WIM System Field Calibration and Validation Summary Report

Kansas SPS-2
SHRP ID – 200200

Validation Date: November 15, 2011
Submitted: December 7, 2011

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1 Executive Summary

A WIM validation was performed on November 15, 2011 at the Kansas SPS-2 site located on route I-70 at milepost 287.5, 7.6 miles west of US 77.

This site was installed on June 08, 2006. The in-road sensors are installed in the westbound, righthand driving 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 December 22, 2010 and this validation visit, it appears that no changes have occurred during this time to the basic operating condition of the equipment.

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

During the on-site pavement evaluation, 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 – 15-Nov-11

Parameter	**95% Confidence Limit of Error**	**Site Values**	**Pass/Fail**
Steering Axles	±20 percent	-0.9 ± 5.9%	Pass
Tandem Axles	±15 percent	-2.1 ± 7.1%	Pass
GVW	±10 percent	-1.9 ± 5.9%	Pass
Vehicle Length	±3.0 percent (1.9 ft)	-0.4 ± 1.0 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.1 ft	Pass

Truck speeds were manually collected for each test run by a radar gun and compared with the speed reported by the WIM equipment. For this site, the error in speed measurement was 0.5 ± 1.6 mph, which is greater than the ±1.0 mph tolerance established by the LTPP Field Operations Guide for SPS WIM Sites. However, since the site is measuring axle spacing length with a mean error of 0.0 feet, and the speed and axle spacing measurements are based on the distance between the axle detector sensors, it can be concluded that the distance factor is set correctly and that the speeds being reported by the WIM equipment are within acceptable ranges.

This site is not providing research quality vehicle classification data for heavy trucks (Class 6 – 13). The heavy truck misclassification rate of 2.2% is not within the 2.0% acceptability criterion for LTPP SPS WIM sites. The overall misclassification rate of 4.7% from the 106 truck sample (Class 4 – 13) was due to the 9 cross-classifications of Class 3, 4, 5, and 8 vehicles and two Class 9 vehicles being identified as Class 14 vehicles.

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 grain.

- 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 grain.

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	74.7	11.0	16.5	15.8	15.7	15.8	18.2	4.3	32.3	4.0	58.8	63.4
2	64.7	10.9	14.6	14.7	12.1	12.3	19.5	4.3	31.5	4.0	59.3	63.9

The posted speed limit at the site is 75 mph. During the testing, the speed of the test trucks ranged from to 54 to 75 mph, a variance of 21 mph.

During test truck runs, pavement temperature was collected using a hand-held infrared temperature device. The validation pavement surface temperatures varied from 40.6 to 68.7 degrees Fahrenheit, a range of 28.1 degrees Fahrenheit. The sunny weather conditions enabled to almost attain the desired 30 degree range in temperature.

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

2 WIM System Data Availability and Pre-Visit Data Analysis

To assess the quality of the current traffic data, a pre-visit analysis was conducted by comparing a two-week data sample from October 17, 2011 (Data) to the most recent Comparison Data Set (CDS) from December 20, 2010. The assessments performed prior to the site visits are used to develop reasonable expectations for the validation. The results of further investigations performed as a result of the analyses are provided in Section 5 of this report.

2.1 LTPP WIM Data Availability

A review of the LTPP Standard Release Database 25 shows that there are 4 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	199	7
2007	180	8
2008	361	12
2009	365	12
2010	358	12
2011	229	9

As shown in the table, this site requires 1 additional year of data to meet the minimum of five years of research quality data. The data for years 2006 and 2007 do not meet the 210-day minimum requirement for a calendar year.

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						19	31	31	30	31	29	28	7
2007	28	28	30	4					7	28	27	28	8
2008	31	29	31	30	31	29	31	31	30	31	26	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	24	30	31	12
2011	17	26	31	30	31	29	26	30	9				9

