years of data to meet the minimum of five years of research quality data.

2 Pre-Visit Data Analysis

To assess the quality of the current data, a pre-visit analysis was conducted by comparing a two-week data sample from June 14, 2010 (Data) to the most recent Comparison Data Set (CDS) from March 31, 2008. 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 Classification Data Analysis

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



	4	5	6	7	8	9	10	11	12	13	14	15
Data	0.9%	22.3%	2.7%	0.0%	5.4%	59.1%	0.3%	7.9%	0.9%	0.0%	0.0%	0.5%
CDS	0.6%	20.3%	2.8%	0.1%	6.0%	61.3%	0.3%	7.0%	1.0%	0.0%	0.0%	0.7%

Figure 2-1 – Comparison of Truck Distribution

Table 2-1 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 (59.1%) and Class 5 (22.3%). It also indicates that 0.5 percent of the vehicles at this site are unclassified. Table 2-1 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.

During the classification study, observations of Class 15 vehicles are made to determine if unclassified vehicles are valid, as in the case of oversized vehicles with irregular trailer axle spacings.

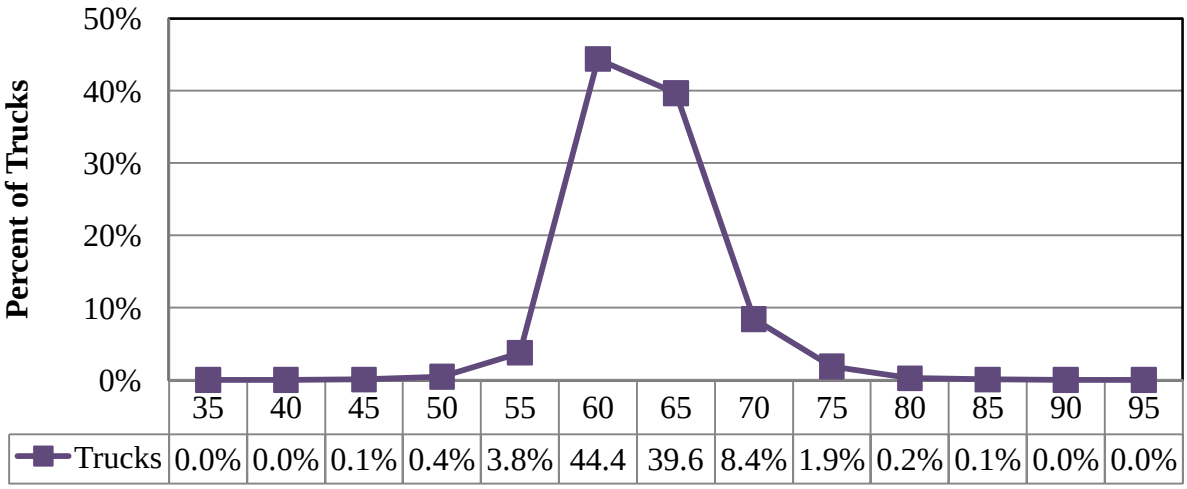
Table 2-1 – Truck Distribution from W-Card

Vehicle Classification	CDS		Data		Change
	Date				
	3/31/2008		6/14/2010		
4	414	0.6%	576	0.9%	0.3%
5	14285	20.3%	14049	22.3%	2.0%
6	1968	2.8%	1699	2.7%	-0.1%
7	37	0.1%	22	0.0%	0.0%
8	4246	6.0%	3408	5.4%	-0.6%
9	43204	61.3%	37328	59.1%	-2.1%
10	224	0.3%	188	0.3%	0.0%
11	4936	7.0%	4993	7.9%	0.9%
12	697	1.0%	553	0.9%	-0.1%
13	11	0.0%	14	0.0%	0.0%
14	0	0.0%	0	0.0%	0.0%
15	477	0.7%	294	0.5%	-0.2%

The table shows that the number of Class 5 vehicles has increased by 2.0 percent from March 2008 and June 2010. This increase may be attributed to small sample size used to develop vehicle class distributions, decreased use of the roadway for local deliveries, cross-classifications of type 3 and 5 vehicles, as well as natural variations in truck volumes. During the same time period, there was an increase of 2.1 percent in the number of Class 9 trucks. Small increases in the number of heavier trucks may be attributed to seasonal variations in truck distributions.

2.2 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 the speed of the test trucks during validation testing. The SDC distribution of truck speeds is presented in Figure 2.2.



	35	40	45	50	55	60	65	70	75	80	85	90	95
Trucks	0.0%	0.0%	0.1%	0.4%	3.8%	44.4	39.6	8.4%	1.9%	0.2%	0.1%	0.0%	0.0%

Figure 2-2 – Truck Speed Distribution from ASCII File

As shown in Figure 2-2, the majority of the trucks at this site are traveling between 55 and 65 mph. The posted speed limit at this site is 55 and the 85th percentile speed for trucks at this site is 64 mph. The coverage of truck speeds for the validation will be between 50 and 60 mph. Since the 85th percentile speeds for trucks is above the posted speed limit, the post-visit applied calibration will be used to develop compensation factors for speed points from 65 and 70 mph.

2.3 GVW Data Analysis

The 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 June 2010 and the Comparison Data Set from March 2008.

As shown in the figure, there is an increase in the unloaded peak and a decrease in the loaded peak between the March 2008 Comparison Data Set (CDS) and the June 2010 sample W-card dataset (Data). There is also a slight shift to the left of each peak. The results indicate possible drifting in WIM weight measurement accuracy.

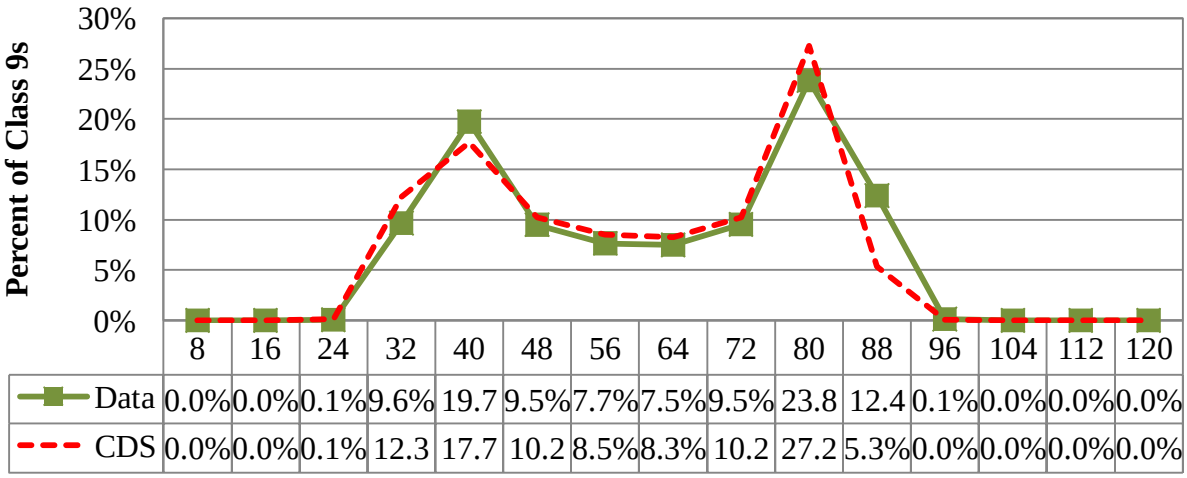


Figure 2-3 – Comparison of Class 9 GVW Distribution

Table 2-2 is provided to demonstrate the statistical comparison between the Comparison Data Set and the current dataset.

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

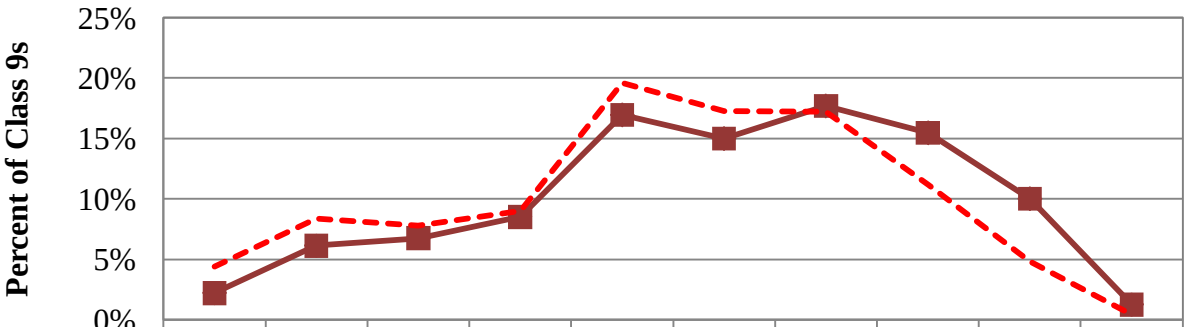
GVW weight bins (kips)	CDS		Data		Change
	Date				
	3/31/2008		6/14/2010		
8	0	0.0%	0	0.0%	0.0%
16	0	0.0%	0	0.0%	0.0%
24	50	0.1%	19	0.1%	-0.1%
32	5272	12.3%	3581	9.6%	-2.6%
40	7591	17.7%	7322	19.7%	2.0%
48	4395	10.2%	3525	9.5%	-0.7%
56	3668	8.5%	2841	7.7%	-0.9%
64	3551	8.3%	2789	7.5%	-0.8%
72	4395	10.2%	3543	9.5%	-0.7%
80	11698	27.2%	8848	23.8%	-3.4%
88	2293	5.3%	4602	12.4%	7.1%
96	21	0.0%	42	0.1%	0.1%
104	3	0.0%	3	0.0%	0.0%
112	3	0.0%	2	0.0%	0.0%
120	2	0.0%	2	0.0%	0.0%
Average =	55.5		57.1		1.5

As shown in the table, the number of unloaded class 9 trucks in the 32 to 40 kips range increased by 2.0 percent while the number of loaded class 9 trucks in the 72 to 80 kips range decreased by 3.4 percent. The number of overweight trucks increased during this time period by 7.2 percent and the overall GVW average for this site increased from 55.5 kips to 57.1 kips.

2.4 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 observed average front axle weight with the expected average front axle weight for Class 9 trucks of 10.3 kips.

Figure 2-4 shows a comparison between Class 9 front axle weight plots generated by using the two week W-card sample in June 2010 and the Comparison Data Set from March 2008. The class 9 front axle weight plot is provided to indicate possible drifting in WIM weight measurement accuracies.



	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5
Data	2.2%	6.1%	6.7%	8.5%	17.0%	15.0%	17.7%	15.5%	10.0%	1.2%
CDS	4.4%	8.3%	7.8%	9.0%	19.6%	17.3%	17.2%	11.2%	4.8%	0.4%

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

As can be seen in the figure, there is no significant difference between the March 2008 Comparison Data Set (CDS) and the June 2010 dataset (Data F/A).

Table 2-3 indicates that the average front axle weight for Class 9 trucks has decreased by -0.3 kips, or by -2.4 percent.

Table 2-3 – Class 9 Front Axle Weight Distribution from W-Card

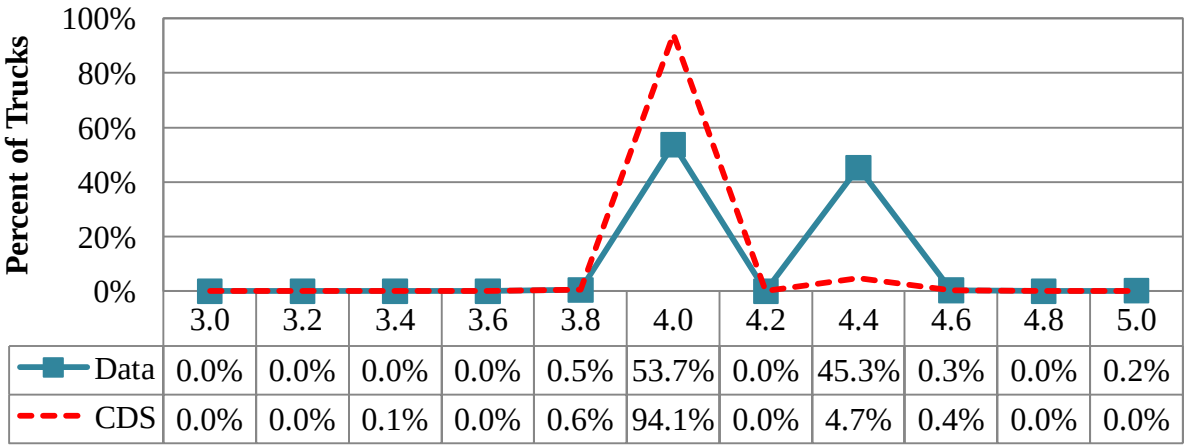
F/A weight bins (kips)	CDS		Data		Change
	Date				
	3/31/2008		6/14/2010		
9.0	1870	4.4%	815	2.2%	-2.2%
9.5	3569	8.3%	2261	6.1%	-2.2%
10.0	3338	7.8%	2487	6.7%	-1.1%
10.5	3848	9.0%	3140	8.5%	-0.5%
11.0	8371	19.6%	6256	17.0%	-2.6%
11.5	7388	17.3%	5533	15.0%	-2.3%
12.0	7351	17.2%	6528	17.7%	0.5%
12.5	4785	11.2%	5708	15.5%	4.3%
13.0	2068	4.8%	3696	10.0%	5.2%
13.5	173	0.4%	460	1.2%	0.8%
Average =	11.0		11.2		-0.3

According to the current data, the majority of the Class 9 front axle weights are between 11.0 and 12.0 kips and the average front axle weight for Class 9 trucks is 11.2 kips.

2.5 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 with the expected average tractor tandem spacing of 4.25 feet.

The class 9 tractor tandem spacing plots in Figure 2-5 are 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%	0.5%	53.7%	0.0%	45.3%	0.3%	0.0%	0.2%
CDS	0.0%	0.0%	0.1%	0.0%	0.6%	94.1%	0.0%	4.7%	0.4%	0.0%	0.0%

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

As seen in the figure, the Class 9 tractor tandem spacing for the March 2008 Comparison Data Set and the June 2010 dataset indicate that the current data contain an additional axle spacing group of 4.4 feet, which may indicate that an adjustment to the distance factor was performed at some point between the dates of the two data sets.

Table 2-4 indicates that the spacing of the tractor tandems for Class 9 trucks at this site is between 3.8 and 4.6 feet. The average tractor tandem spacing is 4.1 feet, which is below the expected average of 4.25 feet. Further analyses are performed during the validation and post-validation analysis.

