WIM System Field Calibration and Validation Summary Report

Colorado SPS-2
SHRP ID – 080200

Validation Date: February 21, 2012
Submitted: March 9, 2012

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1 Executive Summary

A WIM validation was performed on February 21, 2012 at the Colorado SPS-2 site located on route I-76, milepost 39.7, .75 miles east of Market Street interchange.

This site was installed on April 27, 2006. The in-road sensors are installed in the eastbound, righthand driving lane. The site is equipped with weighpad 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 March 17, 2011 and this validation visit, it appears that no changes have occurred during this time to the basic operating condition of the equipment.

The equipment is in working order. Electronic and electrical checks of the WIM components determined that the the equipment is operating within the manufacturer's tolerances. None of the in-road sensors show signs of damage or excessive wear and appear to be fully secured in the pavement. Further equipment discussion is provided in Section 3.

During the on-site pavement evaluation, There were no pavement distresses noted that may affect the accuracies of the WIM system. A visual observation of the trucks as they approach, traverse, and leave the sensor area did not indicate any adverse dynamics that would affect the accuracy of the WIM system. The trucks appear to track down the center of the lane. Further pavement condition discussion is provided in Section 4.

Based on the criteria contained in the LTPP Field Operations Guide for SPS WIM Sites, Version 1.0 (05/09), this site is providing research quality loading data. The summary results of the validation are provided in Table 1-1 below.

Table 1-1 – Validation Results – 21-Feb-12

Parameter	**95% Confidence Limit of Error**	**Site Values**	**Pass/Fail**
Steering Axles	±20 percent	1.2 ± 5.3%	Pass
Tandem Axles	±15 percent	0.0 ± 4.5%	Pass
GVW	±10 percent	0.4 ± 2.9%	Pass
Vehicle Length	±3.0 percent (1.7 ft)	0.8 ± 1.0 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.2 ± 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 -0.1 ± 1.7 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 0.2 feet, and the speed and axle spacing measurements are based on the distance between the axle detector sensors, it can be concluded that the distance factor is set correctly and that the speeds being reported by the WIM equipment are within acceptable ranges.

This site is providing research quality vehicle classification data for heavy trucks (Class 6 – 13). The heavy truck misclassification rate of 1.1% is greater than the 2.0% acceptability criterion for LTPP SPS WIM sites. The overall misclassification rate of 10.3% from the 116 vehicle sample (Class 4 – 13) was primarily due to the 12 cross-classifications of vehicle Classes 3 through 8.

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

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

- The Secondary truck was a Class 9 vehicle with air suspension on the tractor tandem, air suspension on the trailer tandem, standard tandem spacing on the tractor and standard tandem on the trailer. The Secondary truck was loaded with pipe bedding sand.

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

Table 1-2 – Validation Test Truck Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	74.5	9.7	16.6	16.6	15.8	15.8	18.3	4.3	27.3	4.0	53.9	58.7
2	65.7	9.7	14.9	14.9	13.1	13.1	17.7	4.3	24.7	3.9	50.6	55.7

The posted speed limit at the site is 75 mph. During the testing, the speed of the test trucks ranged from to 63 to 77 mph, a variance of 14 mph.

During test truck runs, pavement temperature was collected using a hand-held infrared temperature device. The Validation pavement surface temperatures varied from 30.4 to 59.1 degrees Fahrenheit, a range of 28.7 degrees Fahrenheit. The sunny weather conditions nearly provided the desired 30 degree range in temperatures.

A review of the LTPP Standard Release Database 25 shows that there are 5 years of level “E” WIM data for this site. This site requires no additional years of data to meet the minimum of five years of research quality data.

2 WIM System Data Availability and Pre-Visit Data Analysis

To assess the quality of the current traffic data, a pre-visit analysis was conducted by comparing a two-week data sample from January 9, 2012 (Data) to the most recent Comparison Data Set (CDS) from March 21, 2011. The assessments performed prior to the site visits are used to develop similar expectations for the validation. The results of further investigations performed as a result of the analyses are provided in Section 5 of this report.

2.1 LTPP WIM Data Availability

A review of the LTPP Standard Release Database 25 shows that there are 5 years of level "E" WIM data for this site. Table 2-1 provides a breakdown of the available data for years 2006 to 2011.

Table 2-1 – LTPP Data Availability

Year	Total Number of Days in Year	Number of Months
2006	194	8
2007	351	12
2008	363	12
2009	365	12
2010	365	12
2011	260	10

As shown in the table, this site requires no additional years of data to meet the minimum of five years of research quality data. The data does not meet the 210-day minimum requirement for calendar year 2006.

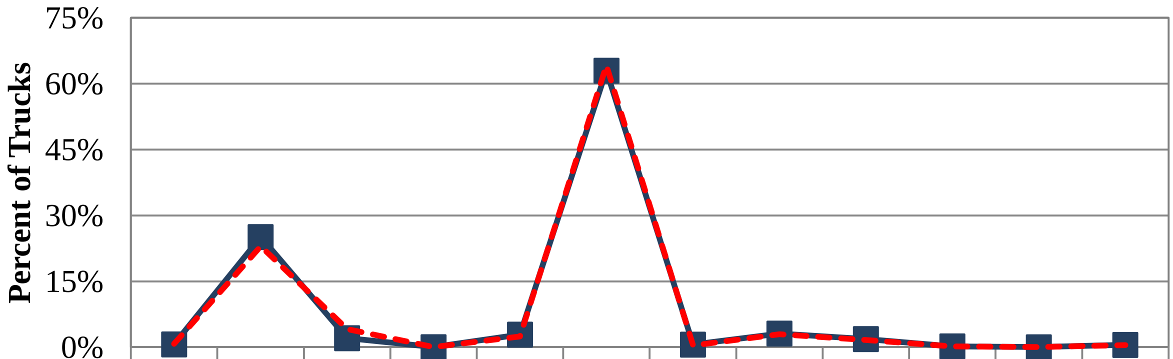
Table 2-2 provides a monthly breakdown of the available data for years 2006 through 2011.

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	
2006				3	31	30	30	10		29	30	31	8
2007	31	28	31	30	31	30	31	31	30	31	30	17	12
2008	31	29	29	30	31	30	31	30	30	31	30	31	12
2009	31	28	31	30	31	30	31	31	30	31	30	31	12
2010	31	28	31	30	31	30	31	31	30	31	30	31	12
2011	31	28	26	27	31	23	31	31	30	2			10

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 January 9, 2012 (Data) and the most recent Comparison Data Set (CDS) from March 21, 2011.



	4	5	6	7	8	9	10	11	12	13	14	15
Data	0.7%	25.1%	2.1%	0.0%	2.9%	63.0%	0.6%	3.1%	1.9%	0.2%	0.0%	0.5%
CDS	0.7%	23.0%	4.1%	0.0%	2.4%	64.2%	0.4%	2.9%	1.6%	0.2%	0.0%	0.5%

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 (63.0%) and Class 5 (25.1%) vehicles.

Table 2-3 also provides data for vehicle Classes 14 and 15. Class 14 vehicles are vehicles that are reported by the WIM equipment as having irregular measurements and cannot be classified properly, such as negative speeds from vehicles passing in the opposite direction of a two-lane road. Class 15 vehicles are unclassified vehicles. The table indicates that 0.5 percent of the vehicles at this site are unclassified.

Table 2-3 – Truck Distribution from W-Card

Vehicle Classification	CDS		Data		Change
	Date				
	3/21/2011		1/9/2012		
4	67	0.7%	111	0.7%	-0.1%
5	2115	23.0%	4263	25.1%	2.1%
6	380	4.1%	351	2.1%	-2.1%
7	1	0.0%	3	0.0%	0.0%
8	222	2.4%	489	2.9%	0.5%
9	5909	64.2%	10698	63.0%	-1.2%
10	33	0.4%	102	0.6%	0.2%
11	268	2.9%	529	3.1%	0.2%
12	149	1.6%	317	1.9%	0.2%
13	18	0.2%	35	0.2%	0.0%
14	0	0.0%	0	0.0%	0.0%
15	46	0.5%	91	0.5%	0.0%

From the table it can be seen that the percentage of Class 9 vehicles has decreased by 1.2 percent from March 2011 and January 2012. Changes in the number of heavier trucks may be attributed to natural and seasonal variations in truck distributions. During the same time period, the percentage of Class 5 trucks increased by 2.1 percent. These differences may be attributed to changes in the use of the roadway for local deliveries, cross-classifications of type 3 and 5 vehicles, as well as natural variations in truck volumes.

2.3 Speed Data Analysis

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

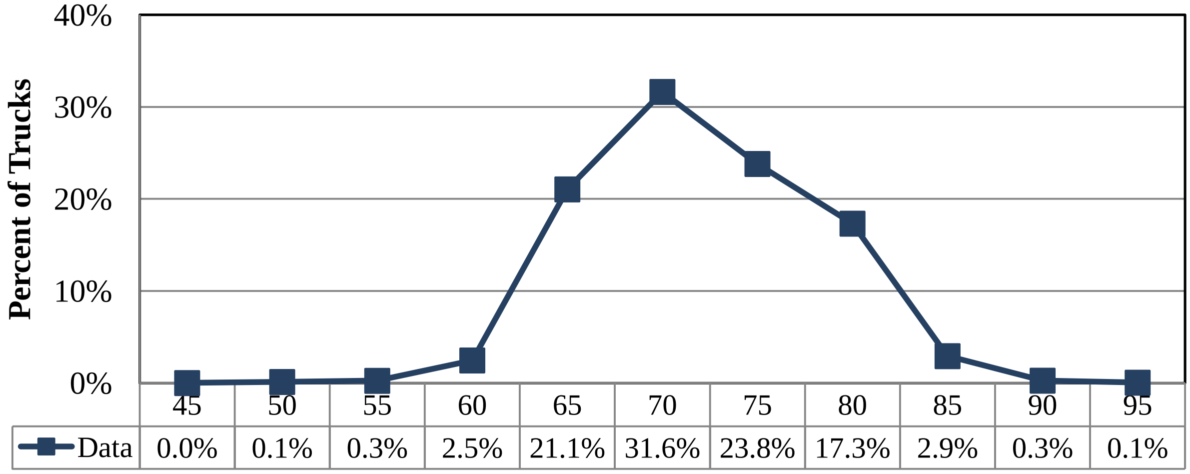


Figure 2-2 – Truck Speed Distribution – 17-Jan-12

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 76 mph. The range of truck speeds for the validation will be 65 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 January 2012 and the Comparison Data Set from March 2011.