2.2 Classification Data Analysis

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

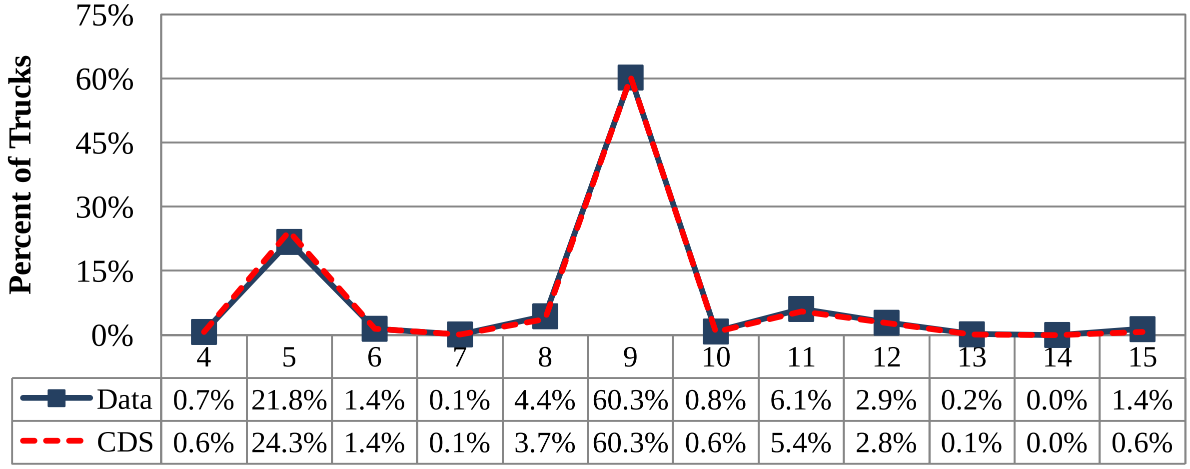


Figure 2-1 – Comparison of Truck Distribution

Table 2-3 provides statistics for the truck distributions at the site for the two periods represented by the two datasets. The table shows that according to the most recent data, the most frequent truck types crossing the WIM scale are Class 9 (60.3%) and Class 5 (21.8%). 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 1.4 percent of the vehicles at this site are unclassified.

Table 2-3 – Truck Distribution from W-Card

Vehicle Classification	CDS		Data		Change
	Date				
	12/20/2010		10/17/2011		
4	109	0.6%	170	0.7%	0.1%
5	4229	24.3%	5285	21.8%	-2.5%
6	250	1.4%	351	1.4%	0.0%
7	12	0.1%	31	0.1%	0.1%
8	650	3.7%	1062	4.4%	0.6%
9	10508	60.3%	14622	60.3%	0.0%
10	112	0.6%	198	0.8%	0.2%

Vehicle Classification	CDS		Data		Change
	Date				
	12/20/2010		10/17/2011		
11	949	5.4%	1476	6.1%	0.6%
12	488	2.8%	693	2.9%	0.1%
13	19	0.1%	38	0.2%	0.0%
14	0	0.0%	0	0.0%	0.0%
15	107	0.6%	331	1.4%	0.8%

From the table it can be seen that the percentage of Class 9 vehicles has remained the same from December 2010 to October 2011. During the same time period, the percentage of Class 5 trucks decreased by 2.5 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.