Table 2-4 – Class 9 Axle 3 to 4 Spacing from W-Card

Tandem 1 spacing bins (feet)	CDS		Data		Change
	Date				
	3/31/2008		6/14/2010		
3.0	10	0.0%	0	0.0%	0.0%
3.2	10	0.0%	0	0.0%	0.0%
3.4	35	0.1%	7	0.0%	-0.1%
3.6	0	0.0%	0	0.0%	0.0%
3.8	279	0.6%	181	0.5%	-0.2%
4.0	40419	94.1%	19944	53.7%	-40.4%
4.2	0	0.0%	0	0.0%	0.0%
4.4	2026	4.7%	16802	45.3%	40.5%
4.6	153	0.4%	125	0.3%	0.0%
4.8	0	0.0%	0	0.0%	0.0%
5.0	10	0.0%	60	0.2%	0.1%
Average =	4.0		4.1		-0.1

2.6 Data Analysis Summary

Historical data analysis involved the comparison of the most recent Comparison Data Set (March 2008) based on the last calibration with the most recent two-week WIM data sample from the site (June 2010). Comparison of vehicle class distribution indicated a decrease in the number of Class 5 vehicles. Analysis of Class 9 GVW and Class 9 front axle weights indicated a decrease in the June 2010 data. The Class 9 Tractor Tandem Spacing did not indicate any significant deviation in the WIM equipment performance.

3 WIM Equipment Discussion

From a comparison between the report of the most recent Validation of this equipment on March 26, 2008 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 November 30, 2007 by International Road Dynamics. It is instrumented with bending plate weighing sensors and 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. A hole in the solar panel was discovered and entire solar panel appeared to be cracked, as shown in Photo 3-1.

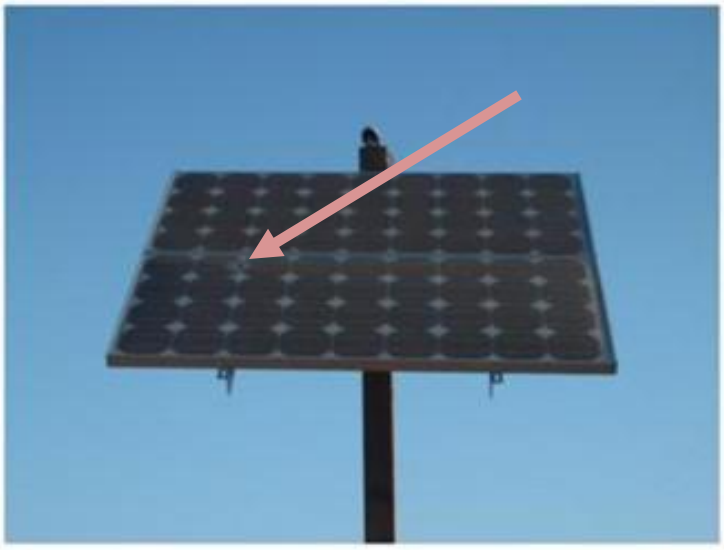


Photo 3-1 - Solar Panel Damage

No other discrepancies were noted. Photographs of all system components were taken and are presented in 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 insulation and resistive values for the bending plates and inductive loops were within tolerances. Electronic tests of the solar panel indicated that it was 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

The solar panel should be replaced. No other equipment maintenance actions are recommended.

4 Pavement Discussion

4.1 Pavement Condition Survey

During a visual distress survey of the pavement conducted from the shoulder, no significant pavement distress was noted and no adverse truck movements prior to, or as they traversed the WIM scale area, were noted. The pavement in the entire WIM section is polished as shown in Photo 4-1. This does not appear to affect the dynamics of the trucks in the WIM area.

Photo 4-1 - Polished PCC in WIM Section

4.2 Profile and Vehicle Interaction

Profile data collected on December 15, 2009 by the Western Regional Support Contractor was obtained using a high-speed profiler, where the operator measures the pavement profile over the entire one-thousand foot long WIM Section, 900 feet prior to WIM scales and 100 feet after the WIM scales. Each pass collects International Roughness Index (IRI) values in both the left and right wheel paths. For this site, 10 profile passes were made, 4 in the center of the travel lane and 6 that were shifted to the left and to the right of the center of the travel lane.

From a pre-visit review of the IRI values for the center, right, and left profile runs, the highest IRI value within the 1000-foot WIM section was 497 in/mi and is located approximately 585 feet prior to the WIM scale. The highest IRI value within the 400 foot approach section was 160 in/mi and is located approximately 382 feet prior to the WIM scale. These areas of the pavement were closely investigated during the validation visit, and truck dynamics in this area were closely observed. There were no distresses observed that would influence truck dynamics in the WIM scale area.

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

4.3 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 three left, three right, and four 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**	**Avg**
Left	LWP	LRI (m/km)	0.796	0.887	0.786		0.823
		SRI (m/km)	*0.371*	0.625	0.584		0.527
		Peak LRI (m/km)	1.259	1.413	1.162		1.278
		Peak SRI (m/km)	0.761	0.930	0.911		0.867
	RWP	LRI (m/km)	0.778	0.839	0.961		0.859
		SRI (m/km)	*0.366*	0.628	*0.357*		*0.450*
		Peak LRI (m/km)	0.836	0.839	0.961		0.879
		Peak SRI (m/km)	0.753	0.825	0.872		0.817
Center	LWP	LRI (m/km)	0.700	0.711	0.629	0.659	0.675
		SRI (m/km)	0.701	*0.479*	1.241	*0.395*	0.704
		Peak LRI (m/km)	0.855	0.815	0.792	0.805	0.817
		Peak SRI (m/km)	0.850	*0.642*	*0.638*	*0.567*	*0.674*
	RWP	LRI (m/km)	1.191	1.416	1.241	1.332	1.295
		SRI (m/km)	1.525	**3.990**	1.241	1.371	2.032
		Peak LRI (m/km)	1.191	1.416	1.241	1.332	1.295
		Peak SRI (m/km)	1.595	**4.268**	1.462	1.646	**2.243**
Right	LWP	LRI (m/km)	0.763	0.848	0.660		0.757
		SRI (m/km)	*0.427*	*0.492*	*0.431*		*0.450*
		Peak LRI (m/km)	0.882	0.936	0.993		0.937
		Peak SRI (m/km)	0.793	0.751	*0.597*		*0.714*
	RWP	LRI (m/km)	0.864	1.054	0.925		0.948
		SRI (m/km)	0.729	0.912	0.829		0.823
		Peak LRI (m/km)	0.880	1.054	0.925		0.953
		Peak SRI (m/km)	0.999	1.071	1.060		1.043

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 most of the remaining values below the lower threshold, as indicated in italics. One of the SRI values and a single Peak SRI value in the right wheel path of the second Center run exceeded the maximum threshold. Since this value is not consistent with values collected for the other passes, it is believed to be errant.

4.4 Recommended Pavement Remediation

No pavement remediation is recommended.

5 Statistical Reliability of the WIM Equipment

The following section provides summaries of data collected during the pre-validation, the calibration, and the 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 tests 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 August 16, 2010, beginning at approximately 12:49 PM and continuing until 4:36 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with scrap metal loaded on pallets, in bales, and in bins loaded on the trailer, 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 palletized particle board loaded on the trailer, and equipped with air suspension on the tractor, air suspension on the trailer, with standard tandem spacing on the tractor and a split tandem spacing on the trailer.

Prior to the pre-validation, the test trucks were weighed. The test trucks were re-weighed at the conclusion of the pre-validation. The average pre-validation 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	76.2	11.9	14.9	13.8	18.1	17.6	14.0	4.4	31.8	4.1	54.3	61.8
2	68.0	9.3	15.4	15.1	14.1	14.1	17.8	4.4	28.8	8.5	59.5	65.0

Test truck speeds varied by 11 mph, from 49 to 60 mph. The measured pre-validation pavement temperatures varied 8.2 degrees Fahrenheit, from 109.0 to 117.2. The cloudy weather conditions prevented reaching the desired 30 degree temperature range. Table 5-12 is a summary of pre-validation results.

Table 5-2 – Pre-Validation Overall Results – 17-Aug-10

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	3.0 ± 3.8%	Pass
Single Axles	±20 percent	3.0 ± 4.2%	Pass
Tandem Axles	±15 percent	3.6 ± 4.1%	Pass
GVW	±10 percent	3.2 ± 2.5%	Pass
Vehicle Length	±3 percent (1.9 ft)	5.4 ± 1.5 ft	FAIL
Axle Spacing Length	± 0.5 ft [150mm]	1.2 ± 1.1 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 0.5 ± 2.2 mph, which is greater than the ±1.0 mph tolerance established by the LTPP Field Guide. Since the site is also measuring axle spacing length outside of specified tolerances, and the two measurements are based on the distance between the axle detector sensors, it can be concluded that the distance factor is not set correctly and that the speeds being reported by the WIM equipment are outside of acceptable ranges.

5.1.1 Statistical Speed Analysis

Statistical analysis was conducted on the test truck run data to investigate whether a relationship exists between speed and WIM equipment weight and distance measurement accuracy. The posted speed limit at this site is 55 mph. The test runs were divided into three speed groups - low, medium and high speeds, as shown in Table 5-3 below.

Table 5-3 – Pre-Validation Results by Speed – 17-Aug-10

Parameter	95% Confidence Limit of Error	Low	Medium	High
		49.0 to 52.7 mph	52.8 to 57.0 mph	57.1 to 60.0 mph
Steering Axles	±20 percent	2.5 ± 4.8%	3.6 ± 2.9%	3.1 ± 3.9%
Single Axles	±20 percent	2.0 ± 4.8%	3.4 ± 2.4%	3.7 ± 4.0%
Tandem Axles	±15 percent	1.7 ± 3.1%	2.2 ± 8.5%	4.3 ± 3.4%
GVW	±10 percent	2.5 ± 2.1%	2.6 ± 1.8%	4.1 ± 2.1%
Vehicle Length	±3 percent (1.9 ft)	5.1 ± 1.5 ft	5.5 ± 1.8 ft	5.6 ± 1.5 ft
Axle Spacing Length	± 0.5 ft [150mm]	1.0 ± 0.8 ft	0.8 ± 0.8 ft	1.5 ± 1.2 ft

From the table, it can be seen that the WIM equipment overestimated all weight measurements at all speeds. The bias and range of the weight errors were reasonably consistent over the entire 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 paragraphs.

5.1.1.1 GVW Errors by Speed

As shown in Figure 5-1, gross vehicle weights were consistently overestimated by the WIM equipment. From the figure, it can be seen that the positive bias in GVW is greater at the higher speeds when compared with the low and medium speeds. Distribution of errors is shown graphically in the figure.

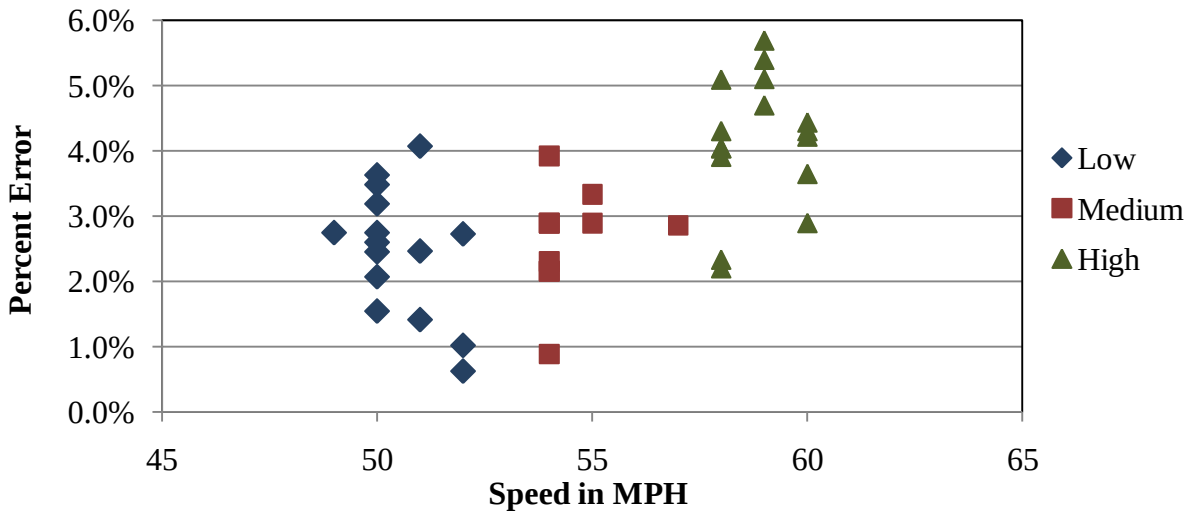


Figure 5-1 – Pre-Validation GVW Error by Speed – 17-Aug-10

5.1.1.2 Steering Axle Weight Errors by Speed

Steering axle weights were generally overestimated by the WIM equipment. As shown in Figure 5-2, the positive bias in steering axle weight appears to be consistent for low and high speeds. Low speeds exhibit the widest range of errors while medium speeds exhibit the narrowest error range. Distribution of errors is shown graphically in the figure.

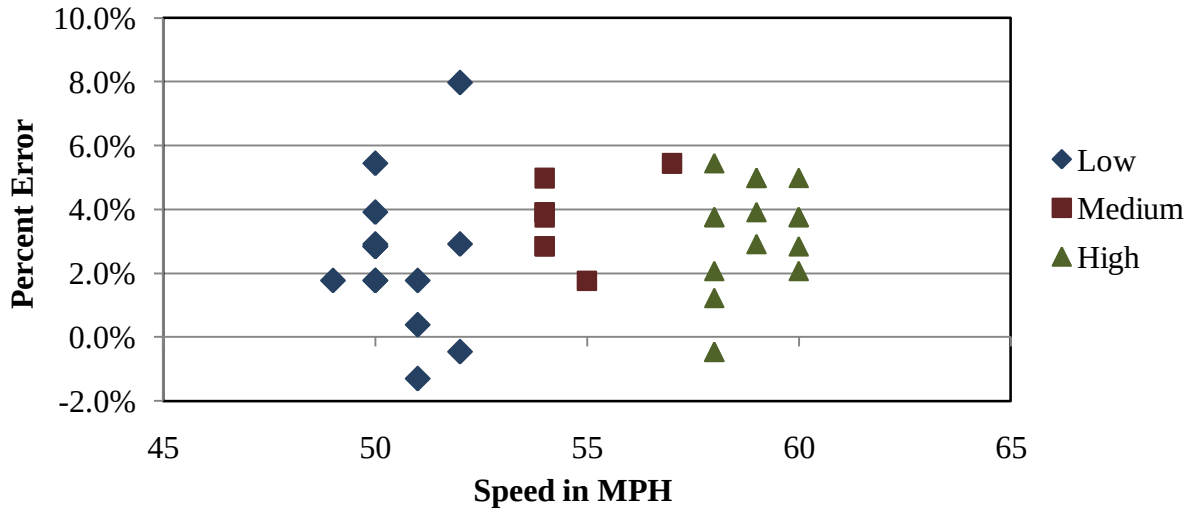


Figure 5-2 – Pre-Validation Steering Axle Error by Speed – 17-Aug-10

5.1.1.3 Single Axle Weight Errors by Speed

Single axles include the steering axles and any axles pairs on the either the truck or trailer that are separated by more than 10 feet. For this site, the single axle weights were generally overestimated by the WIM equipment. As shown in Figure 5-3, the positive bias in single axle weight appears to increase as speed increases. Range in error appears to be lesser at medium speeds when compared with lower and higher speeds. Distribution of errors is shown graphically in the figure.