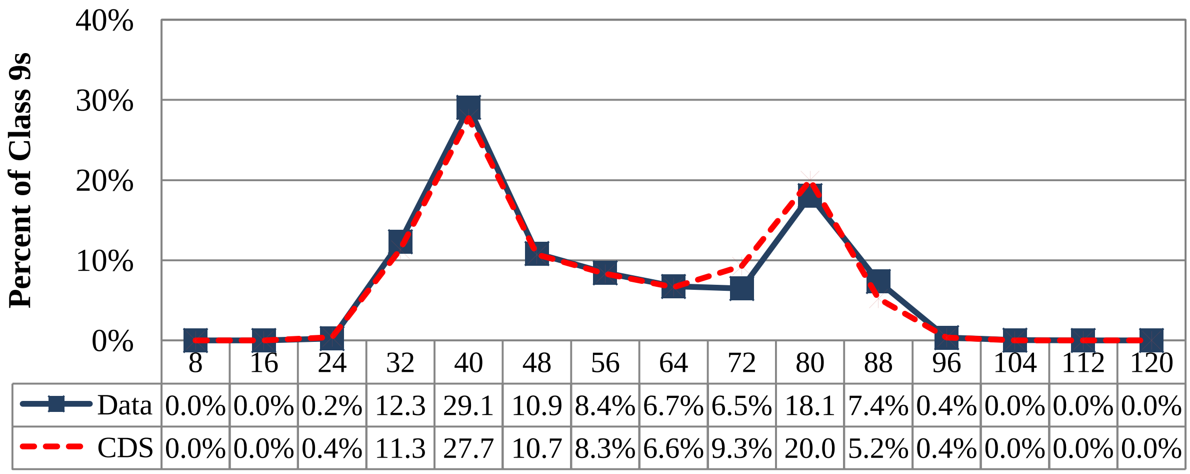


Figure 2-3 – Comparison of Class 9 GVW Distribution

As shown in Figure 2-3, there is a slight shift to the right for the loaded peak between the March 2011 Comparison Data Set (CDS) and the January 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 possible positive bias (overestimation of loads).

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

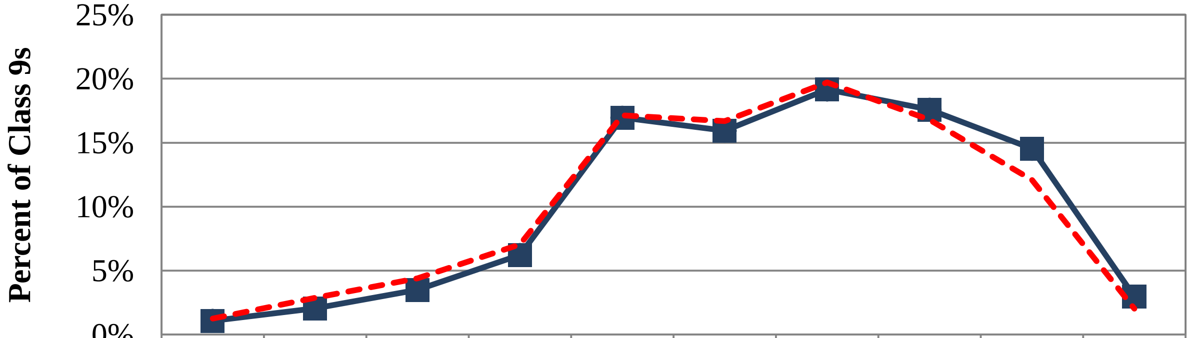
GVW weight bins (kips)	CDS		Data		Change
	Date				
	3/21/2011		1/9/2012		
8	0	0.0%	0	0.0%	0.0%
16	0	0.0%	0	0.0%	0.0%
24	23	0.4%	26	0.2%	-0.1%
32	668	11.3%	1313	12.3%	1.0%
40	1635	27.7%	3099	29.1%	1.4%
48	631	10.7%	1156	10.9%	0.1%
56	491	8.3%	899	8.4%	0.1%
64	391	6.6%	718	6.7%	0.1%
72	547	9.3%	691	6.5%	-2.8%
80	1178	20.0%	1926	18.1%	-1.9%
88	309	5.2%	784	7.4%	2.1%
96	21	0.4%	38	0.4%	0.0%
104	1	0.0%	4	0.0%	0.0%
112	0	0.0%	0	0.0%	0.0%
120	0	0.0%	0	0.0%	0.0%
Average =	52.5 kips		51.9 kips		-0.6 kips

As shown in the table, the percentage of unloaded class 9 trucks in the 32 to 40 kips range increased by 1.4 percent while the percentage of loaded class 9 trucks in the 72 to 80 kips range decreased by 1.9 percent. During this time period the percentage of overweight trucks increased by 2.1 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 52.5 to 51.9 kips.

2.5 Class 9 Front Axle Weight Data Analysis

The CDS data received from the Regional Support Contractor was analyzed to determine the expected average front axle weight. This will provide a basis for the evaluation of the quality of the data by comparing the average front axle weight from the current data sample set with the expected average front axle weight average from the Data Comparison Set.

Figure 2-4 shows a comparison between Class 9 front axle weight plots generated by using the two week W-card sample from January 2012 and the Comparison Data Set from March 2011. The percentage of light axles (9.5 to 10.5 kips) decreased by approximately 1.9 percent and the percentage of heavy axles (12.0 to 13.0 kips) increased by approximately 3.2%, indicating possible positive bias (overestimation of loads) in front axle measurement.



	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5
Data	1.1%	2.1%	3.5%	6.2%	17.0%	15.9%	19.2%	17.6%	14.5%	3.0%
CDS	1.2%	2.9%	4.4%	7.1%	17.1%	16.7%	19.7%	16.8%	12.1%	2.0%

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 11.5 and 12.0 kips. The percentage of trucks in this range has increased between the March 2011 Comparison Data Set (CDS) and the January 2012 dataset (Data).

Table 2-5 provides the Class 9 front axle weight distribution data for the March 2011 Comparison Data Set (CDS) and the January 2012 dataset (Data).

The table shows that the average front axle weight for Class 9 trucks has increased 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 11.6 kips.

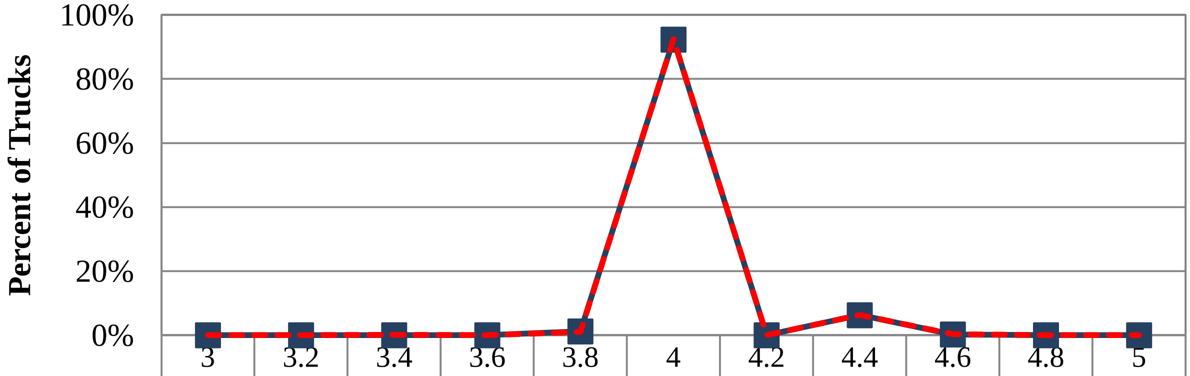
Table 2-5 – Class 9 Front Axle Weight Distribution from W-Card

F/A weight bins (kips)	CDS		Data		Change
	Date				
	3/21/2011		1/9/2012		
9.0	73	1.2%	114	1.1%	-0.2%
9.5	168	2.9%	216	2.1%	-0.8%
10.0	257	4.4%	367	3.5%	-0.9%
10.5	413	7.1%	655	6.2%	-0.8%
11.0	1004	17.1%	1783	17.0%	-0.2%
11.5	978	16.7%	1675	15.9%	-0.8%
12.0	1154	19.7%	2014	19.2%	-0.5%
12.5	983	16.8%	1849	17.6%	0.8%
13.0	708	12.1%	1527	14.5%	2.4%
13.5	119	2.0%	312	3.0%	0.9%
Average =	11.5 kips		11.6 kips		0.1 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. As seen in the figure, the Class 9 tractor tandem spacings for the March 2011 Comparison Data Set and the January 2012 Data are nearly identical.