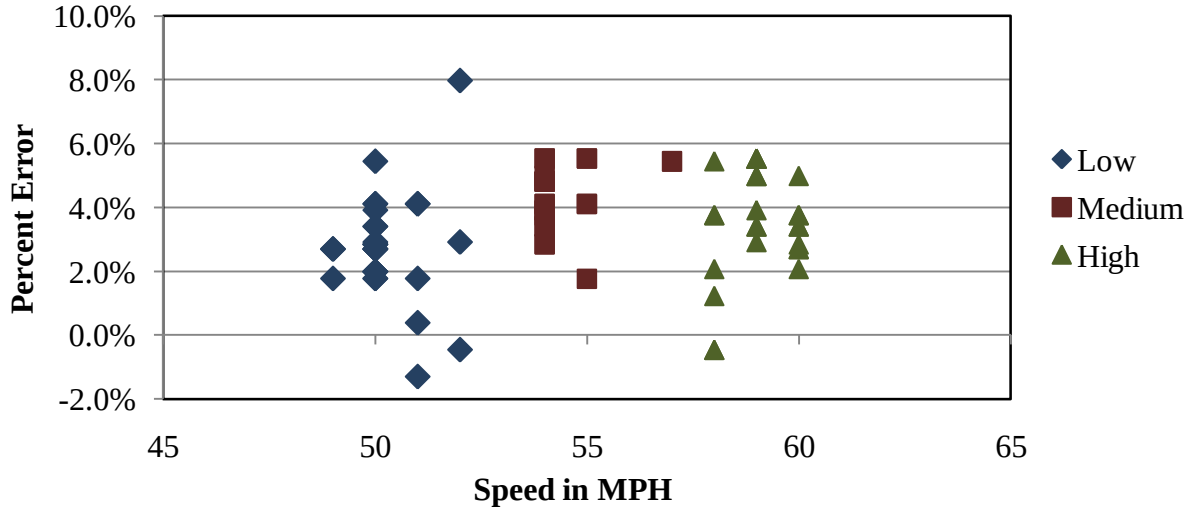


Figure 5-3 – Pre-Validation Single Axle Error by Speed – 17-Aug-10

5.1.1.4 Tandem Axle Weight Errors by Speed

Tandem axle weight measurements demonstrated similar results as steering and single axle weights and were generally overestimated by the WIM equipment. Distribution of errors is shown graphically in Figure 5-4.

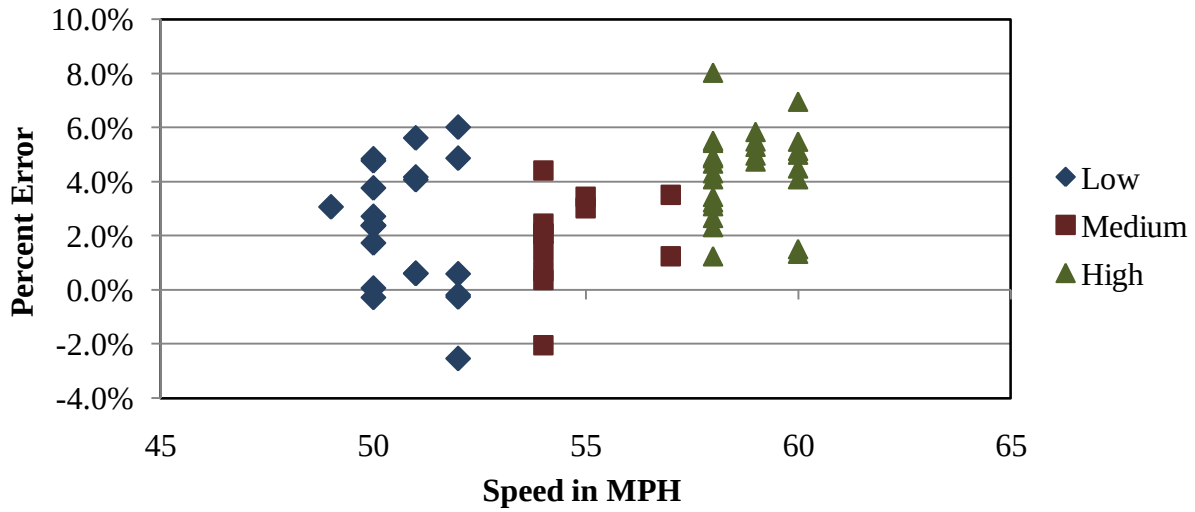


Figure 5-4 – Pre-Validation Tandem Axle Error by Speed – 17-Aug-10

5.1.1.5 GVW Errors by Speed and Truck Type

It can be seen in Figure 5-5 that when the GVW errors for each truck are analyzed as the function of speed, the overestimation of weights for both trucks increased as speed increased. The degree of overestimation at the low and medium speeds appears to be greater for the Secondary truck when compared with the Primary truck. The spread of errors for GVW measurement is similar for each truck.

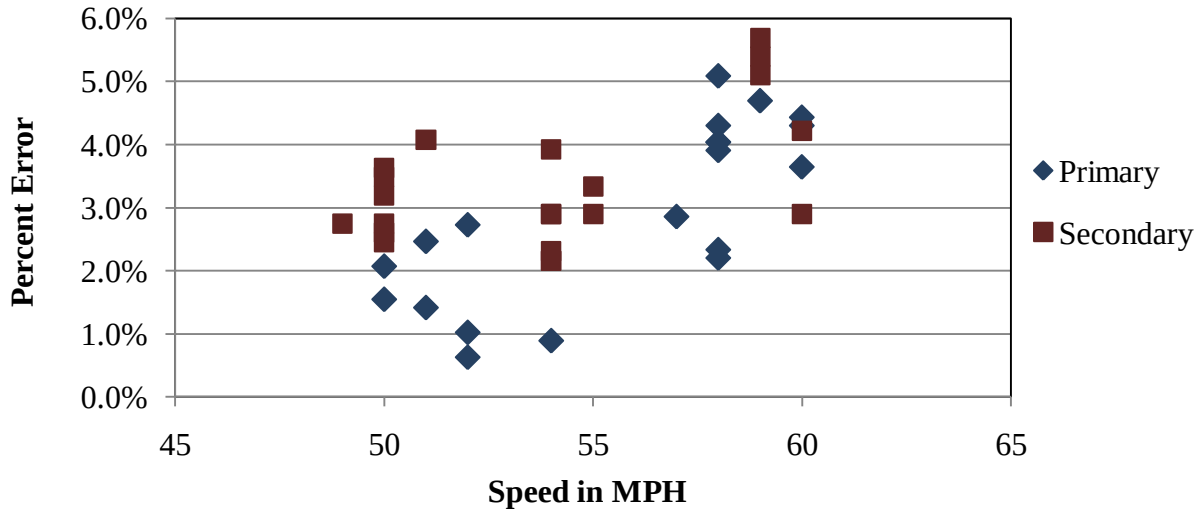


Figure 5-5 – Pre-Validation GVW Error by Truck and Speed – 17-Aug-10

5.1.1.6 Axle Length Errors by Speed

For this site, the error in axle length measurement was consistent at all speeds. As shown in Figure 5-6 the range in axle length measurement error ranged from 0.3 feet to 2.5 feet.

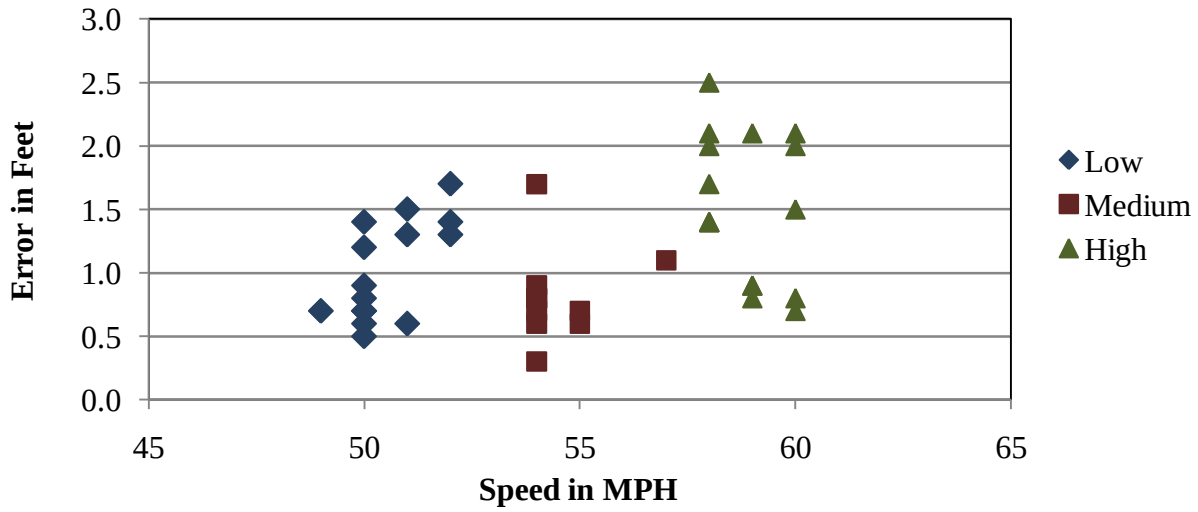


Figure 5-6 – Pre-Validation Axle Length Error by Speed – 17-Aug-10

5.1.1.7 Overall Length Errors by Speed

As shown in Figure 5-7 the WIM equipment overestimated overall vehicle length in all cases, with an error range of 4.2 to 7.0 feet. Distribution of errors is shown graphically in the figure.

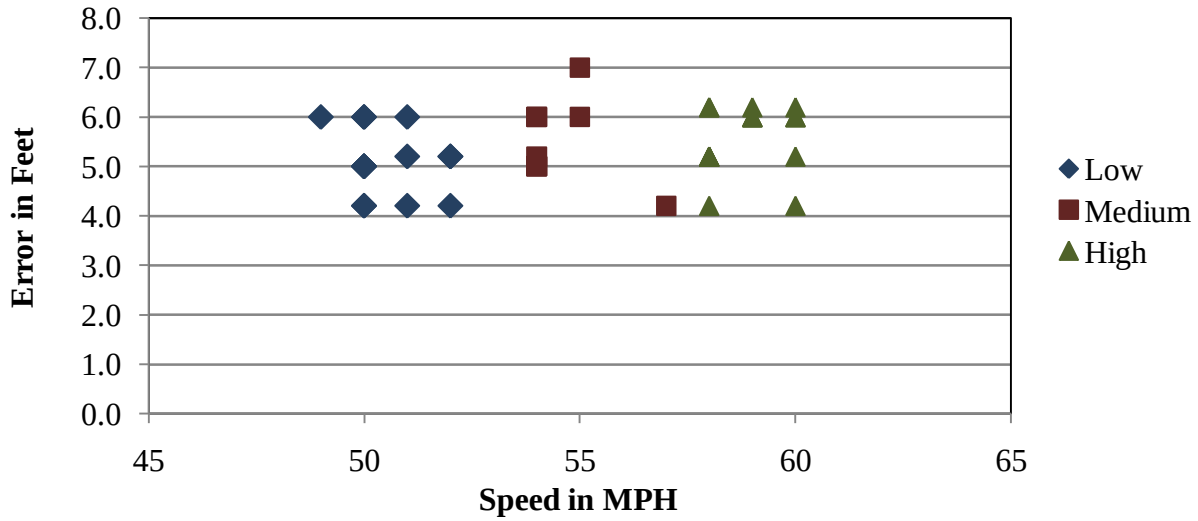


Figure 5-7 – Pre-Validation Overall Length Error by Speed – 17-Aug-10

5.1.2 Statistical Temperature Analysis

Statistical analysis was performed for the test truck run data to investigate whether there is a relation between pavement temperature and WIM equipment weight and distance measurement accuracy. The range of pavement temperatures for the pre-validation only varied 8.2 degrees, from 109.0 to 117.2 degrees Fahrenheit. The pre-validation test runs are being reported under one temperature groups as shown in Table 5-4.

Table 5-4 – Pre-Validation Results by Temperature – 17-Aug-10

Parameter	**95% Confidence Limit of Error**	**Medium**
		109.0 to 117.2 degF
Steering Axles	±20 percent	3.0 ± 3.8%
Single Axles	±20 percent	3.0 ± 4.2%
Tandem Axles	±15 percent	2.9 ± 4.4%
GVW	±10 percent	3.2 ± 2.5%
Vehicle Length	±3 percent (1.9 ft)	5.4 ± 1.5 ft
Vehicle Speed	± 1.0 mph	0.5 ± 2.2 mph
Axle Spacing Length	± 0.5 ft [150mm]	1.2 ± 1.1 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 Vehicle Weight Errors by Temperature

From Figure 5-8, the equipment overestimates GVW at all temperatures. Similar results were given for steering axle, single axle, and tandem axle weights, as shown in Figure 5-9, Figure 5-10, and Figure 5-11.

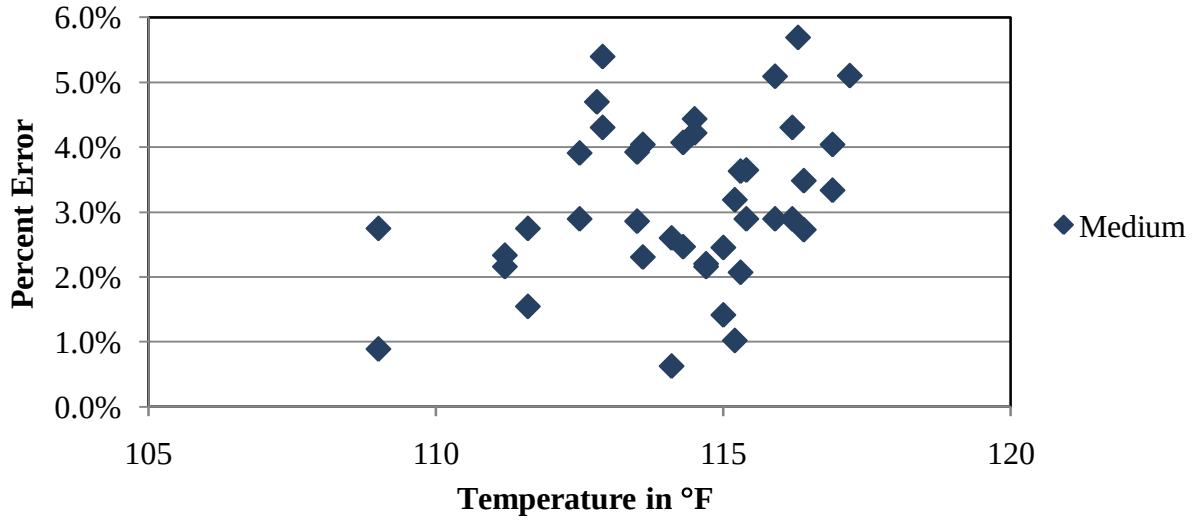


Figure 5-8 – Pre-Validation GVW Error by Temperature – 17-Aug-10

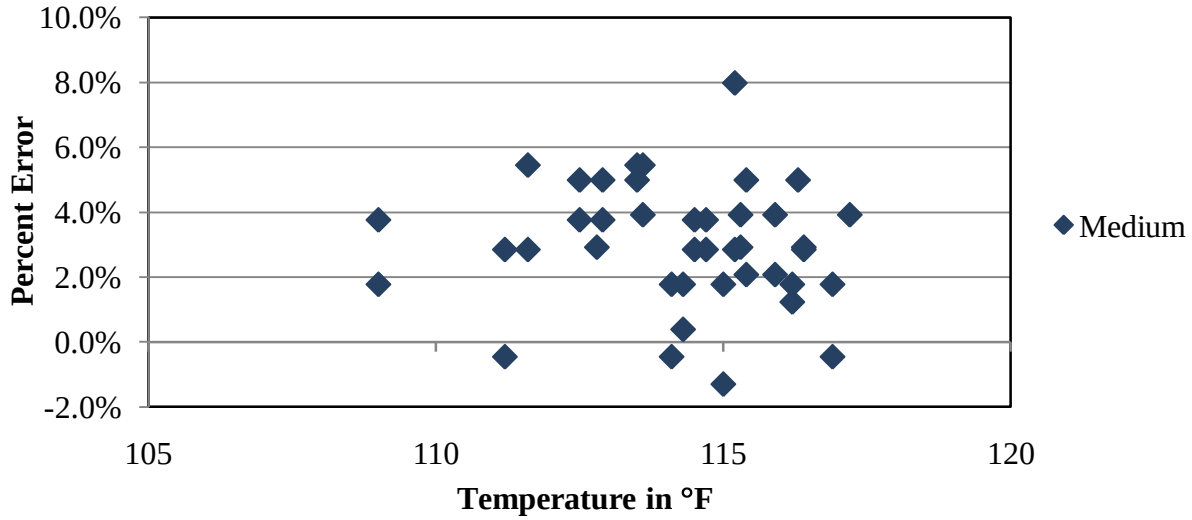


Figure 5-9 – Pre-Validation Steering Axle Weight Error by Temperature – 17-Aug-10

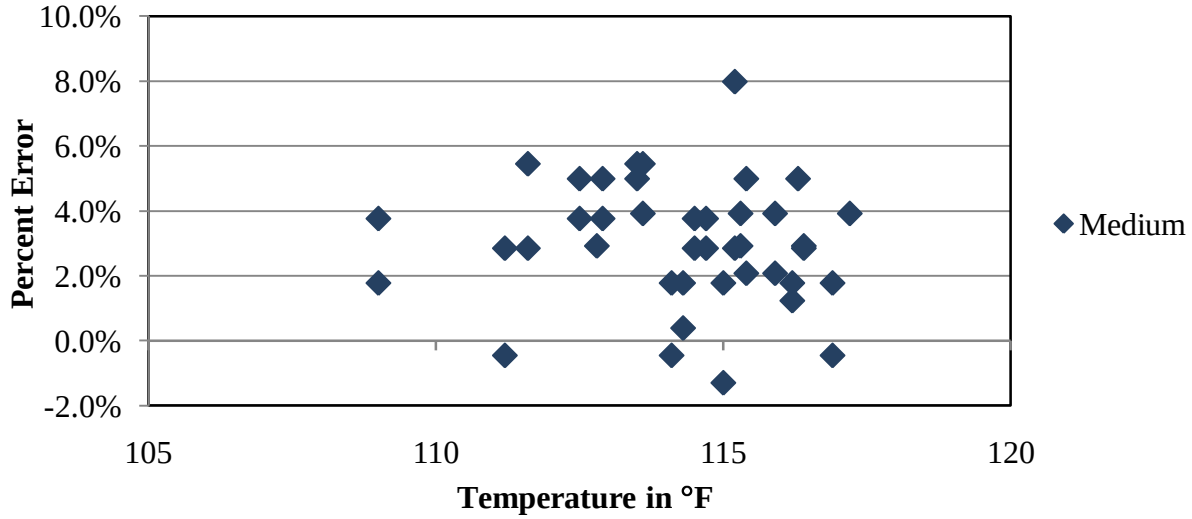


Figure 5-10 – Pre-Validation Single Axle Error by Temperature – 17-Aug-10

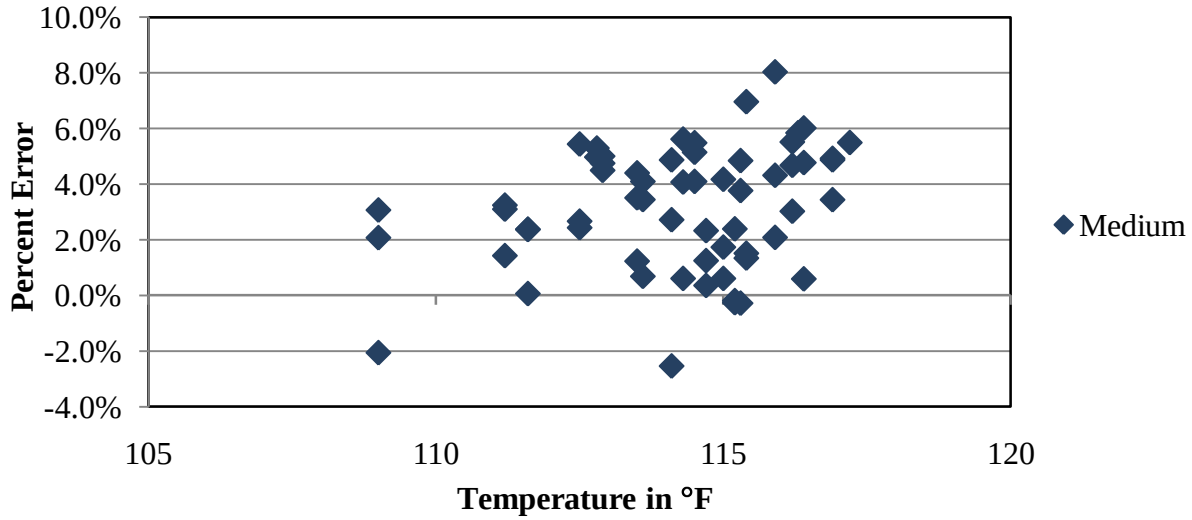


Figure 5-11 – Pre-Validation Tandem Axle Weight Error by Temperature – 17-Aug-10

5.1.2.2 GVW Errors by Temperature and Truck Type

When analyzed for each test truck, GVW average error and spread of errors are similar for the heavily loaded (Primary) truck and the partially loaded (Secondary) truck. Both trucks demonstrate the tendency to overestimate GVW at all temperatures, as shown in Figure 5-12.

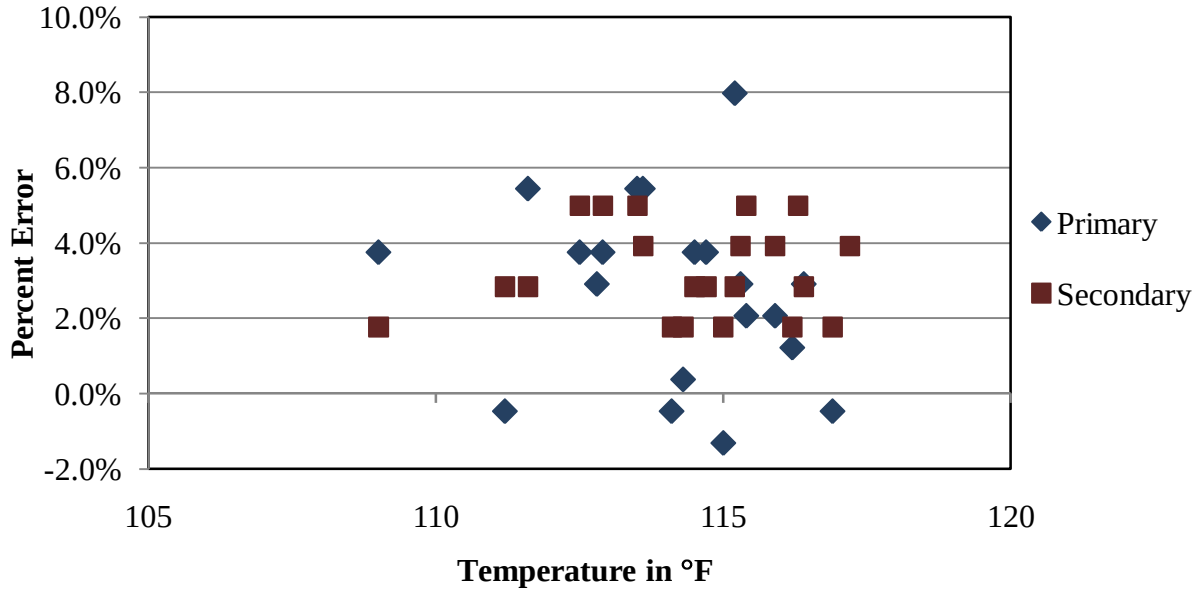


Figure 5-12 – Pre-Validation GVW Error by Truck and Temperature – 17-Aug-10

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 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. Table 5-5 illustrates the breakdown of vehicles observed and identified by the WIM equipment for the manual classification study.

Table 5-5 – Pre-Validation Classification Study Results – 17-Aug-10

Class	4	5	6	7	8	9	10	11	12	13
Observed Count	0	16	6	0	4	70	1	20	0	0
WIM Count	1	15	6	0	4	70	1	20	0	0
Obs. Distr. (%)	0%	14%	5%	0%	3%	60%	1%	17%	0%	0%
WIM Distr. (%)	1%	13%	5%	0%	3%	60%	1%	17%	0%	0%
Misclass/Unclass	0	1	0	0	0	0	0	0	0	0
Misclassified (%)	N/A	6%	0%	N/A	0%	0%	0%	0%	N/A	N/A

Misclassified vehicles are manually classified by observation as one type of vehicle but identified by the WIM equipment as another type of vehicle. The misclassifications by pair are provided in Table 5-6.

Table 5-6 – Pre-Validation Misclassifications by Pair – 17-Aug-10

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

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 0.9%. As shown in the table, only 1 vehicle was misclassified by the equipment. The single misclassification was a Class 5 identified by the WIM equipment as a Class 4.

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 – 17-Aug-10

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

Based on the manually collected sample of the 117 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 1.6 mph; the range of errors was 1.6 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 – 18-Aug-10

Speed Point	MPH	Left	Right
80	50	3395	3395
88	55	3395	3395
96	60	3420	3420
105	65	3360	3360
112	70	3360	3360
Axle Distance (cm)	283		
Dynamic Comp (%)	100		

The dynamic compensation percentage shown in the table is an IRD iSINC specific compensation factor that is adjusted to compensate for front axle weight errors and is adjusted independently and with respect to the speed point compensation factor changes.

5.2.1 Calibration Iteration 1

5.2.1.1 Equipment Adjustments

For the GVW, the pre-validation test truck runs produced an overall error of 3.2% and errors of 2.5%, 2.6%, and 4.1% at the 50, 55 and 60 mph speed points, respectively. The errors for 65 mph and 70 mph speeds were extrapolated to derive new compensation factors for the speed points. To compensate for these errors, the changes shown in Table 5-9 were made to the compensation factors.

Table 5-9 – Calibration 1 Equipment Factor Changes – 18-Aug-10

Speed Points	GVW Error	Old Factors		New Factors	
		Right	Left	Right	Left
80	2.47%	3395	3395	3314	3314
88	2.65%	3395	3395	3314	3314
96	4.16%	3420	3420	3333	3333
105	4.16%	3360	3360	3229	3229
112	4.16%	3360	3360	3229	3229
Axle Distance (cm)	2.0%	283		277	
Dynamic Comp (%)	3.0%	100		100	

5.2.1.2 Calibration 1 Results

The results of the first calibration verification runs are provided in Table 5-10 and Figure 5-13.

Table 5-10 – Calibration 1 Results – 18-Aug-10

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-1.1 ± 4.7%	Pass
Single Axles	±20 percent	-0.2 ± 6.0%	Pass
Tandem Axles	±15 percent	-0.9 ± 2.7%	Pass
GVW	±10 percent	-0.4 ± 1.9%	Pass
Vehicle Length	±3 percent (1.9 ft)	2.1 ± 1.1 ft	FAIL
Axle Spacing Length	± 0.5 ft [150mm]	-0.1 ± 0.5 ft	FAIL

As can be seen in the table, the WIM equipment meets all established criteria for weight measurement. It does not meet the requirements for vehicle length or axle spacing length.

From Figure 5-13, it can be seen that as a result of the calibration, the WIM equipment estimates GVW with reasonable accuracy.

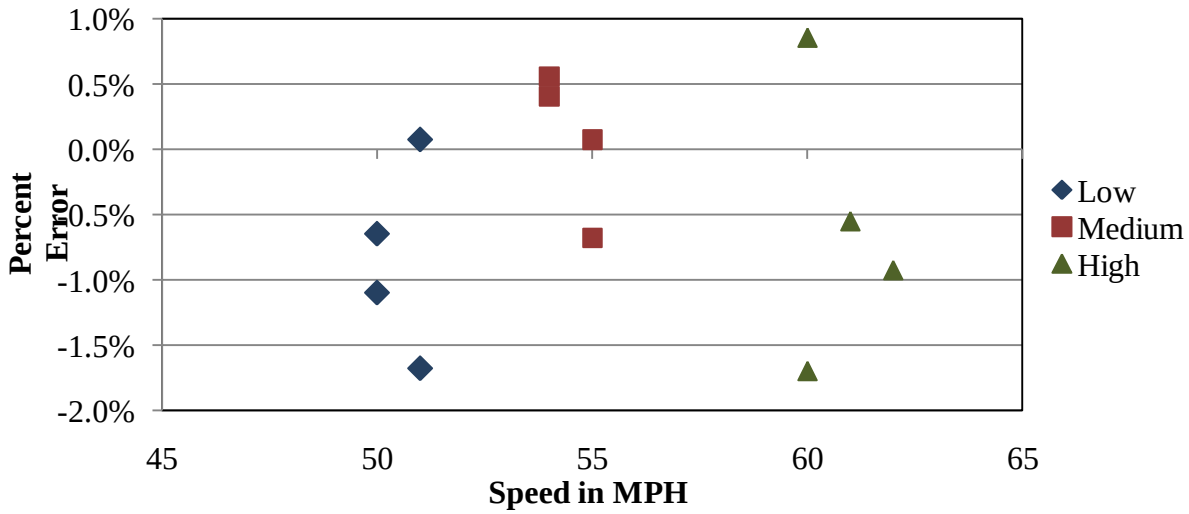


Figure 5-13 – Calibration 1 GVW Error by Speed – 18-Aug-10

Based on the results of the first calibration a second calibration was not required to improve system accuracy. 28 additional test trucks runs were performed to complete the post-validation.

5.3 Post-Validation

The 40 post-validation test truck runs were conducted on August 18, 2010, beginning at approximately 3:14 PM and continuing until 7:56 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with scrap metal loaded on pallets, in bales, and in bins loaded on the trailer, 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 palletized particle board loaded on trailer, and equipped with air suspension on the tractor, air suspension on the trailer, with standard tandem spacing on the tractor and standard tandem spacing on the trailer.

Prior to the post-validation, the test trucks were weighed. The test trucks were re-weighed at the conclusion of the post-validation. The average post-validation 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	79.8	12.2	17.4	16.8	16.6	16.7	15.6	4.4	31.9	4.1	56.0	61.0
2	66.2	11.8	14.5	14.3	12.8	12.8	19.9	4.4	30.0	4.1	58.4	66.0

Test truck speeds varied by 13 mph, from 49 to 62 mph. The measured post-validation pavement temperatures varied 29.7 degrees Fahrenheit, from 84.2 to 113.9. The sunny weather conditions nearly provided the desired 30 degree temperature range. Table 5-12 is a summary of post validation results.