	3	3.2	3.4	3.6	3.8	4	4.2	4.4	4.6	4.8	5
Data	0.0%	0.0%	0.0%	0.0%	1.2%	92.3%	0.0%	6.3%	0.2%	0.0%	0.0%
CDS	0.0%	0.0%	0.1%	0.0%	0.9%	92.4%	0.0%	6.3%	0.3%	0.0%	0.0%

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

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				
	3/21/2011		1/9/2012		
3.0	0	0.0%	0	0.0%	0.0%
3.2	0	0.0%	0	0.0%	0.0%
3.4	3	0.1%	1	0.0%	0.0%
3.6	0	0.0%	0	0.0%	0.0%
3.8	56	0.9%	127	1.2%	0.2%
4.0	5448	92.4%	9834	92.3%	-0.1%
4.2	0	0.0%	0	0.0%	0.0%
4.4	373	6.3%	666	6.3%	-0.1%
4.6	15	0.3%	26	0.2%	0.0%
4.8	0	0.0%	0	0.0%	0.0%
5.0	0	0.0%	0	0.0%	0.0%
Average =	4.0 feet		4.0 feet		0.0 feet

From the table it can be seen that the drive tandem spacing of Class 9 trucks at this site is between 3.8 and 4.6 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 the expected average of 4.0 from the CDS per vehicle records. Further axle spacing analyses are performed during the validation and Validation analysis.

2.7 Data Analysis Summary

Historical data analysis involved the comparison of the most recent Comparison Data Set (March 2011) based on the last calibration with the most recent two-week WIM data sample from the site (January 2012). Comparison of vehicle class distribution data indicates a 1.2 percent increase in the number of Class 9 vehicles. Analysis of Class 9 weight data indicates that front axle weights have increased by 0.9 percent and average Class 9 GVW has decreased by 1.1 percent for the January 2012 data. The data indicates an average truck tandem spacing of 4.0 feet, which is identical the expected average of 4.0 feet.

3 WIM Equipment Discussion

From a comparison between the report of the most recent validation of this equipment on December 10, 2012 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 April 27, 2006 by International Road Dynamics. It is instrumented with weighpad weighing sensors and an IRD iSINC WIM Controller. As the installation contractor, IRD also performs routine equipment maintenance and data quality checks of the WIM data.

3.2 Physical Inspection

Prior to the Validation test truck runs, a physical inspection of all WIM equipment and support services equipment was conducted. No deficiencies were noted. Photographs of all system components were taken and are presented after Section 7.

3.3 Electronic and Electrical Testing

Electronic and electrical checks of all system components were conducted prior to the Validation test truck runs. Dynamic and static electronic checks of the in-road sensors were performed. All values for the WIM sensors and inductive loops were within tolerances. Electronic tests of the power and communication devices indicated that they were operating normally.

3.4 Equipment Troubleshooting and Diagnostics

The WIM system appeared to collect, analyze and report vehicle measurements normally. No troubleshooting actions were taken.

3.5 Recommended Equipment Maintenance

No unscheduled equipment maintenance actions are recommended.

4 Pavement Discussion

4.1 Pavement Condition Survey

During a visual distress survey of the pavement conducted from the shoulder, no areas of pavement distress that may affect the accuracy of the WIM sensors were noted.

4.2 Profile and Vehicle Interaction

Profile data was collected on September 22, 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, 10 profile passes were made, 4 in the center of the travel lane and 6 that were shifted to the left and to the right of the center of the travel lane.

From a pre-visit review of the IRI values for the center, right, and left profile runs, the highest IRI value within the 1000 foot WIM section is 127 in/mi and is located approximately 469 feet prior to the WIM scale. The highest IRI value within the 400 foot approach section was 129 in/mi and is located approximately 393 feet prior to the WIM scale. These areas of the pavement were closely investigated during the validation visit, and truck dynamics in this area were closely observed. There were no distresses observed at these locations that would influence truck dynamics in the WIM scale area.

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

4.3 LTPP Pavement Profile Data Analysis

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

Table 4-1 – Recommended WIM Smoothness Index Thresholds

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

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

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

Table 4-2 – WIM Index Values

Profiler Passes			**Pass 1**	**Pass 2**	**Pass 3**	**Pass 4**	**Pass 5**	**Avg**
Left	LWP	LRI (m/km)	0.956	0.929	0.840			0.908
		SRI (m/km)	1.299	1.404	1.131			1.278
		Peak LRI (m/km)	1.102	1.081	1.026			1.070
		Peak SRI (m/km)	**1.633**	**1.610**	**1.223**			**1.489**
	RWP	LRI (m/km)	0.733	0.675	0.652			0.687
		SRI (m/km)	1.007	0.974	0.875			0.952
		Peak LRI (m/km)	0.739	0.715	0.698			0.717
		Peak SRI (m/km)	1.023	1.050	1.065			1.046
Center	LWP	LRI (m/km)	0.879	0.826	0.778	0.843		0.832
		SRI (m/km)	1.568	1.044	1.082	0.945		1.160
		Peak LRI (m/km)	0.960	0.934	0.997	1.029		0.980
		Peak SRI (m/km)	1.626	1.323	1.107	1.027		1.271
	RWP	LRI (m/km)	0.672	0.626	0.684	0.653		0.659
		SRI (m/km)	1.173	1.048	1.032	0.997		1.063
		Peak LRI (m/km)	0.851	0.729	0.723	0.671		0.744
		Peak SRI (m/km)	1.173	1.054	1.081	1.050		1.090
Right	LWP	LRI (m/km)	0.741	0.691	0.649			0.694
		SRI (m/km)	0.885	1.006	0.851			0.914
		Peak LRI (m/km)	0.870	0.841	0.919			0.877
		Peak SRI (m/km)	0.938	1.072	0.919			0.976
	RWP	LRI (m/km)	0.789	0.865	0.979			0.878
		SRI (m/km)	0.909	0.893	0.973			0.925
		Peak LRI (m/km)	0.908	1.109	1.099			1.039
		Peak SRI (m/km)	1.069	0.910	1.021			1.000

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

4.4 Recommended Pavement Remediation

No pavement remediation is recommended.

5 Statistical Reliability of the WIM Equipment

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

5.1 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 Validation test truck runs were conducted on February 21, 2012, beginning at approximately 8:16 AM and continuing until 5:29 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with pipe bedding sand, 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 pipe bedding sand, 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.

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

Table 5-1 – Validation Test Truck 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	74.5	9.7	16.6	16.6	15.8	15.8	18.3	4.3	27.3	4.0	53.9	58.7
2	65.7	9.7	14.9	14.9	13.1	13.1	17.7	4.3	24.7	3.9	50.6	55.7

Test truck speeds varied by 14 mph, from 63 to 77 mph. The measured Validation pavement temperatures varied 28.7 degrees Fahrenheit, from 30.4 to 59.1. The sunny weather conditions nearly provided the desired 30 degree temperature range. Table 5-2 provides a summary of the Validation results.

Table 5-2 – Validation Overall Results – 21-Feb-12

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	+20 percent	1.2 ± 5.3%	Pass
Tandem Axles	+15 percent	0.0 ± 4.5%	Pass
GVW	+10 percent	0.4 ± 2.9%	Pass
Vehicle Length	±3.0 percent (1.7 ft)	0.8 ± 1.0 ft	Pass
Axle Length	+ 0.5 ft [150mm]	0.2 ± 0.2 ft	Pass

As shown in Table 5-2, the site met all LTPP requirements for loading and distance measurement as a result of the Validation test truck runs.

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 -0.1 ± 1.7 mph, which is greater than the +1.0 mph tolerance established by the LTPP Field Guide. However, since the site is measuring axle spacing length with a mean error of 0.2 feet, and the speed and axle spacing measurements are based on the distance between the axle detector sensors, it can be concluded that the distance factor is set correctly and that the speeds being reported by the WIM equipment are within similar acceptable ranges.

5.1.1 Statistical Speed Analysis

Statistical analysis was conducted on the test truck run data to investigate whether a relationship exists between speed and WIM equipment weight and distance measurement accuracy. The posted speed limit at this site is 75 mph. The test runs were divided into three speed groups - low, medium and high speeds, as shown in Table 5-3.

Table 5-3 – Validation Results by Speed – 21-Feb-12

Parameter	95% Confidence Limit of Error	Low	Medium	High
		63.0 to 67.7 mph	67.8 to 72.4 mph	72.5 to 77.0 mph
Steering Axles	+20 percent	3.0 ± 5.0%	0.0 ± 4.5%	0.0 ± 4.7%
Tandem Axles	+15 percent	0.3 ± 4.4%	0.5 ± 5.5%	-0.3 ± 4.6%
GVW	+10 percent	0.7 ± 3.0%	0.5 ± 3.5%	-0.1 ± 2.7%
Vehicle Length	±3.0 percent (1.7 ft)	0.7 ± 1.1 ft	0.9 ± 1.1 ft	0.8 ± 1.2 ft
Vehicle Speed	± 1.0 mph	0.2 ± 0.2 mph	0.2 ± 0.2 mph	0.1 ± 0.2 mph
Axle Length	+ 0.5 ft [150mm]	-0.2 ± 1.6 ft	-0.4 ± 1.4 ft	0.3 ± 2.2 ft

From the table, it can be seen that, on average, the WIM equipment estimates all weights with similar accuracy at all speeds.

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

5.1.1.1 GVW Errors by Speed

As shown in Figure 5-1, the equipment overestimates GVW at the low speeds and estimates correctly with similar accuracy at the medium and high speeds. The range in error is similar at all speeds.