Table 5-12 – Post-Validation Overall Results – 18-Aug-10

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-1.1 ± 4.3%	Pass
Tandem Axles	±15 percent	0.2 ± 3.7%	Pass
GVW	±10 percent	-0.1 ± 2.5%	Pass
Vehicle Length	±3 percent (1.9 ft)	2.1 ± 0.7 ft	FAIL
Axle Spacing Length	± 0.5 ft [150mm]	0.1 ± 0.5 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 for all speeds was 0.4 ± 1.6 mph, which is greater than the ±1.0 mph tolerance established by the LTPP Field Guide. However, the site is measuring mean axle spacing length within the specified

tolerances, and since the spacing and speed measurements are based on the distance between the axle detector sensors, it can be concluded that the distance factor was properly adjusted and is set correctly and that the speeds being reported by the WIM equipment are within an acceptable range.

5.3.1 Statistical Speed Analysis

Statistical analysis was conducted on the test truck run data to investigate whether a relation exists between speed and WIM equipment weight and distance measurement accuracy. The posted speed limit at this site is 55 mph. The test runs were divided into three speed groups - low, medium and high speeds, as shown in Table 5-13.

Table 5-13 – Post-Validation Results by Speed – 18-Aug-10

Parameter	95% Confidence Limit of Error	Low	Medium	High
		49.0 to 53.3 mph	53.4 to 57.8 mph	57.9 to 62.0 mph
Steering Axles	±20 percent	-0.8 ± 3.8%	-0.6 ± 3.3%	-2.0 ± 5.9%
Tandem Axles	±15 percent	-0.1 ± 2.6%	0.9 ± 4.1%	-0.2 ± 4.0%
GVW	±10 percent	-0.2 ± 1.8%	0.5 ± 2.5%	-0.5 ± 3.2%
Vehicle Length	±3 percent (1.9 ft)	2.2 ± 0.8 ft	2.1 ± 0.6 ft	2.0 ± 0.8 ft
Vehicle Speed	± 1.0 mph	0.2 ± 1.7 mph	0.5 ± 1.4 mph	0.4 ± 2.0 mph
Axle Spacing Length	± 0.5 ft [150mm]	0.2 ± 0.7 ft	0.1 ± 0.5 ft	0.2 ± 0.6 ft

From the table, it can be seen that the WIM equipment estimates all weights with reasonable accuracy. For all weights, the range of errors is greater at the higher speeds when compared with the lower speeds. However, there does not appear to be a significant relationship between weight estimates and speed at this site.

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

5.3.1.1 GVW Errors by Speed

As shown in Figure 5-14, the equipment estimated GVW at all speed with reasonable accuracy. The range in error was slightly greater at the higher speeds when compared with the low and medium speeds.

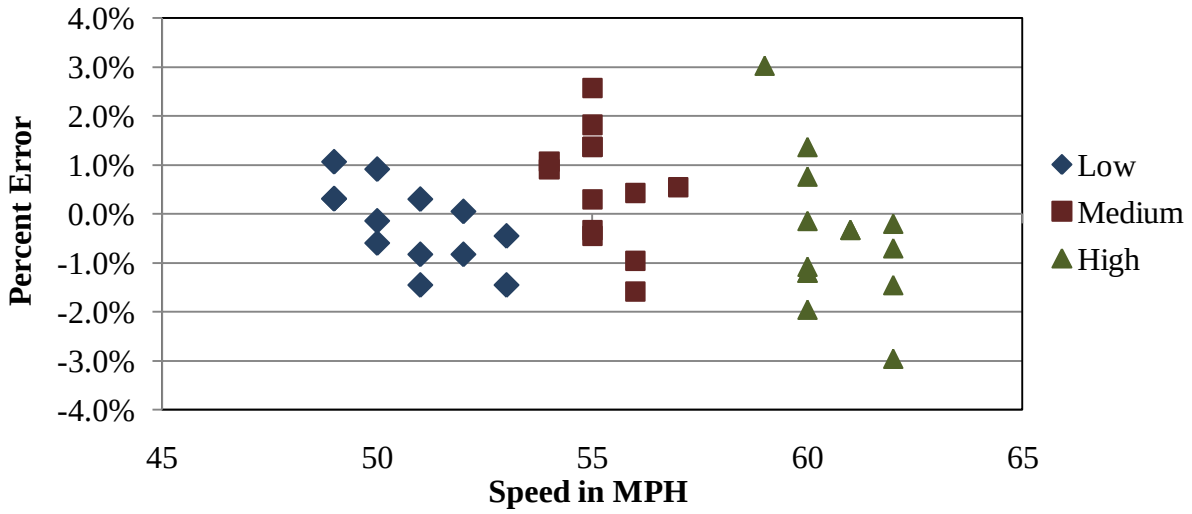


Figure 5-14 – Post-Validation GVW Error by Speed – 18-Aug-10

5.3.1.2 Steering Axle Weight Errors by Speed

Steering axle weights were estimated with reasonable accuracy by the WIM equipment. From Figure 5-15 it can be seen that the range in error appears to be greater at the higher speeds when compared with the low and medium speeds.

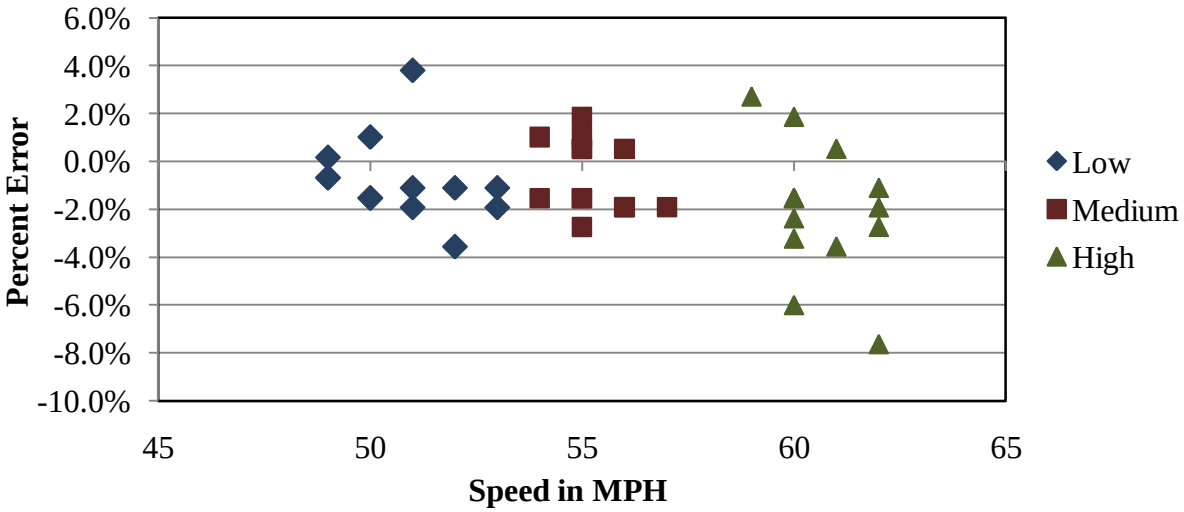


Figure 5-15 – Post-Validation Steering Axle Weight Error by Speed – 18-Aug-10

5.3.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 5-16, the equipment estimates tandem axle weights with reasonable accuracy at all speeds. The range in error is greater at the medium speeds.

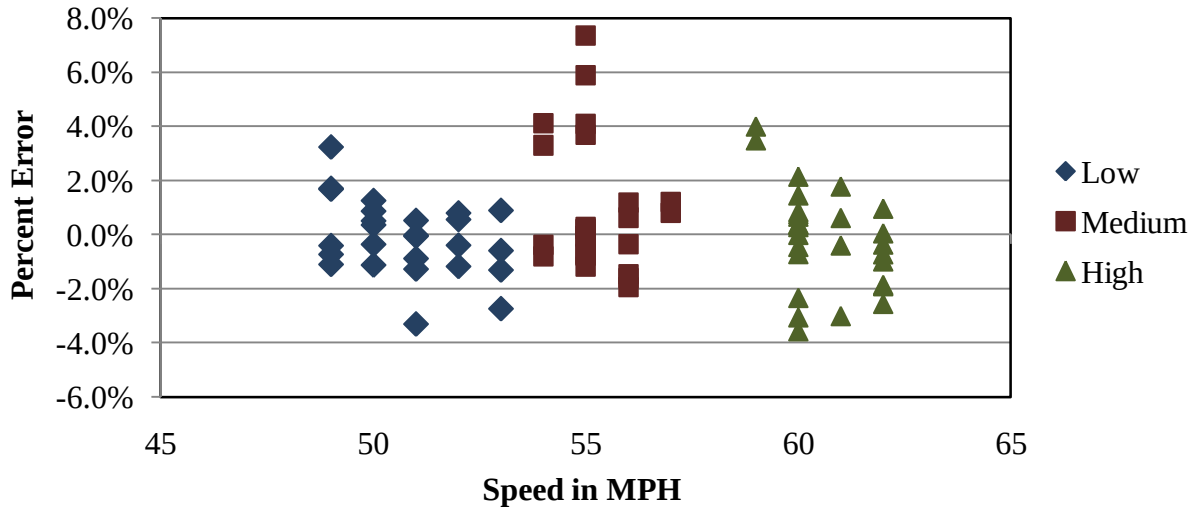


Figure 5-16 – Post-Validation Tandem Axle Weight Error by Speed – 18-Aug-10

5.3.1.4 Truck GVW Errors by Speed and Truck Type

As shown in Figure 5-17, when the GVW errors are analyzed by truck type, it can be seen that the equipment estimates GVW for each truck differently at the medium speeds, where the weight of the Primary truck is estimated accurately and the weight of the Secondary truck is overestimated. The spread of errors for GVW measurement is similar for the two trucks.

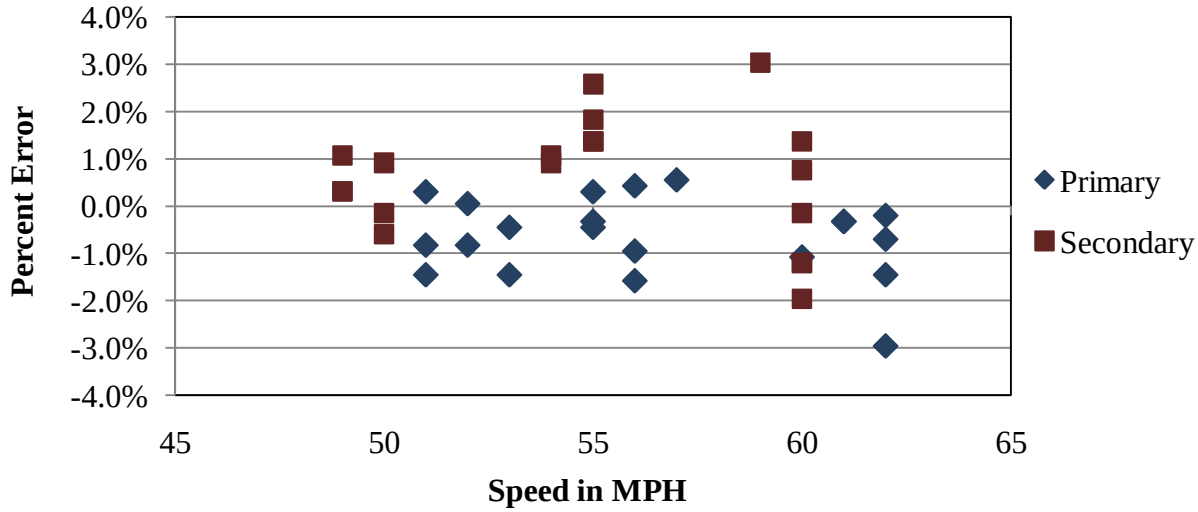


Figure 5-17 – Post-Validation GVW Error by Truck Type and Speed – 18-Aug-10

5.3.1.5 Axle Length Errors by Speed

For this site, the range in axle length measurement error ranged from -0.3 feet to 0.7 feet, as shown in Figure 5-18. WIM equipment estimated axle length with reasonable accuracy. Distribution of errors is shown graphically in the figure.

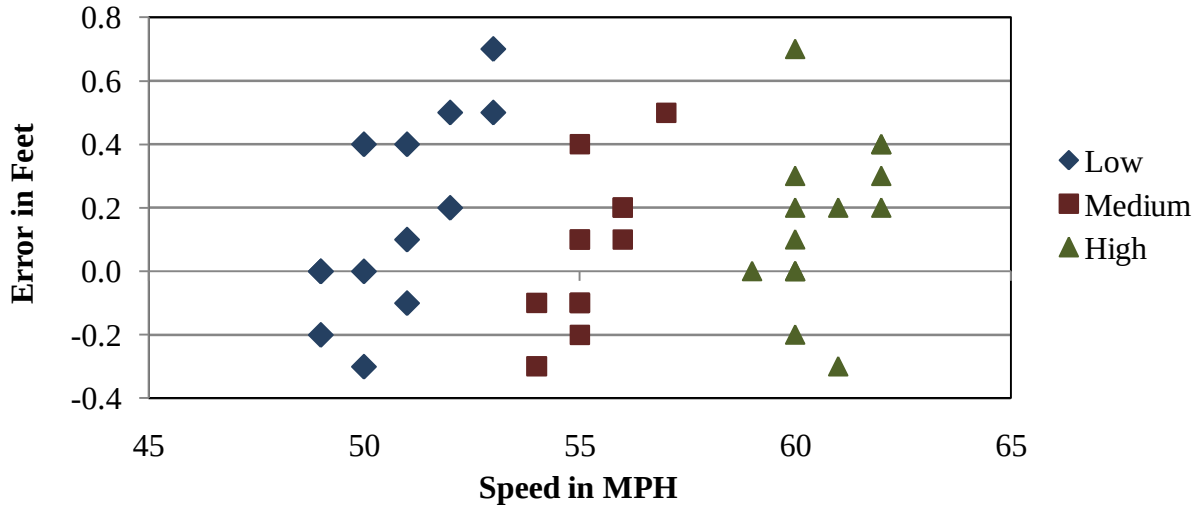


Figure 5-18 – Post-Validation Axle Length Error by Speed – 18-Aug-10

5.3.1.6 Overall Length Errors by Speed

For this system, the WIM equipment overestimates overall length over the entire range of speeds, with errors ranging from 1.0 to 3.0 feet. Distribution of errors is shown graphically in Figure 5-19.

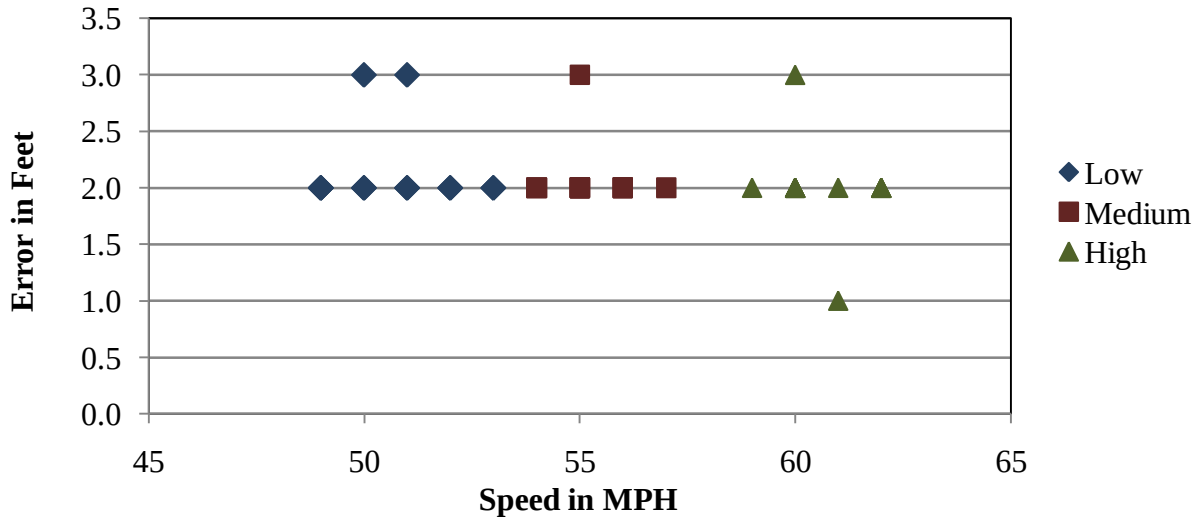


Figure 5-19 – Post-Validation Overall Length Error by Speed – 18-Aug-10

5.3.2 Statistical Temperature Analysis

Statistical analysis was performed for the test truck run data to investigate whether there is a relationship between pavement temperature and WIM equipment weight and distance measurement accuracy. The range of pavement temperatures varied 29.7 degrees, from 84.2 to 113.9 degrees Fahrenheit. The post-validation test runs are being reported under three temperature groups as shown in Table 5-14.

Table 5-14 – Post-Validation Results by Temperature – 18-Aug-10

Parameter	95% Confidence Limit of Error	Low	Medium	High
		84.2 to 94.1 degF	94.2 to 105.0 degF	105.1 to 113.9 degF
Steering Axles	±20 percent	-1.7 ± 3.6%	-1.3 ± 5.6%	-0.4 ± 4.4%
Tandem Axles	±15 percent	0.3 ± 4.4%	0.2 ± 4.2%	0.0 ± 3.4%
GVW	±10 percent	0.0 ± 2.8%	0.0 ± 3.2%	-0.1 ± 2.0%
Vehicle Length	±3 percent (1.9 ft)	2.0 ± 0.0 ft	2.1 ± 0.8 ft	2.1 ± 1.1 ft
Vehicle Speed	± 1.0 mph	0.3 ± 2.5 mph	0.7 ± 1.3 mph	0.1 ± 0.6 mph
Axle Spacing Length	± 0.5 ft [150mm]	0.2 ± 0.6 ft	0.2 ± 0.4 ft	-0.1 ± 0.5 ft

As shown in the table, the equipment appears to measure all weights with reasonable accuracy. For each of the measurements, the deviation in error appears to be reasonably consistent for all temperatures, with only a slight increase in error range for steering axles at medium temperatures.

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 5-20, it can be seen that the equipment appears to estimate GVW with reasonable accuracy at all temperatures. The spread in GVW measurement errors appears to be slightly greater at the medium temperatures when compared with low and high temperatures. The consistent error indicates that temperature does not affect the estimation of gross vehicle weight measurement by the WIM sensor.

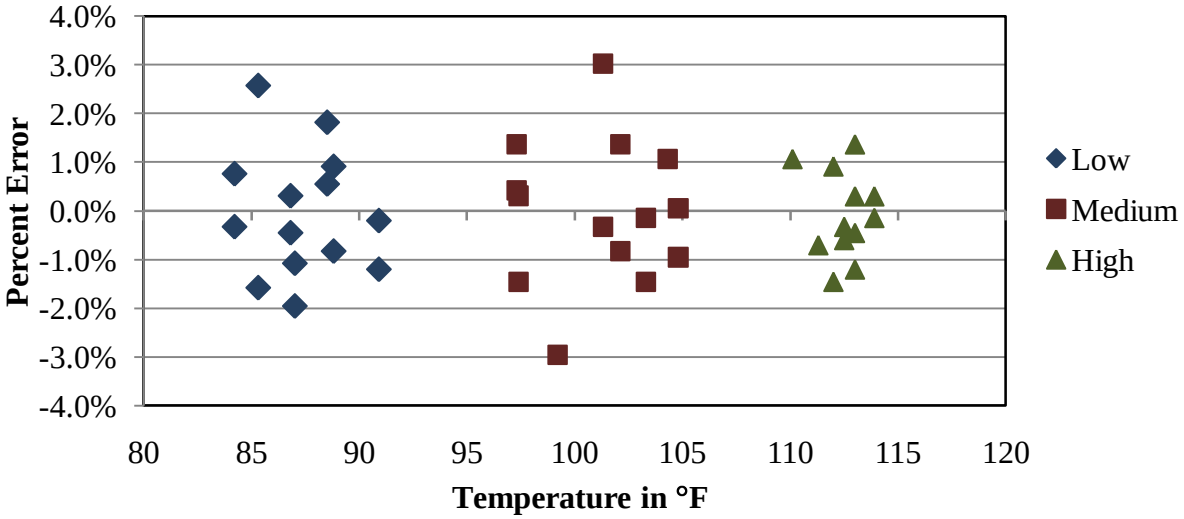


Figure 5-20 – Post-Validation GVW Error by Temperature – 18-Aug-10

5.3.2.2 Steering Axle Weight Errors by Temperature

Figure 5-21 demonstrates that for steering axles, the weights are slightly underestimated by the equipment at all temperatures. The consistent error indicates that temperature does not affect the estimation of steering axle weight measurement by the WIM sensor. Distribution of errors is shown graphically in the following figure.

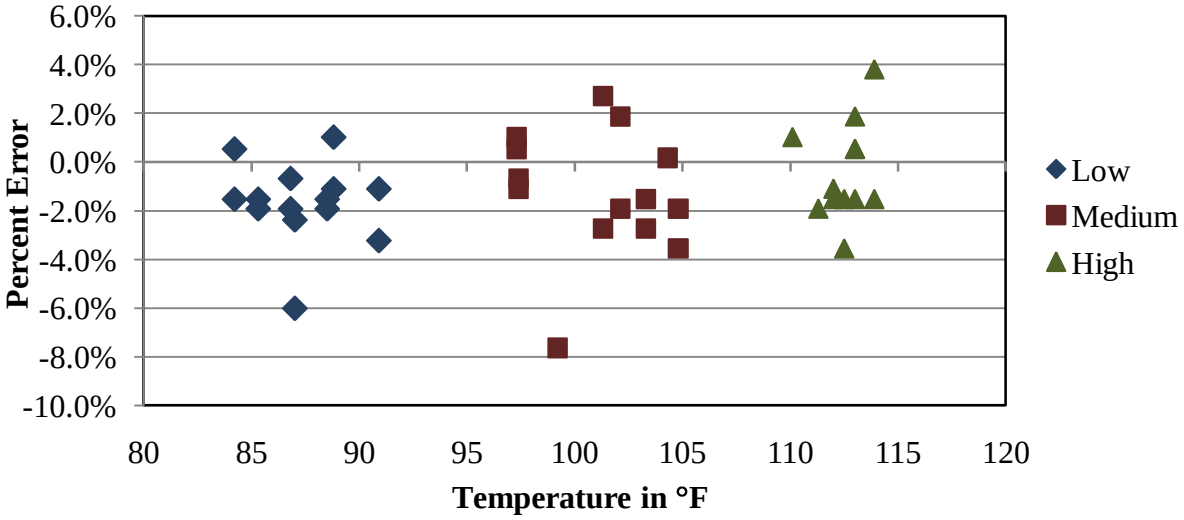


Figure 5-21 – Post-Validation Steering Axle Error by Temperature – 18-Aug-10

5.3.2.3 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-22, there does not appear to be a relationship between tandem axle weight measurement error and temperature. Measurement bias and spread of errors appear to be consistent at all temperatures.

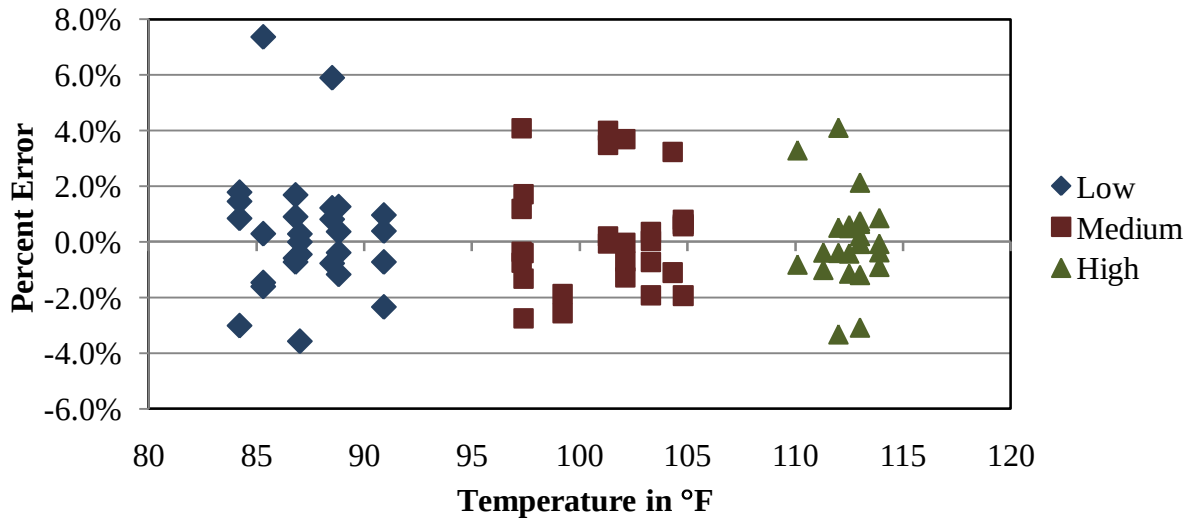


Figure 5-22 – Post-Validation Tandem Axle Weight Error by Temperature – 18-Aug-10

5.3.2.4 GVW Errors by Temperature and Truck Type

As shown in Figure 5-23, when analyzed by truck type, GVW errors and spread of errors are similar for the heavily loaded (Primary) truck and the partially loaded (Secondary) truck.

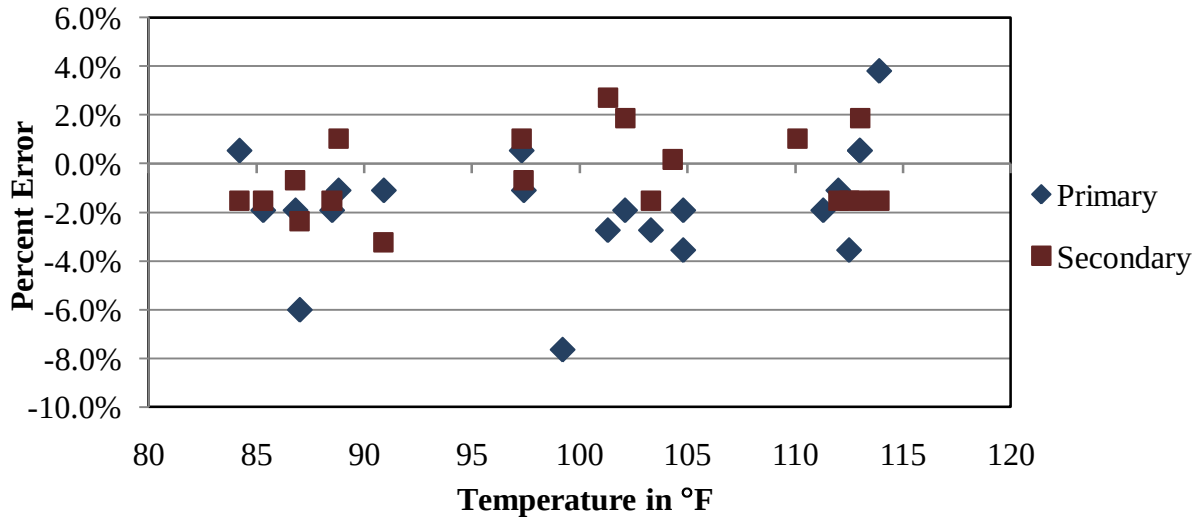


Figure 5-23 – Post-Validation GVW Error by Truck and Temperature – 18-Aug-10

5.3.3 Multivariable Analysis

This section provides additional analysis of post-validation results using a multivariable statistical technique of multiple linear regressions. 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.

5.3.3.1 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 trailers. The separate evaluation was carried out because the tandem axle on the secondary tractor had a different suspension compared to all other tandem axles.

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 49 to 62 mph.
- Pavement temperature. Pavement temperature ranged from 84.2 to 113.9 degrees Fahrenheit.
- Interaction between the factors such as the interaction between speed and pavement temperature.

5.3.3.2 Results

For analysis of GVW, 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. The values of the t-distribution (for the regression coefficients) given in the table are for the null hypothesis that assumes that the coefficients are equal to zero. The effects of speed, temperature and truck type were not found statistically significant. The probabilities that the effects of speed, temperature and truck type on the observed GVW errors occurred by chance alone ranged from 17% to 88% based on values in the last column.

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

Parameter	Regression coefficients	Standard error	Value of t-distribution	Probability value
Intercept	4.133	3.434	1.204	0.24
Speed	-0.066	0.047	-1.395	0.17
Temperature	-0.005	0.019	-0.265	0.79
Truck type	-0.057	0.388	-0.146	0.88

The quantification is provided by the value of the regression coefficient, in this case -0.066 (in Table 5-15). This means, for example, that for a 20 mph increase in speed, the %error is increased by about 1.3% (0.066 x 20). The statistical assessment of the relationship is provided by the probability value of the regression coefficient.

The relationship between speed and GVW measurement errors is shown in Figure 5-24. The figure includes observed percent errors and a trend line for the predicted error. The trend line in Figure 5-24 is not statistically significant.