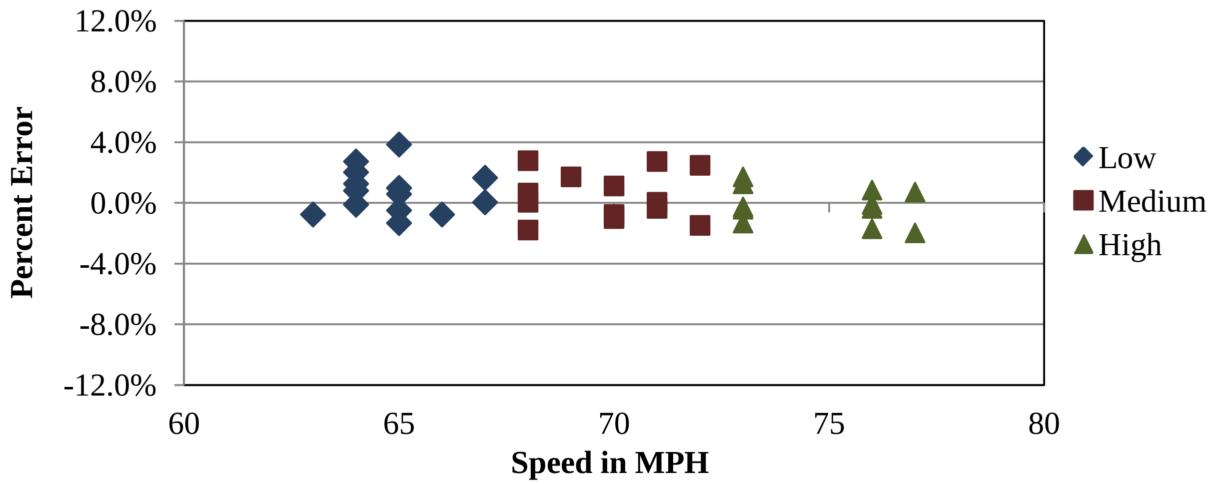


Figure 5-1 – Validation GVW Error by Speed – 21-Feb-12

5.1.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-2, the equipment overestimates steering axle weights at the low speeds and estimates correctly with similar accuracy at the medium and high speeds. It appears that the percent error decreases as the speed increases.

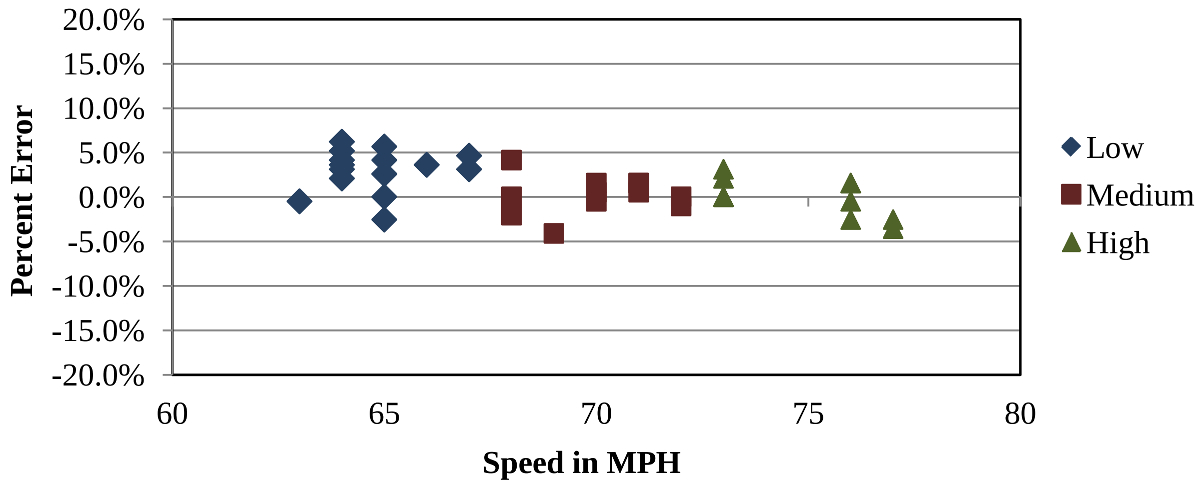


Figure 5-2 – Validation Steering Axle Weight Errors by Speed – 21-Feb-12

5.1.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 5-3, the equipment estimated tandem axle weights with similar accuracy at all speeds. The range in error is consistent throughout the entire speed range.

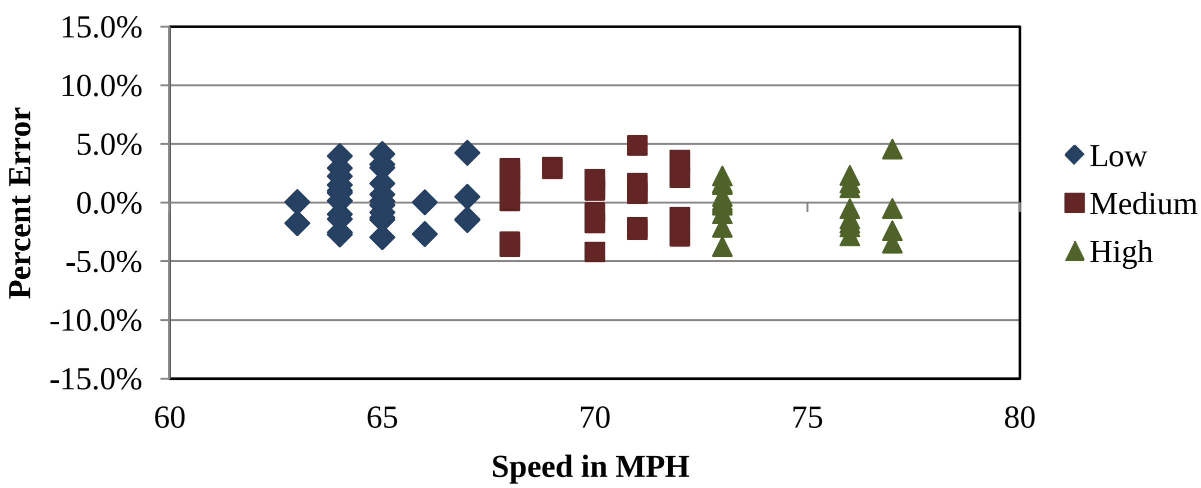


Figure 5-3 – Validation Tandem Axle Weight Errors by Speed – 21-Feb-12

5.1.1.4 GVW Errors by Speed and Truck Type

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

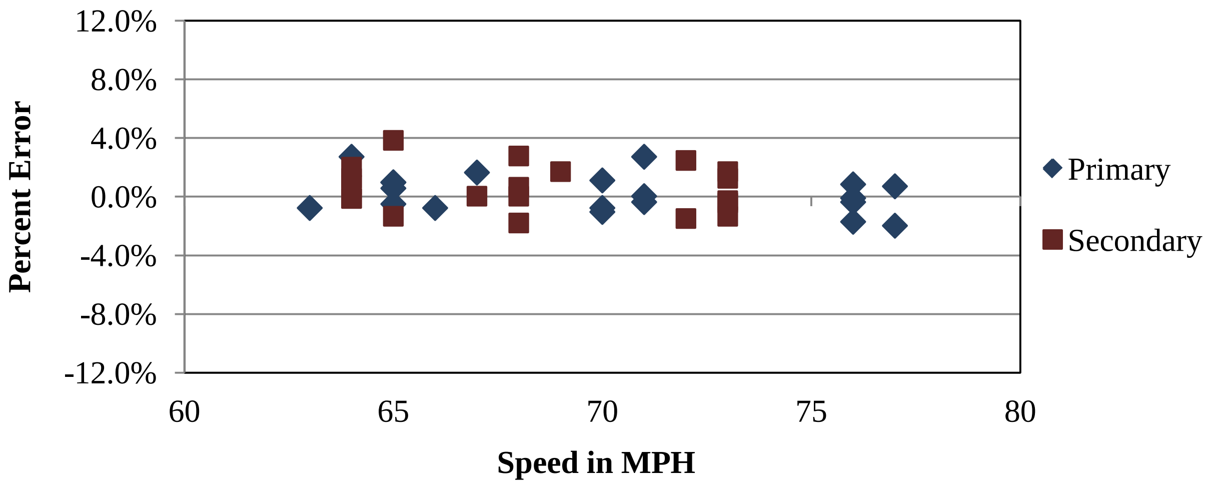


Figure 5-4 – Validation GVW Errors by Truck and Speed – 21-Feb-12

5.1.1.5 Axle Length Errors by Speed

For this site, the error in axle length measurement was consistent at all speeds. The range in axle length measurement error ranged from 0.0 feet to 0.3 feet. Distribution of errors is shown graphically in Figure 5-5.

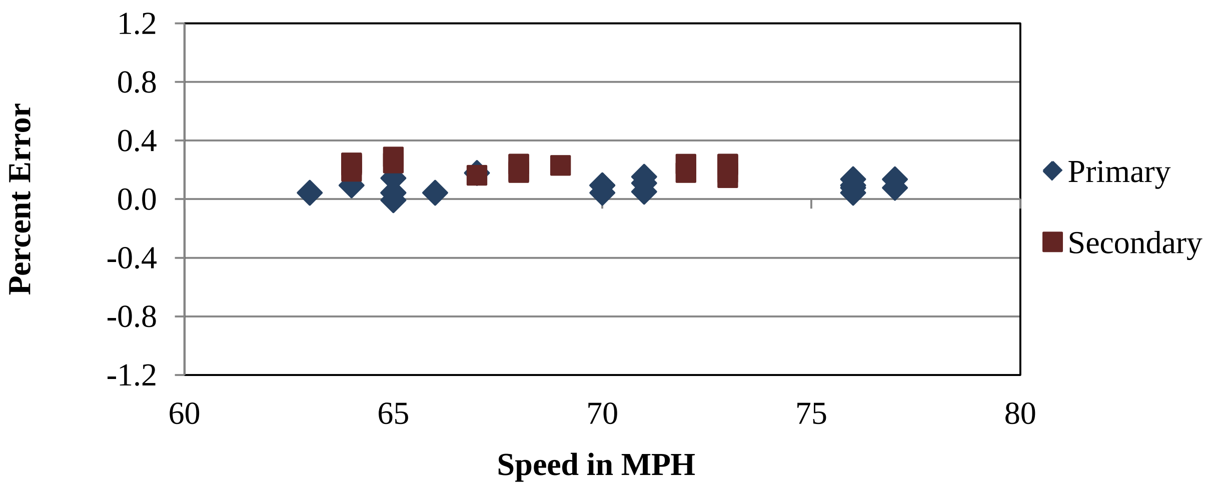


Figure 5-5 – Validation Axle Length Errors by Speed – 21-Feb-12

5.1.1.6 Overall Length Errors by Speed

For this system, the WIM equipment overestimated overall vehicle length consistently over the entire range of speeds, with an error range of 0.3 to 1.3 feet. Distribution of errors is shown graphically in Figure 5-6.