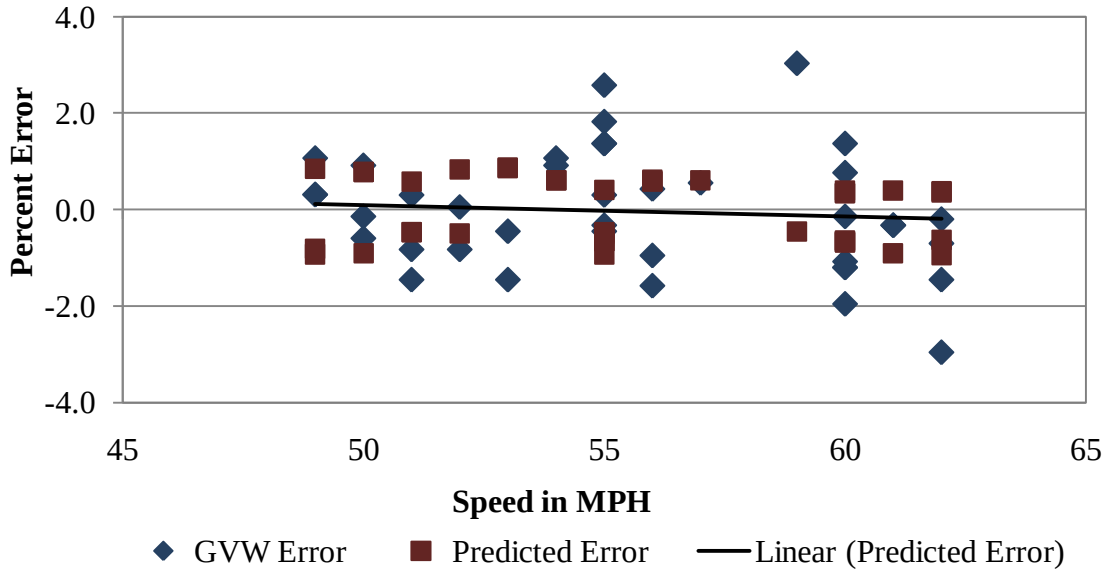


Figure 5-24 – Influence of Speed (in MPH) on the Measurement Error of GVW

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.

5.3.3.3 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

	Factor					
	Speed		**Temperature**		**Truck type**	
Weight, % error	Regression coefficient	Probability value	Regression coefficient	Probability value	Regression coefficient	Probability value
GVW	-0.066	0.17	-	-	-	-
Steering axle	-0.160	0.058	-	-	-	-
Tandem axle tractor	0.0978	0.077	-	-	-	-
Tandem axle trailer	-0.200	0.028	-	-	-	-

5.3.3.4 Conclusions

1. Temperature and truck type had no statistically significant effect on measurement errors.
2. Speed affected measurement error of all axles weights, but not the measurement error of the GVW. The regression coefficients ranged from 0.098 for the tandem axle on tractor to -0.2 for the tandem axel on trailer. The apparent contradiction of the statistically significant effect of speed on all axle weight measurement errors, but not on the GVW error, is due to the positive and negative effects of speed on axle weights errors (the regression coefficients have mines and plus signs).
3. Even though the speed had statistically significant effect on measurement errors for axle weights , the practical significance of speed is small and does not affect the validity of the calibration.
4. Truck type was not statistically significant. Axle weights of both test trucks are measured with the same degree of accuracy.

5.3.4 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 120 vehicles including 120 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.

Table 5-17 – Post-Validation Classification Study Results – 18-Aug-10

Class	4	5	6	7	8	9	10	11	12	13
WIM Count	2	9	7	0	12	73	0	15	1	0
Observed Count	0	12	7	1	11	73	0	15	1	0
Obs. Distr. (%)	0%	10%	6%	1%	9%	61%	0%	13%	1%	0%
WIM Distr. (%)	2%	8%	6%	0%	10%	61%	0%	13%	1%	0%
Misclass/Unclass	0	3	0	1	0	0	0	0	0	0
Misclassified (%)	N/A	25%	0%	100%	0%	0%	N/A	0%	0%	N/A

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 misclassified percentage represents the percent of the observed vehicles that were identified as another vehicle class by the WIM equipment. The overall misclassification rate for all vehicles (3 – 15) is 2.5%. The misclassifications by pair are provided in Table 5-18.

Table 5-18 – Post-Validation Misclassifications by Pair – 18-Aug-10

Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs
3/5	0	8/9	0
3/8	0	9/5	0
4/5	0	9/8	0
4/6	0	9/10	0
5/3	0	10/9	0
5/4	2	10/13	0
5/8	1	11/12	0
6/4	0	12/11	0
7/6	0	13/10	0
8/3	0	13/11	0
8/5	0		

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. As shown in the table, a total of three vehicles, including no heavy trucks (6 – 13) were misclassified by the equipment. All of the misclassifications were Class 5s identified by the WIM equipment as Class 4 or Class 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 5-19.

Table 5-19 – Post-Validation Unclassified Trucks by Pair – 18-Aug-10

Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs
3/15	0	9/15	0
4/15	0	10/15	0
5/15	0	11/15	0
6/15	0	12/15	0
7/15	1	13/15	0
8/15	0		

Based on the manually collected sample of the 120 trucks, 0.8% of the vehicles at this site were reported as unclassified during the study. One class 7 truck was unclassified by the equipment. The reason for the inability of the WIM equipment to classify this vehicle could not be resolved in the field. The 0.8% unclassified rate is within the established criteria of 2.0% for LTTP SPS WIM sites.

For speed, the mean error for WIM equipment speed measurement was 2.1 mph. The corresponding range of errors was 1.8 mph.

5.4 Post Visit Applied Calibration

The 85th percentile speed for trucks, based on CDS data, is 64 mph, 9 mph above the posted speed limit of 55 mph and 2 mph above the highest test truck speed. Consequently, applied calibration will be utilized and recommendations for changes to the 65 and 70 mph speed point compensation factors will be made. The final calibration factors that were in place at the conclusion of the post-validation conducted on August 18, 2010 are provided in **Error! eference source not found.**.

The GVW error trend for the equipment was developed using the post-validation results and is shown in Figure 5-25.

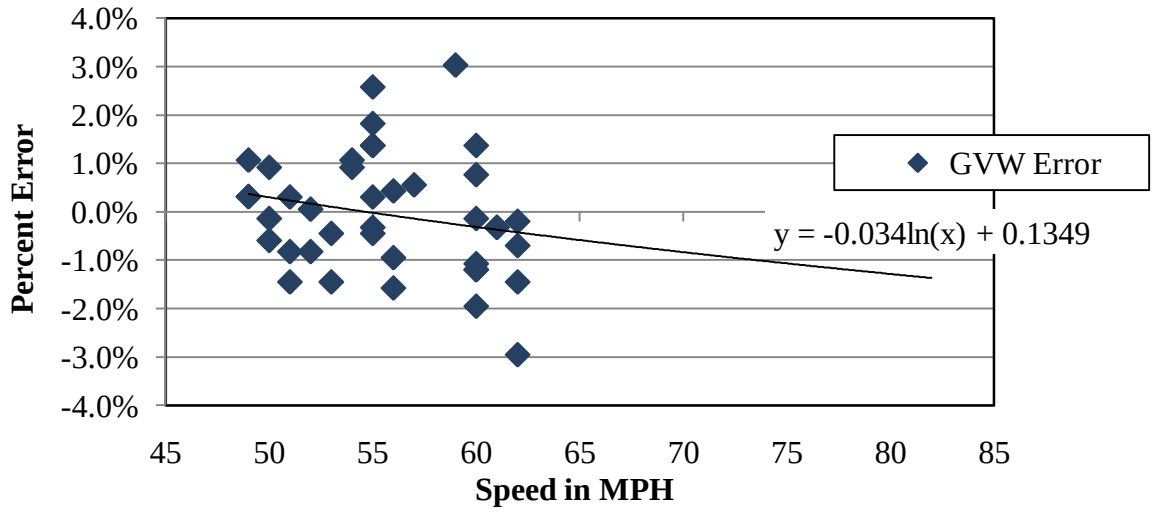


Figure 5-25 – GVW Error Trend

For the applied calibration, pre- and post-visit front axle error for Class 9 trucks and pre- and post-validation GVW error for the test trucks were used to develop an applied GVW error and plotted, as shown in Figure 5-26.

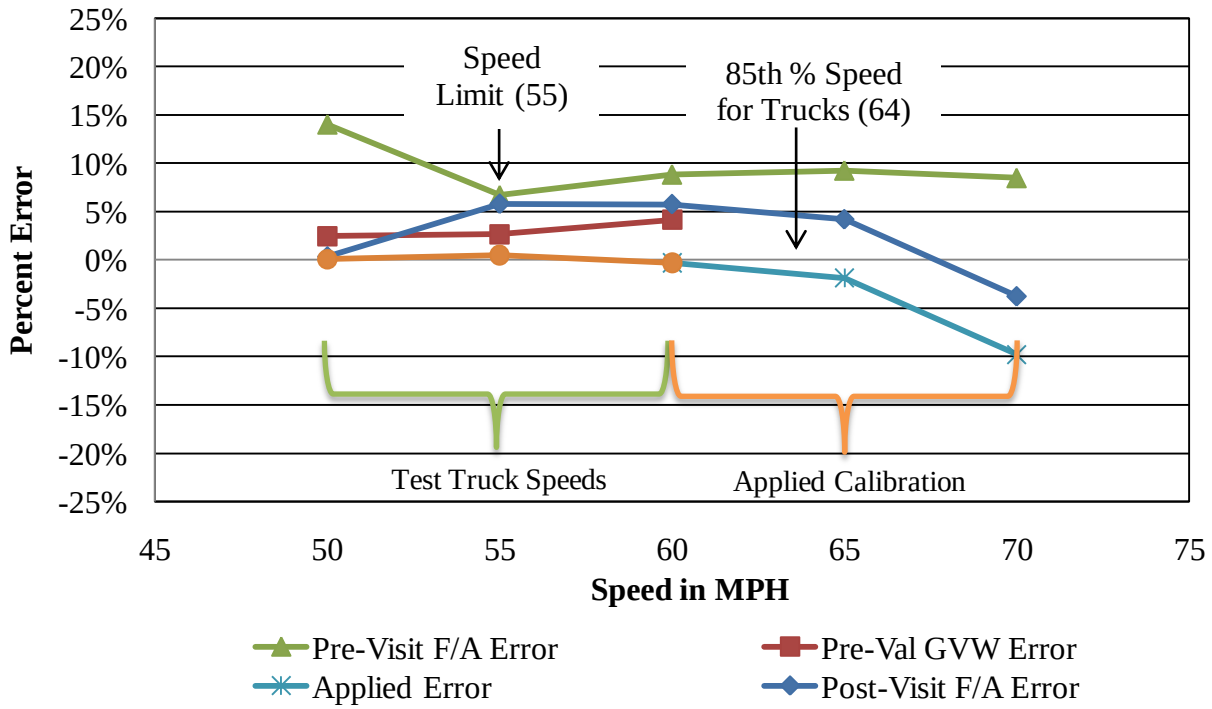


Figure 5-26 – Applied Calibration

Based on these errors and the GVW error trend developed from the post-validation test truck runs and shown in Figure 5-26, applied errors were calculated and are given in Table 5-20.

Table 5-20 – Recommended Factor Changes from Applied Error

Speed Point	Speed	Old Factors		Applied Error	New Factors	
	mph	Left	Right		Left	Right
96	60	3333	3333	-0.3%	3343	3343
104	65	3229	3229	-1.9%	3290	3290
112	70	3229	3229	-9.8%	3579	3579

Considering the parameters left in place at the conclusion of the validation on August 18, 2010, along with the post-visit applied calibration recommendations shown above, the final factor recommendations for this site are provided in Table 5-21. Since the 85th percentile speed for trucks is 64 mph, and there were less than 100 trucks used to develop the 112 speed point factor for 70 mph, it is suggested that the speed factors for the 70 mph are not changed, as reflected in Table 5-21.

Table 5-21 – Recommended Final Speed Factors

Speed Point	Speed	Old Factors		Applied Error	New Factors	
		Left	Right		Left	Right
80	50	3314	3314	0.0%	3314	3314
88	55	3314	3314	0.0%	3314	3314
96	60	3333	3333	-0.3%	3343	3343
104	65	3229	3229	-1.9%	3290	3290
112	70	3229	3229	0.0%	3229	3229

6 Previous WIM Site Validation Information

As of March 26, 2008, the date of the most recent validation, this site required 5 more years of research quality data. Research quality data is defined to be at least 210 days in a year of data of known calibration meeting LTPP's precision requirements. A review of the LTPP Standard Release Database 24 shows that there are 19 consecutive months of level "E" WIM data for this site. This site requires 3 additional years of data to meet the minimum of five years of research quality data.

6.1 Sheet 16s

This site has validation information from one previous visit as well as the current one as summarized in the tables below. Table 6-1 data was extracted from the most recent previous validation report 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	
25-Mar-08	N/A	0%	0%	N/A	0%	0%	0%	0%	N/A	N/A	0%
26-Mar-08	0%	0%	0%	N/A	0%	0%	N/A	0%	N/A	N/A	0%
17-Aug-10	N/A	6%	0%	N/A	0%	0%	0%	0%	N/A	N/A	0%
18-Aug-10	N/A	25%	0%	100%	0%	0%	N/A	0%	0%	N/A	1%

Table 6-2 data was extracted from the most recent previous validation and was updated to include the results of this validation.

Table 6-2 – Weight Validation History

Date	Method	Mean Error and (SD)		
		GVW	Single Axles	Tandem
25-Mar-08	Test Trucks	1.1 (1.1)	1.2 (1.7)	1.0 (1.4)
26-Mar-08	Test Trucks	1.2 (0.7)	0.3 (1.8)	1.3 (1.4)
17-Aug-10	Test Trucks	3.2 (1.2)	3.0 (2.1)	3.6 (2.0)
18-Aug-10	Test Trucks	-0.1 (1.2)	-1.1 (2.1)	0.2 (1.9)

The variability of the weight errors appears to have remained reasonably consistent since the site was first validated. From this information, it appears that the system demonstrates a slight tendency for the equipment to move toward an underestimation of GVW over time.

6.2 Comparison of Past Validation Results

A comparison of the post-validation results from previous visits is provided in Table 6-3.

Table 6-3 – Comparison of Post-Validation Results

Parameter	95 %Confidence Limit of Error	Site Values	
		26-Mar-08	18-Aug-10
Single Axles	±20 percent	0.3 ± 3.6	0.1 ± 5.5
Tandem Axles	±15 percent	1.3 ± 2.7	-0.3 ± 2.9
GVW	±10 percent	1.2 ± 1.4	0.0 ± 2.5

From the table, it appears that the variance for all weights has remained reasonably consistent since the equipment was installed.