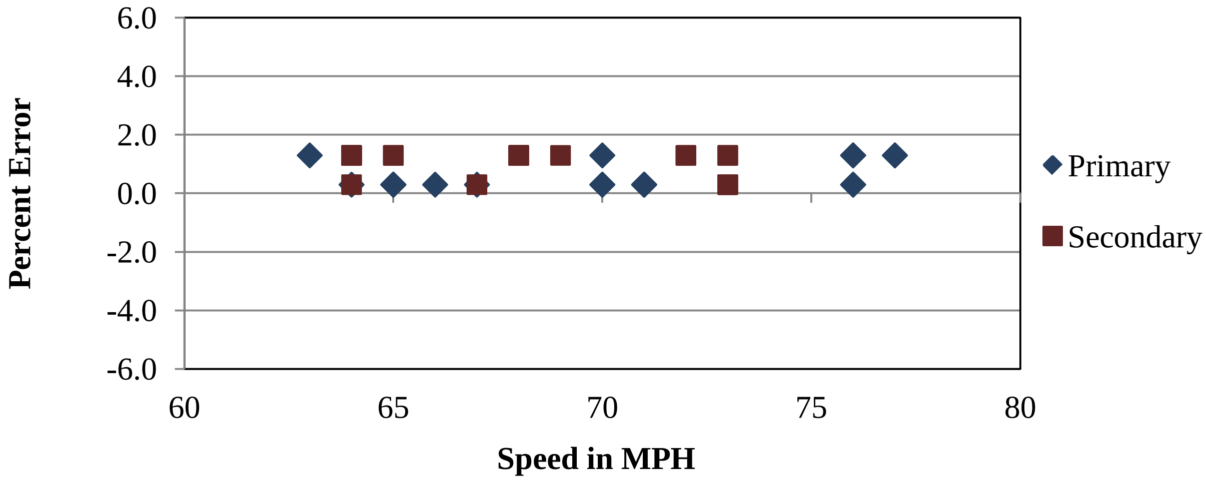


Figure 5-6 – Validation Overall Length Error by Speed – 21-Feb-12

5.1.2 Statistical Temperature Analysis

Statistical analysis was performed for the test truck run data to investigate whether a relationship exists between pavement temperature and WIM equipment weight and distance measurement accuracy. The range of pavement temperatures varied *28.7* degrees, from *30.4 to 59.1* degrees Fahrenheit. The Validation test runs are being reported under three temperature groups – low, medium and high, as shown in Table 5-4.

Table 5-4 – Validation Results by Temperature – 21-Feb-12

Parameter	95% Confidence Limit of Error	Low	Medium	High
		30.4 to 40 degF	40.1 to 50.0 degF	50.1 to 59.1 degF
Steering Axles	±20 percent	0.3 ± 3.4%	1.2 ± 6.6%	1.6 ± 5.8%
Tandem Axles	±15 percent	-0.8 ± 4.6%	1.0 ± 5.5%	0.2 ± 4.2%
GVW	±10 percent	-0.5 ± 2.0%	1.0 ± 3.4%	0.5 ± 2.9%
Vehicle Length	±3.0 percent (1.7 ft)	0.7 ± 1.2 ft	0.8 ± 1.2 ft	0.9 ± 1.1 ft
Vehicle Speed	± 1.0 mph	0.2 ± 0.2 mph	0.2 ± 0.2 mph	0.1 ± 0.2 mph
Axle Length	± 0.5 ft [150mm]	-0.4 ± 1.2 ft	0.3 ± 2.5 ft	-0.2 ± 1.5 ft

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

5.1.2.1 GVW Errors by Temperature

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

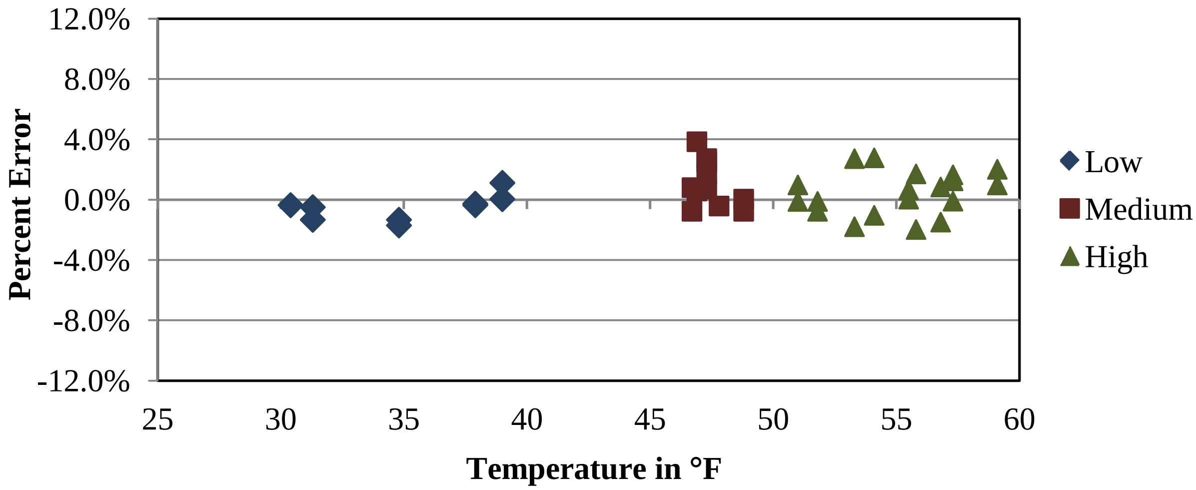


Figure 5-7 – Validation GVW Errors by Temperature – 21-Feb-12

5.1.2.2 Steering Axle Weight Errors by Temperature

Figure 5-8 illustrates that for steering axles, the WIM equipment appears to estimate weights with similar accuracy across the range of temperatures observed in the field. There does not appear to be a correlation between temperature and steering axle weight estimates at this site. The range in error is slightly lower at low temperatures, although this may be due to the lower number of samples at those temperatures.

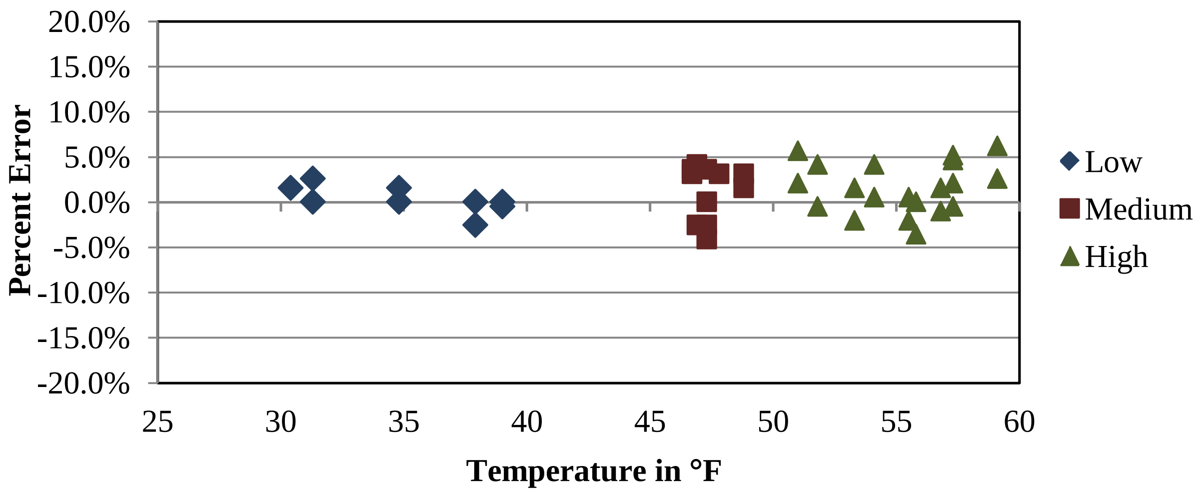


Figure 5-8 – Validation Steering Axle Weight Errors by Temperature – 21-Feb-12

5.1.2.3 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-9, the WIM equipment appears to estimate tandem axle weights with similar accuracy across the range of temperatures observed in the field. There does not appear to be a correlation between temperature and tandem axle weight estimates at this site.

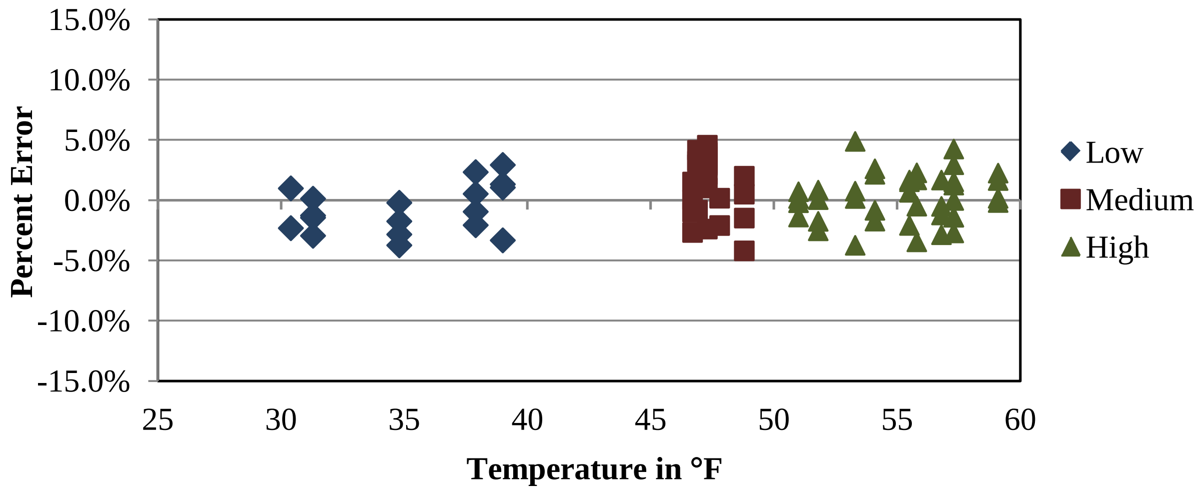


Figure 5-9 – Validation Tandem Axle Weight Errors by Temperature – 21-Feb-12

5.1.2.4 GVW Errors by Temperature and Truck Type

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

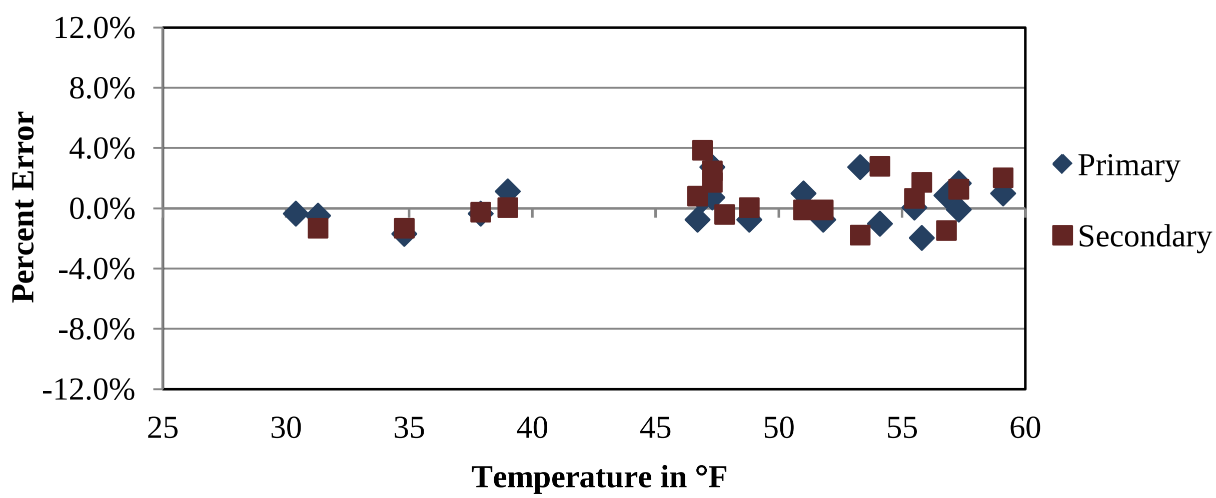


Figure 5-10 – Validation GVW Error by Truck and Temperature – 21-Feb-12

5.2 Calibration

Since the equipment is measuring all weight and distance parameters within the LTPP requirements for SPS WIM sites and with a very low bias (the average measurement error for GVW is 0.4 %), a calibration of the system was not needed and was not carried out.

5.3 GVW and Steering Axle Trends

Figure 5-11 is provided to illustrate the predicted GVW error with respect to the Validation errors by speed.

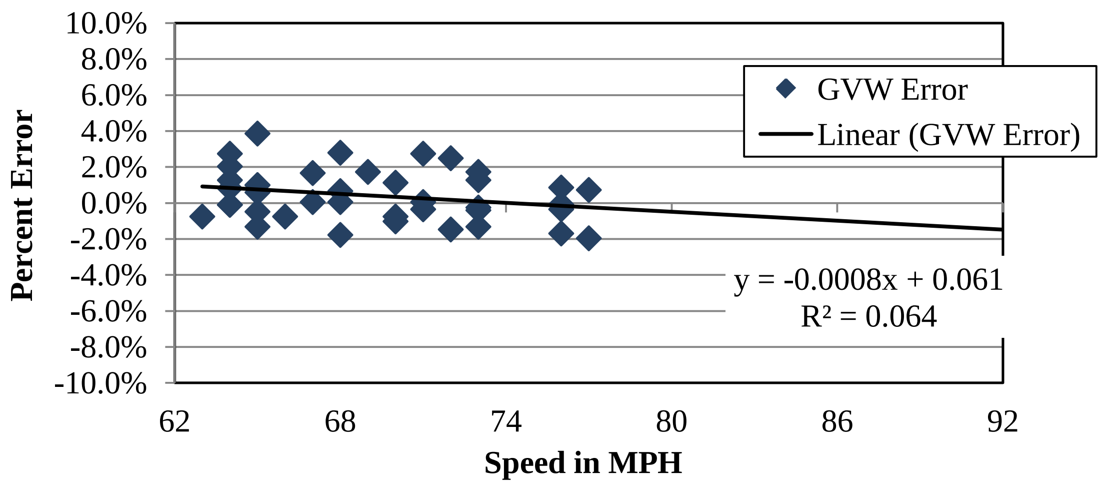


Figure 5-11 – GVW Error Trend by Speed

Figure 5-12 is provided to illustrate the predicted Steering Axle error with respect to the Validation errors by speed.

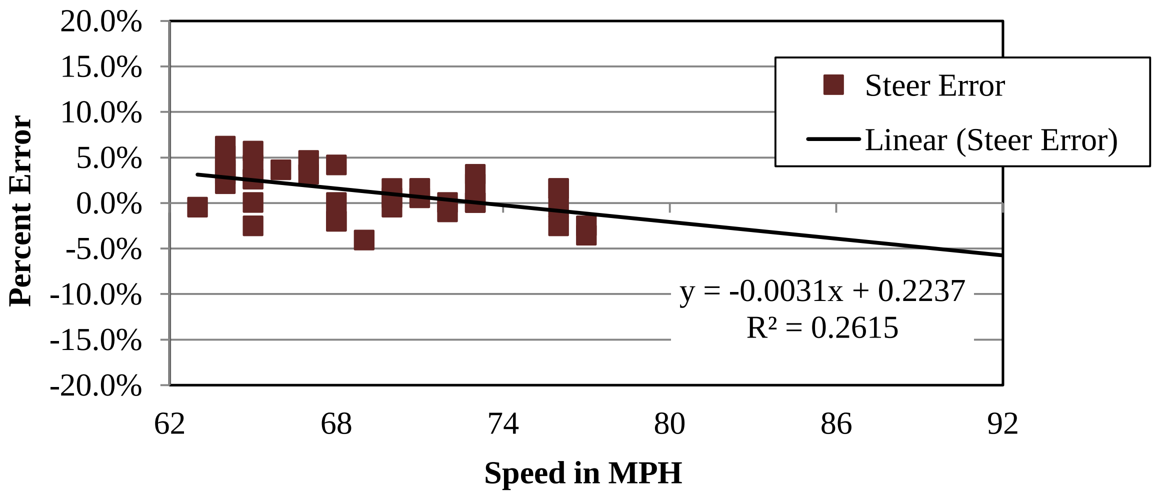


Figure 5-12 – Steering Axle Trend by Speed

5.4 Multivariable 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.

5.4.1.1 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 63 to 77 mph.
- Pavement temperature. Pavement temperature ranged from 30.4 to 59.1 degrees Fahrenheit.

5.4.1.2 Results

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

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

Parameter	Regression coefficients	Standard error	Value of t-distribution	Probability value (p-value)
Intercept	2.9678	3.8673	0.7674	0.4478
Speed	-0.0717	0.0511	-1.4030	0.1692
Temp	0.0471	0.0261	1.8065	0.0792
Truck	0.2228	0.4392	0.5073	0.6151

The lowest probability value given in Table 5-5 was 0.0792 for temperature. This means that there is about an 8 percent chance that the value of regression coefficient for temperature (0.0471) can occur by chance alone. The speed and truck type did not have a statistically significant effect on the GVW measurement errors.

The relationship between temperature and GVW measurement errors is shown in Figure 5-13. The figure includes a trend line for the predicted percent error. Besides the visual assessment of the relationship, Figure 5-13 provides quantification and statistical assessment of the relationship.

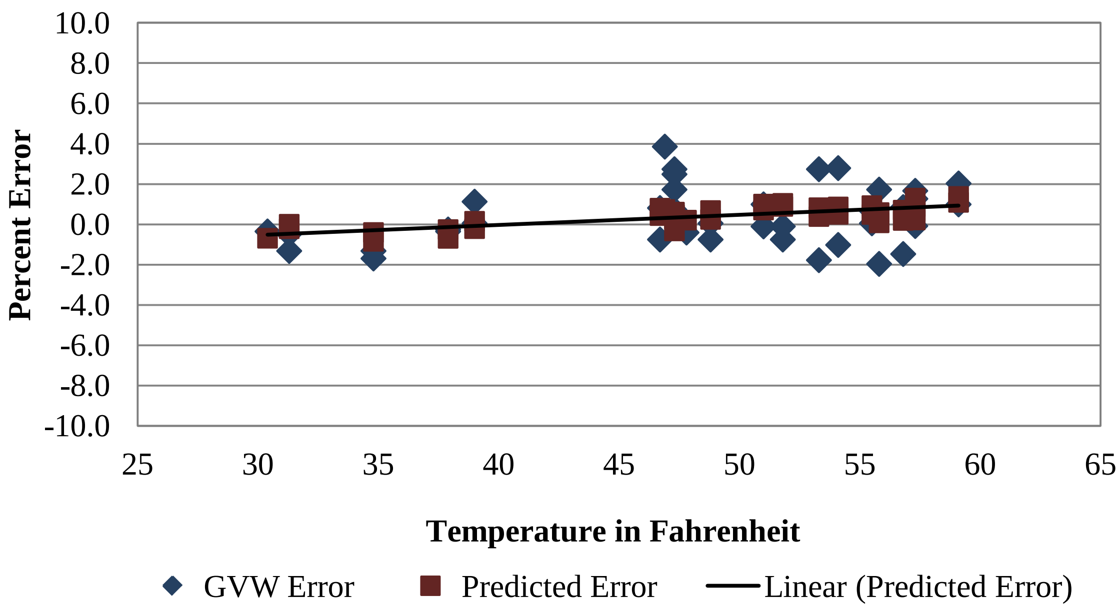


Figure 5-13 – Influence of Speed on the Measurement Error of GVW

The quantification of the relationship is provided by the value of the regression coefficient, in this case -0.0471 (in Table 5-5). This means, for example, that for a 10 degree increase in temperature, the error is increased by about .47 percent (-0.0471 x 10). The statistical assessment of the relationship is provided by the probability value of the regression coefficient (0.0792).