As shown in the table above, the WIM equipment has demonstrated a positive drift of approximately 1.2 percent per year, on average. The graph demonstrates the effectiveness of the validations in bringing the weight estimations back to 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 – Calibration Test Truck Data
- Sheet 21 – WIM System Truck Records
- Sheet 22 – Site Equipment Assessment plus Addendum
- Sheet 23 – WIM Troubleshooting Outline
- Sheet 24A/B/C – Site Photograph Logs
- Updated Handout Guide

WIM System Field Calibration and Validation - Photos

California, SPS-2
SHRP ID: 060200

Validation Date: August 18, 2010
Submitted: 10/22/2010

Photo 1 – Cabinet Exterior

Photo 2 – Cabinet Interior (Back)

Photo 3 – Cabinet Interior (Front)

Photo 4 – Leading Loop

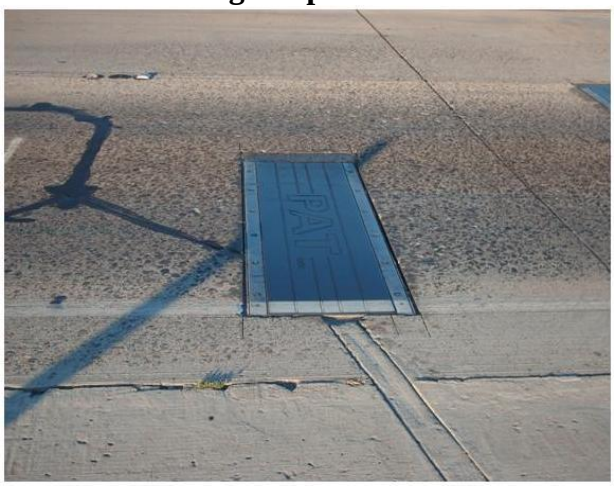


Photo 5 – Leading WIM Sensor

Photo 6 – Trailing WIM Sensor

Photo 7 – Trailing Loop Sensor

Photo 10 – Cellular Modem

Photo 8 – Solar Panel

Photo 11 – Downstream

Photo 9 – Solar Panel Damage

Photo 12 – Upstream

Photo 13 – Pavement Condition at WIM Site

Photo 16 – Day 1 – Truck 1 Trailer and Load

Photo 14 – Day 1 – Truck 1

Photo 17 – Day 1 – Truck 1 Suspension 1

Photo 15 – Day 1 – Truck 1 Tractor

Photo 18 – Day 1 – Truck 1 Suspension 2/3

Photo 19 – Day 1 – Truck 1 Suspension 4

Photo 20 – Day 1 – Truck 1 Suspension 5

Photo 21 – Day 1 – Truck 2

Photo 22 – Day 1 – Truck 2 Tractor

Photo 23 – Day 1 – Truck 2 Trailer and Load

Photo 24 – Day 1 – Truck 2 Suspension 1

Photo 25 – Day 1 – Truck 2 Suspension 2/3

Photo 28 – Day 2 – Truck 1 Tractor

Photo 26 – Day 1 – Truck 2 Suspension 4

Photo 29 – Day 2 – Truck 1 –Load

Photo 27 – Day 1 – Truck 2 Suspension 5

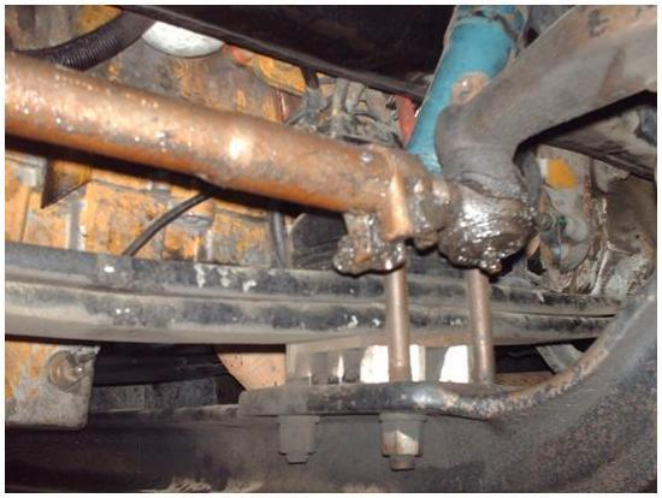


Photo 30 – Day 2 – Truck 1 – Suspension 1

Photo 31 – Day 2 – Truck 1 – Suspension 2/3

Photo 34 – Day 2 – Truck 2 – Load

Photo 32 – Day 2 – Truck 1 – Suspension 4

Photo 35 – Day 2 – Truck 2 – Suspension 1

Photo 33 – Day 2 – Truck 1 – Suspension 5

Photo 36 – Day 2 – Truck 2 – Suspension 2/3

Photo 37 – Day 2 – Truck 2 – Suspension 4

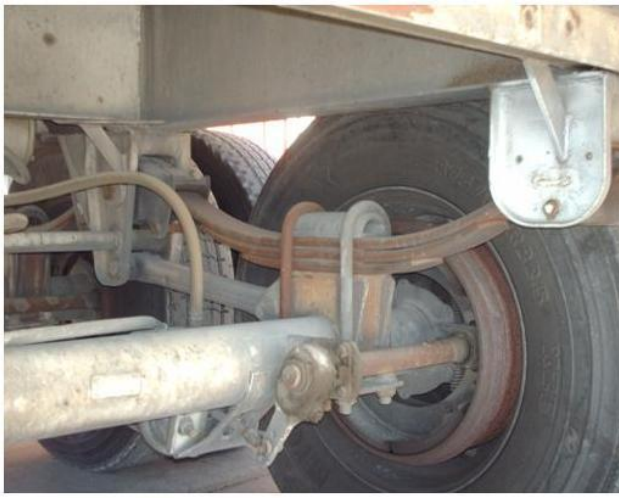


Photo 38 – Day 2 – Truck 2 – Suspension 5

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 06 SPS WIM ID: 060200 DATE (mm/dd/yyyy) 8/17/2010

SITE CALIBRATION INFORMATION

1. **DATE OF CALIBRATION** {mm/dd/yy} 8/17/10

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. Bending Plates
   - b. Inductance Loops
   - c.
   - 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	air
Truck 3:	0	0	0

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

   Mean Difference Between -

Dynamic and Static GVW:	3.2%	Standard Deviation:	1.2%
Dynamic and Static Single Axle:	3.0%	Standard Deviation:	2.1%
Dynamic and Static Double Axles:	3.6%	Standard Deviation:	2.0%

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

9. **DEFINE SPEED RANGES IN MPH:**

			Low		High	Runs
a.	Low	-	49.0	to	52.7	15
b.	Medium	-	52.8	to	57.0	10
c.	High	-	57.1	to	60.0	16
d.	0	-		to		
e.	0	-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 06 SPS WIM ID: 060200 DATE (mm/dd/yyyy) 8/17/2010

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3283 | 3283

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

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

The Auto-cal feature is using a linear progression of numerical values, starting at 1000 for 0 degrees, with a value incremented by 4 for every degree up to 100 degrees.

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:	0.0	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: 06 SPS WIM ID: 060200 DATE (mm/dd/yyyy) 8/18/2010

SITE CALIBRATION INFORMATION

1. **DATE OF CALIBRATION** {mm/dd/yy} 8/18/10

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

5. **EQUIPMENT MANUFACTURER:** IRD iSINC

WIM SYSTEM CALIBRATION SPECIFICS

6. **CALIBRATION TECHNIQUE USED:** Test Trucks

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

	Type	Drive Suspension	Trailer Suspension
Truck 1:	9	air	air
Truck 2:	9	air	air
Truck 3:	0	0	0

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

Mean Difference Between -

Dynamic and Static GVW:	-0.1%	Standard Deviation:	1.2%
Dynamic and Static Single Axle:	-1.1%	Standard Deviation:	2.1%
Dynamic and Static Double Axles:	0.2%	Standard Deviation:	1.9%

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

9. **DEFINE SPEED RANGES IN MPH:**

			Low		High	Runs
a.	Low	-	49.0	to	53.3	13
b.	Medium	-	53.4	to	57.8	13
c.	High	-	57.9	to	62.0	14
d.	0	-		to		
e.	0	-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 06 SPS WIM ID: 060200 DATE (mm/dd/yyyy) 8/18/2010

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3342 | 3342

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

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

The Auto-cal feature is using a linear progression of numerical values, starting at 1000 for 0 degrees, with a value incremented by 4 for every degree up to 100 degrees.

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:	9.0	FHWA Class	-	
		FHWA Class	-	
		FHWA Class	-	

Percent of "Unclassified" Vehicles: 0.8%

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: 06 SPS WIM ID: 060200 DATE (mm/dd/yyyy) 8/17/2010

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
61	9	2345	59	9	58	8	2534	56	8
57	11	2350	58	11	60	9	2548	58	9
63	8	2370	61	8	61	9	2551	62	9
62	9	2374	58	9	57	9	2555	54	9
64	9	2376	64	9	60	9	2562	57	9
59	9	2377	59	9	56	9	2568	53	9
59	11	2386	56	11	59	9	2599	55	9
59	9	2398	59	9	57	9	2603	56	9
55	9	2411	54	9	63	11	2608	60	11
58	9	2420	57	9	58	9	2614	58	9
62	5	2423	60	5	59	9	2616	57	9
59	9	2428	57	9	60	9	2622	58	9
59	9	2434	58	9	60	6	2627	58	6
56	9	2443	58	9	65	4	2630	61	5
60	9	2461	59	9	64	6	2643	59	6
59	5	2466	57	5	60	9	2646	58	9
58	9	2472	55	9	61	9	2653	60	9
56	9	2486	54	9	58	9	2661	56	9
57	9	2495	54	9	59	9	2665	57	9
54	9	2500	52	9	57	11	2671	54	11
57	11	2503	57	11	59	5	2676	56	5
55	9	2519	53	9	60	5	2682	57	5
60	9	2522	58	9	64	11	2689	60	11
60	9	2526	58	9	62	9	2696	63	9
60	9	2531	57	9	60	9	2700	58	9

Validation Test Truck Run Set - Pre

Sheet 1 - 0 to 50 Start: _____ Stop: _____

Recorded By: djw Verified By: kt

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 06 SPS WIM ID: 060200 DATE (mm/dd/yyyy) 8/17/2010

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
59	11	2710	57	11	65	5	2854	65	5
58	9	2717	56	9	64	9	2858	62	9
64	5	2720	63	5	62	11	2862	62	11
60	9	2723	57	9	60	9	2866	59	9
60	6	2727	58	6	56	9	2869	57	9
61	9	2731	59	9	65	9	2875	62	9
64	5	2738	66	5	59	5	2877	59	5
57	6	2742	54	6	57	9	2881	56	9
61	9	2749	59	9	62	11	2888	60	11
59	11	2751	58	11	58	9	2892	55	9
57	6	2754	56	6	67	5	2897	64	5
59	8	2761	57	8	63	5	2899	69	5
59	9	2769	56	9	62	5	2912	60	5
60	11	2773	57	11	60	9	2914	58	9
61	11	2779	59	11	59	9	2918	58	9
59	9	2786	56	9	60	9	2933	59	9
59	9	2797	58	9	57	9	2936	56	9
60	9	2802	59	9	59	11	2942	58	11
60	11	2810	58	11	67	5	2950	64	5
57	5	2818	54	5	60	9	2962	60	9
61	9	2829	57	9	59	9	2975	59	9
59	9	2836	58	9	58	11	2981	55	11
62	5	2842	59	5	65	9	2989	61	9
61	9	2845	60	9	62	9	2990	60	9
60	10	2849	59	10	59	9	2997	57	9

Validation Test Truck Run Set - Pre

Sheet 2 - 51 to 100 Start: _____ Stop: _____

Recorded By: djw Verified By: kt

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 06 SPS WIM ID: 060200 DATE (mm/dd/yyyy) 8/17/2010

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
60	9	3009	59	9					
61	11	3017	60	11					
60	11	3024	59	11					
58	6	3028	57	6					
60	9	3034	59	9					
61	9	3035	59	9					
55	9	3048	53	9					
59	9	3055	56	9					
58	9	3065	57	9					
56	11	3068	60	11					
61	11	3072	58	11					
65	8	3077	61	8					
59	9	3088	58	9					
54	9	3093	54	9					
59	11	3097	57	11					
59	5	3121	56	5					
59	9	3129	58	9					

Validation Test Truck Run Set - Pre

Sheet 101 - 150 Start: _____ Stop: _____

Recorded By: djw Verified By: kt

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 06 SPS WIM ID: 060200 DATE (mm/dd/yyyy) 8/18/2010

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
62	8	15809	59	8	62	11	15951	61	11
60	9	15822	57	9	59	8	15956	62	8
59	9	15830	55	9	61	8	15969	61	8
65	9	15834	62	9	62	9	15979	56	9
55	5	15838	56	5	64	9	15988	61	9
59	9	15846	56	9	61	9	15999	60	9
61	9	15848	59	9	58	9	16007	55	9
59	11	15852	55	11	62	5	16047	60	5
60	9	15858	59	9	59	9	16061	55	9
62	11	15863	59	11	62	8	16067	61	8
60	11	15867	58	11	62	9	16079	59	9
61	9	15869	58	9	62	9	16084	58	9
61	6	15872	58	6	60	9	16086	59	9
62	9	15879	59	9	60	6	16091	59	6
67	4	15880	63	5	59	9	16101	58	9
64	9	15890	61	9	67	4	16108	63	5
62	9	15893	58	9	60	9	16115	59	9
62	9	15902	59	9	62	9	16129	59	9
62	9	15905	58	9	60	11	16134	59	11
60	8	15909	58	8	62	9	16135	59	9
62	9	15914	58	9	59	6	16141	56	6
57	9	15920	56	9	60	9	16146	59	9
60	9	15930	55	9	64	9	16151	65	9
62	9	15934	59	9	58	9	16160	57	9
64	9	15945	62	9	62	9	16166	60	9

Validation Test Truck Run Set - Post

Sheet 1 - 0 to 50 Start: _____ Stop: _____

Recorded By: djw Verified By: kt

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 06 SPS WIM ID: 060200 DATE (mm/dd/yyyy) 8/18/2010

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
60	8	16177	59	8	63	9	16321	61	9
62	9	16187	59	9	59	15	16327	56	7
57	11	16191	54	11	60	6	16339	58	6
57	8	16199	57	8	61	9	16342	58	9
58	9	16201	60	9	58	9	16344	55	9
58	8	16208	55	8	60	6	16349	59	6
60	11	16212	58	11	55	11	16362	53	11
62	9	16218	58	9	62	9	16365	60	9
58	9	16223	53	9	68	9	16370	64	9
59	9	16229	56	9	59	5	16373	57	5
64	9	16236	62	9	64	9	16379	62	9
60	8	16242	59	8	57	9	16383	59	9
59	9	16245	56	9	59	9	16387	56	9
62	11	16248	58	11	61	8	16391	59	5
65	11	16255	64	11	60	9	16397	60	9
60	5	16259	59	5	57	9	16402	55	9
60	9	16246	58	9	60	5	16406	58	5
62	5	16273	59	5	60	9	16409	56	9
59	9	16277	58	9	57	9	16413	61	9
69	5	16285	66	5	64	8	16419	61	8
60	9	16296	58	9	58	11	16420	55	11
64	5	16301	62	5	60	9	16426	57	9
60	9	16306	57	9	62	9	16437	60	9
62	11	16312	60	11	62	12	16448	59	12
58	9	16315	60	9	59	9	16451	57	9

Validation Test Truck Run Set - Post

Sheet 2 - 51 to 100 Start: _____ Stop: _____

Recorded By: djw Verified By: kt

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 06 SPS WIM ID: 060200 DATE (mm/dd/yyyy) 8/18/2010

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
62	9	16465	60	9					
61	5	16469	59	5					
62	9	16474	60	9					
63	11	16482	61	11					
64	9	16491	61	9					
62	11	16494	59	11					
59	8	16498	56	8					
57	9	16506	55	9					
66	9	16513	62	9					
64	9	16518	71	9					
60	9	16522	58	9					
62	9	16532	59	9					
59	9	16534	55	9					
59	6	16538	56	6					
58	11	16544	59	11					
59	9	16552	57	9					
61	6	16559	58	6					
61	9	16564	59	9					
57	9	16567	58	9					
61	9	16571	62	9					

Validation Test Truck Run Set - Post

Sheet 101 - 150 Start: _____ Stop: _____

Recorded By: djw Verified By: kt