5.4.1.3 Summary Results

Table 5-6 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 5-6 indicates that the relationship was not significant (the probability that the relationship can occur by chance alone was greater than 20 percent).

Table 5-6 – Summary of Regression Analysis

Parameter	**Factor**					
	Speed		**Temperature**		**Truck type**	
	Regression coefficient	Probability value (p-value)	Regression coefficient	Probability value (p-value)	Regression coefficient	Probability value (p-value)
GVW	-0.0717	0.1692	0.0471	0.0792	–	–
Steering axle	-0.3029	0.0012	–	–	–	–
Tandem axle tractor	–	–	–	–	2.5377	$1.16\ 10^{-6}$
Tandem axle trailer	–	–	0.0661	0.1461	-2.1347	0.0072

5.4.1.4 Conclusions

1. Speed had a statistically significant effect on the measurement errors of steering axles only.

2. Temperature had only marginally statistically significant effect on the measurement errors of only GVW.

3. Truck type had highly statistically significant effect on the measurement errors of tandem axles. For the tandem axles on tractors the effect was positive and the for tandem axles on trailers negative. The regression coefficients for truck type in Table 5-6 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, for example, the mean measurement error of tractor tandem axles for the Primary truck was about 2.5% lower than the corresponding error for the Secondary truck, as shown in Figure 5-14. The opposite (and highly statistically significant) trend in the measurement errors of the tractor and tandem axles for the two test truck is unexpected – both test trucks have air suspension on all tandem axles and have similar dimensions (length and tandem axle spacings). We will continue monitoring the influence which the tandem axles on trucks and trailers may

have on the measurement errors associated with the truck type. The objective is to see if there are overall trends and how these trends can be utilized in better selection of test trucks.

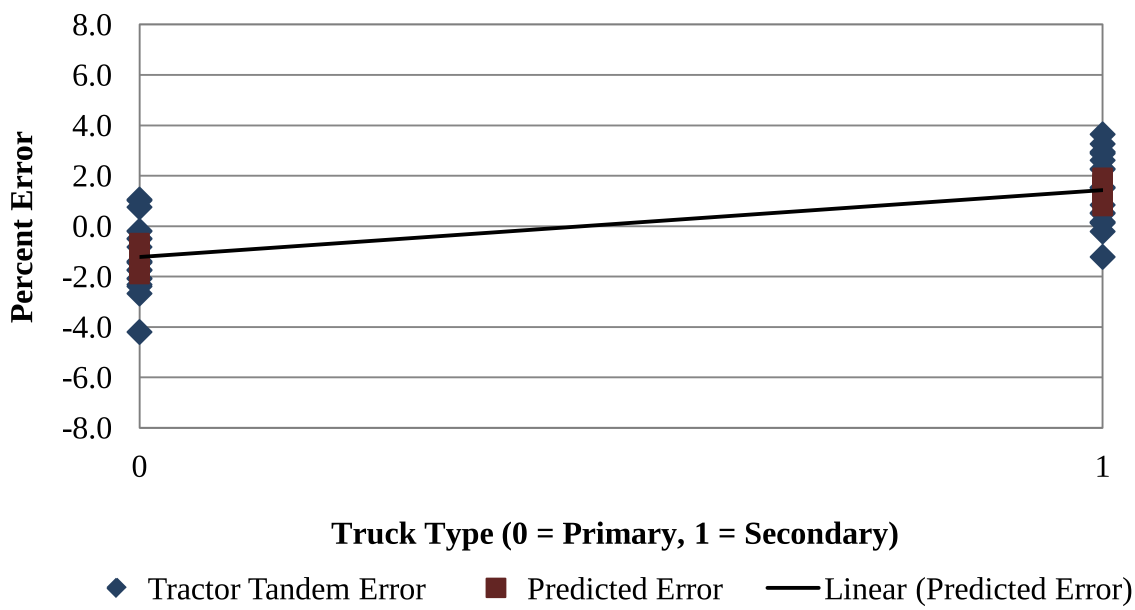


Figure 5-14 – Influence of Truck Type on the Measurement Error of Tractor Tandem Axles

4. Even though speed, temperature 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.

5.5 Classification and Speed Evaluation

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

For the Validation classification study at this site, a manual sample of 116 vehicles including 100 trucks (Class 4 through 13) was collected. Video was collected during the study to provide a means for further analysis of misclassifications and vehicles whose classifications could not be determined with a high degree of certainty in the field.

Misclassified vehicles are defined as those vehicles that are manually classified by observation as one type of vehicle but identified by the WIM equipment as another type of vehicle. The misclassifications by pair are provided in Table 5-7. The table illustrates the breakdown of vehicles observed and identified by the equipment for the manual classification study. As shown in Table 5-7, eight Class 3 vehicles were misclassified as a Class 5 vehicles, two Class 3 vehicles were misclassified as Class 8 vehicles, one Class 5 vehicle was misclassified as a Class 8 vehicle, and one Class 6 vehicle was misclassified as a Class 4 vehicle by the equipment.

Table 5-7 – Validation Misclassifications by Pair – 21-Feb-12

		WIM										
		3	4	5	6	7	8	9	10	11	12	13
Observed	3	-		8			2					
	4		-									
	5			-			1					
	6		1		-							
	7					-						
	8						-					
	9							-				
	10								-			
	11									-		
	12										-	
	13											-

As shown in the table, a total of 12 vehicles, including 1 heavy truck (vehicle classes 6 – 13) were misclassified by the equipment. Based on the vehicles observed during the Validation study, the misclassification percentage is 1.1% for heavy trucks (6 – 13), which is within the 2.0% acceptability criteria for LTPP SPS WIM sites. However, the overall misclassification rate for all vehicles (3 – 15) is high at 10.3 percent, primary due to misclassification of lightweight vehicles in class 3 as class 5 and class 8.

The causes for the misclassifications were not investigated in the field. A post-visit investigation of misclassified vehicles was performed using the collected video. The analysis determined that six of the Class 3s that were identified by the WIM system as Class 5s were full body pick-up trucks. The four other misclassified Class 3s were pick-ups towing trailers. The misclassified Class 5 vehicle was a dual-tired pick-up hauling a trailer. The Class 6 misidentified as a Class 4 was a short motor home.

The combined results of the misclassifications resulted in an undercount of ten Class 3 vehicles and one Class 6 vehicle, and an overcount of one Class 4 vehicle, seven Class 5 vehicles, and three Class 8 vehicles, as shown in Table 5-8. The misclassified percentage represents the percentage of the misclassified vehicles in the manual sample.

Table 5-8 – Validation Classification Study Results – 21-Feb-12

Class	3	4	5	6	7	8	9	10	11	12	13
Observed Count	16	1	10	6	0	2	74	0	7	0	0
WIM Count	6	2	17	5	0	5	74	0	7	0	0
Observed Percent	13.8	0.9	8.6	5.2	0.0	1.7	63.8	0.0	6.0	0.0	0.0
WIM Percent	5.2	1.7	14.7	4.3	0.0	4.3	63.8	0.0	6.0	0.0	0.0
Misclassified Count	10	0	1	1	0	0	0	0	0	0	0
Misclassified Percent	62.5	0.0	10.0	16.7	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. The unclassified vehicles by pair are provided in Table 5-9.

Table 5-9 – Validation Unclassified Trucks by Pair – 21-Feb-12

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

Based on the manually collected sample of the 100 trucks, none 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 1.8 mph.

6 Previous WIM Site Validation Information

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

6.1 Sheet 16s

This site has validation information from four previous visits as well as the current one as summarized in the tables below and provided on the Traffic Sheet 16. Table 6-1 data was extracted from 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	
27-Jun-06	-	0	30	0	-	0	0	-	0	0	-	0
28-Jun-06	-	-	38	0	-	0	0	0	0	-	-	1
16-Oct-07	-	-	0	0	-	0	0	-	0	-	-	0
17-Oct-07	-	100	11	-	-	0	0	-	0	0	-	0
29-Apr-08	-	100	29	25	-	75	3	-	0	-	0	0
30-Apr-08	-	-	22	0	100	100	4	0	0	0	-	5
16-Mar-11	-	0	13	0	0	0	0	0	0	0	0	0
17-Mar-11	-	0	0	0	0	0	0	0	0	0	0	0
21-Feb-12	63	0	10	17	0	0	0	0	0	0	0	0

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 standard deviation for GVW, single axles and tandems for prior pre- and Validations as reported on the LTPP Traffic Sheet 16s.

Table 6-2 – Weight Validation History

Date	Mean Error and SD		
	GVW	Single Axles	Tandem
27-Jun-06	3.3 ± 2.4	3.1 ± 2.8	3.3 ± 3.2
28-Jun-06	-0.6 ± 1.8	-1.2 ± 3.2	-0.5 ± 3.1
16-Oct-07	-3.5 ± 3.3	-7.5 ± 4.7	-2.8 ± 4.5
17-Oct-07	0.9 ± 2.6	-2.3 ± 4.5	1.5 ± 3.9
29-Apr-08	3.5 ± 1.7	-0.1 ± 1.6	4.2 ± 2.4
30-Apr-08	-0.9 ± 1.6	-5.0 ± 2.9	-0.1 ± 2.0
16-Mar-11	-3.0 ± 1.4	-7.2 ± 2.5	-2.7 ± 3.9
17-Mar-11	-0.1 ± 1.6	-1.1 ± 2.8	0.1 ± 2.3
21-Feb-12	0.4 ± 1.4	1.2 ± 2.6	0.2 ± 2.2

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 tendency for the equipment to move toward an underestimation of all weights over time. The table also demonstrates the effectiveness of the validations in bringing the weight estimations within LTPP SPS WIM equipment tolerances.

6.2 Comparison of Past Validation Results

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

Table 6-3 – Comparison of Validation Results

Parameter	95 %Confidence Limit of Error	Site Values (Mean Error and 95% Confidence Interval)				
		28-Jun-06	17-Oct-07	30-Apr-08	17-Mar-11	21-Feb-12
Steering Axles	±20 percent	-1.2 ± 6.6	-2.3 ± 9.2	-5.0 ± 5.8	-1.1 ± 5.7	1.2 ± 5.3
Tandem Axles	±15 percent	-0.5 ± 6.2	1.5 ± 7.8	-0.1 ± 4.0	0.1 ± 4.6	0.2 ± 4.5
GVW	±10 percent	-0.6 ± 3.6	0.9 ± 5.2	-0.9 ± 3.3	-0.1 ± 3.2	0.4 ± 2.9

From Table 6-3, it appears that the 95% confidence interval has decreased for all weights since the equipment was installed, with the exception of the October 17, 2007 validation, where the 95% confidence interval for all weights was increased.

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

Table 6-4 – Final Factors

Speed Point	MPH	Left	Right
		2	1
88	55	3489	3658
96	60	3505	3674
104	65	3470	3635
112	70	3443	3608
120	75	3435	3599
Axle Distance (cm)		372	
Dynamic Comp (%)		105	
Loop Width (cm)		273	

A review of the LTPP Standard Release Database 25 shows that there are 5 years of level "E" WIM data for this site. This site requires no additional years of data to meet the minimum of five years of research quality data.

7 Additional Information

The following information is provided in the attached appendix:

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

Additional information is available upon request through LTPP INFO at ltppinfo@dot.gov, or telephone (202) 493-3035. This information includes:

- Sheet 17 – WIM Site Inventory
- Sheet 18 – WIM Site Coordination
- Sheet 19 – Validation Test Truck Data
- Sheet 21 – WIM System Truck Records
- Sheet 22 – Site Equipment Assessment plus Addendum
- Sheet 24A/B/C – Site Photograph Logs
- Updated Handout Guide

WIM System Field Calibration and Validation - Photos

Colorado, SPS-2
SHRP ID: 080200

Validation Date: February 21, 2012

Photo 1 – Cabinet Exterior

Photo 2 – Cabinet Interior (Front)

Photo 3 – Cabinet Interior (Back)

Photo 4 – Leading Loop

Photo 5 – Leading WIM Sensor

Photo 6 – Trailing WIM Sensor

Photo 7 – Trailing Loop Sensor

Photo 8 – Power Service Box

Photo 9 – Telephone Service Box

Photo 10 – Downstream

Photo 11 – Upstream

Photo 12 – Truck 1

Photo 13 – Truck 1 Tractor

Photo 14 – Truck 1 Trailer and Load

Photo 15 – Truck 1 Suspension 1

Photo 16 – Truck 1 Suspension 2

Photo 17 – Truck 1 Suspension 3

Photo 18 – Truck 1 Suspension 4

Photo 19 – Truck 1 Suspension 5

Photo 20 – Truck 2

Photo 21 – Truck 2 Tractor

Photo 22 – Truck 2 Trailer and Load

Photo 23 – Truck 2 Suspension 1

Photo 24 – Truck 2 Suspension 2

Photo 25 – Truck 2 Suspension 3

Photo 26 – Truck 2 Suspension 5

Photo 27 – Truck 2 Suspension 4

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 08 SPS WIM ID: 080200 DATE (mm/dd/yyyy) 2/21/2012

SITE CALIBRATION INFORMATION

1. **DATE OF CALIBRATION** {mm/dd/yy} 2/21/12

2. **TYPE OF EQUIPMENT CALIBRATED:** Both

3. **REASON FOR CALIBRATION:** LTPP Validation

4. **SENSORS INSTALLED IN LTPP LANE AT THIS SITE** (Select all that apply):
   a. Inductance Loops c. ______
   b. Bending Plates d. ______

5. **EQUIPMENT MANUFACTURER:** IRD iSINC

WIM SYSTEM CALIBRATION SPECIFICS

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

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

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

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

Mean Difference Between -

	Mean Difference		Standard Deviation
Dynamic and Static GVW:	0.4%	Standard Deviation:	1.4%
Dynamic and Static Single Axle:	1.2%	Standard Deviation:	2.6%
Dynamic and Static Double Axles:	0.2%	Standard Deviation:	2.2%

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

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

			Low		High	Runs
a.	Low	-	63.0	to	67.7	16
b.	Medium	-	67.8	to	72.4	13
c.	High	-	72.5	to	77.0	11
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: SPS WIM ID: DATE (mm/dd/yyyy)	08 080200 2/21/2012

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3470 | 3635

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

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

CLASSIFIER TEST SPECIFICS

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

Manual

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

14. MEAN DIFFERENCE IN VOLUMES BY VEHICLES CLASSIFICATION:

FHWA Class 9:	0.0	FHWA Class		-	
FHWA Class 8:	150.0	FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 0.9%

Validation Test Truck Run Set - Pre

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: 08 SPS WIM ID: 080200 DATE (mm/dd/yyyy) 2/21/2012

Count - 116 Time = 1:55:57 Trucks (4-15) - 100 Class 3s - 16

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
78	9	41633	78	9	64	9	41735	64	9
75	9	41638	76	9	80	5	41737	81	5
57	**5**	**41640**	**58**	**3**	70	5	41739	70	5
68	9	41641	68	9	70	9	41741	70	9
67	9	41644	68	9	65	11	41742	66	11
77	**5**	**41652**	**76**	**3**	72	3	41743	72	3
78	3	41653	80	3	63	9	41745	63	9
67	5	41654	77	5	67	9	41746	67	9
68	9	41659	68	9	**64**	**15**	**41751**	**65**	**9**
64	9	41662	65	9	50	9	41752	50	9
75	9	41673	74	9	73	3	41754	73	3
78	5	41675	79	5	50	9	41756	49	9
74	9	41676	75	9	67	11	41758	68	11
75	**5**	**41681**	**75**	**3**	65	6	41759	65	6
52	6	41682	52	6	66	9	41765	67	9
78	5	41684	79	5	64	9	41768	63	9
65	11	41705	67	11	68	9	41772	69	9
68	9	41706	69	9	69	9	41773	69	9
64	11	41707	65	11	67	11	41774	67	11
70	9	41718	70	9	59	9	41776	70	9
67	**5**	**41719**	**65**	**3**	62	9	41783	62	9
65	9	41722	65	9	65	9	41786	65	9
68	9	41725	68	9	**71**	**4**	**41797**	**71**	**6**
70	9	41726	69	9	**73**	**8**	**41800**	**75**	**3**
65	11	41730	65	11	65	9	41801	65	9

Sheet 1 - 0 to 50 Start: 8:33:34 Stop: 9:19:36

Recorded By: ar Verified By: djw

Validation Test Truck Run Set - Pre

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 08 SPS WIM ID: 080200 DATE (mm/dd/yyyy) 2/21/2012

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
76	5	41803	78	5	81	3	41897	80	3
74	4	41804	76	4	66	9	41901	65	9
67	9	41805	67	9	73	9	41902	74	9
68	5	41807	69	5	71	3	41907	71	3
67	9	41808	69	9	70	9	41908	71	9
67	9	41812	67	9	66	9	41909	68	9
69	9	41814	71	9	55	8	41910	55	8
67	9	41823	66	9	77	9	41911	79	9
73	**5**	**41824**	**75**	**3**	77	5	41912	78	5
65	9	41825	67	9	59	9	41913	58	9
66	6	41832	66	6	63	9	41915	63	9
60	9	41842	60	9	75	9	41918	75	9
75	9	41844	76	9	60	9	41921	60	9
73	9	41847	73	9	64	9	41922	62	9
65	9	41849	65	9	71	9	41923	71	9
67	9	41851	72	9	66	11	41924	66	11
70	9	41852	70	9	68	9	41936	69	9
64	9	41861	64	9	**64**	**8**	**41937**	**64**	**3**
72	9	41862	72	9	**67**	**8**	**41938**	**67**	**5**
60	9	41865	67	9	70	9	41945	70	9
60	3	41891	63	3	69	9	41969	70	9
70	9	41892	69	9	72	9	41972	72	9
75	9	41894	76	9	**72**	**5**	**41973**	**73**	**3**
64	9	41895	64	9	68	9	41975	69	9
72	6	41896	71	6	**73**	**5**	**41979**	**73**	**3**

Sheet 2 - 51 to 100 Start: 9:20:11 Stop: 10:21:08

Recorded By: ar Verified By: djw

Validation Test Truck Run Set - Pre

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 08 SPS WIM ID: 080200 DATE (mm/dd/yyyy) 2/21/2012

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
72	**5**	**41980**	**74**	**3**					
78	**9**	**41981**	**79**	**5**					
67	9	41984	66	9					
70	9	41985	70	9					
66	9	41988	66	9					
76	9	41990	76	9					
61	9	41991	61	9					
72	9	41992	72	9					
68	9	41993	69	9					
73	9	41994	75	9					
72	9	41995	72	9					
62	9	41998	62	9					
73	9	41999	75	9					
65	9	42001	66	9					
65	8	42003	65	8					
73	6	42005	73	6					

Sheet 3 - 101 - 150 Start: 10:21:12 Stop: 10:29:31

Recorded By: ar Verified By: djw

Validation Test Truck Run Set - Pre