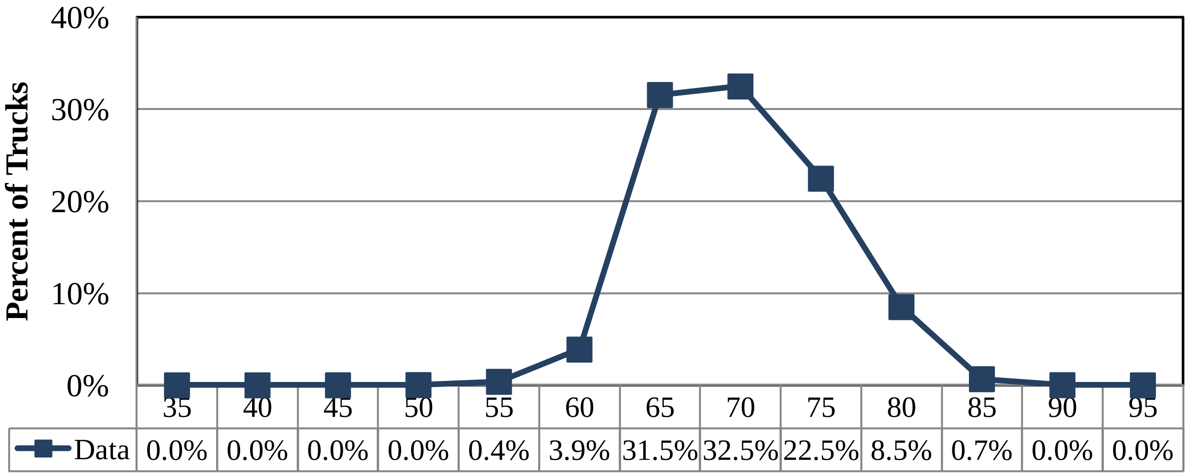


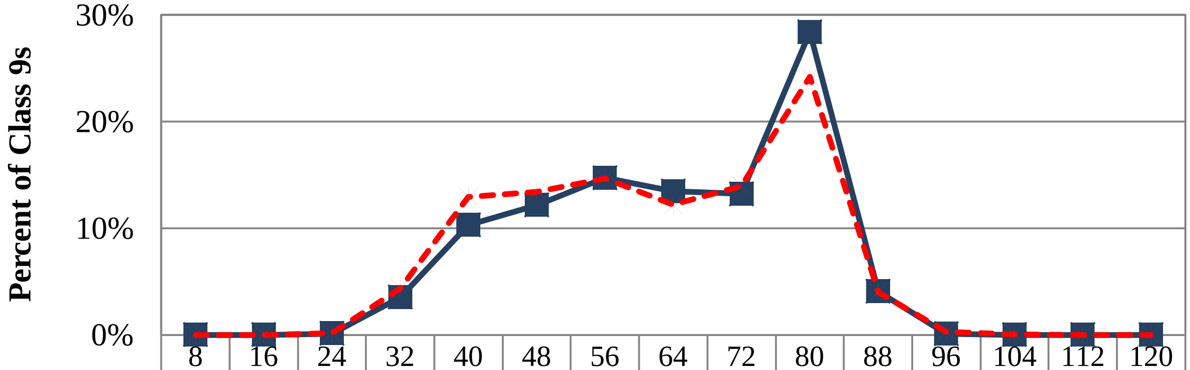
Figure 2-2 – Truck Speed Distribution – 17-Oct-11

As shown in Figure 2-2, the majority of the trucks at this site are traveling between 65 and 75 mph. The posted speed limit at this site is 70 and the 85th percentile speed for trucks at this site is 74 mph. The range of truck speeds for the validation will be 60 to 70 mph.

2.4 GVW Data Analysis

The traffic CDS data received from the Regional Support Contractor was analyzed to determine the expected Class 9 GVW distributions. Figure 2-3 shows a comparison between GVW plots generated using a two-week W-card sample from October 2011 and the Comparison Data Set from December 2010.

As shown in Figure 2-3, there is a shift down for the unloaded peak and an upward shift for the loaded peak between the December 2010 Comparison Data Set (CDS) and the October 2011 two-week sample W-card dataset (Data), indicating a slightly higher percentage of fully loaded trucks and lower percentage of unloaded trucks.



	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
Data	0.0%	0.0%	0.1%	3.5%	10.3	12.2	14.7	13.5	13.2	28.4	4.1%	0.1%	0.0%	0.0%	0.0%
CDS	0.0%	0.0%	0.1%	4.3%	12.9	13.4	14.7	12.2	14.0	24.2	4.0%	0.3%	0.0%	0.0%	0.0%

Figure 2-3 – Comparison of Class 9 GVW Distribution

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

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

GVW weight bins (kips)	CDS		Data		Change
	Date				
	12/20/2010		10/17/2011		
8	0	0.0%	0	0.0%	0.0%
16	0	0.0%	0	0.0%	0.0%
24	14	0.1%	17	0.1%	0.0%
32	453	4.3%	513	3.5%	-0.8%
40	1353	12.9%	1497	10.3%	-2.6%
48	1401	13.4%	1769	12.2%	-1.2%
56	1535	14.7%	2139	14.7%	0.0%

GVW weight bins (kips)	CDS		Data		Change
	Date				
	12/20/2010		10/17/2011		
64	1277	12.2%	1958	13.5%	1.3%
72	1461	14.0%	1919	13.2%	-0.8%
80	2532	24.2%	4131	28.4%	4.2%
88	416	4.0%	591	4.1%	0.1%
96	29	0.3%	12	0.1%	-0.2%
104	2	0.0%	0	0.0%	0.0%
112	0	0.0%	0	0.0%	0.0%
120	0	0.0%	0	0.0%	0.0%
Average =	58.2 kips		59.9 kips		1.7 kips

As shown in the table, the percentage of unloaded class 9 trucks in the 32 to 40 kips range decreased by 2.6 percent while the percentage of loaded class 9 trucks in the 72 to 80 kips range increased by 4.2 percent. During this time period the percentage of overweight trucks decreased by 0.1 percent. Based on the average Class 9 GVW values from the per vehicle records, the GVW average for this site increased by 2.9 percent, from 58.2 kips to 59.9 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 October 2011 and the Comparison Data Set from December 2010. The percentages of light axles (10.0 to 10.5 kips) decreased by approximately 7.6% and the percentages of heavy axles (12.0 to 12.5 kips) increased by approximately 6.3%, indicating possible positive bias (overestimation of loads) in front axle measurement.

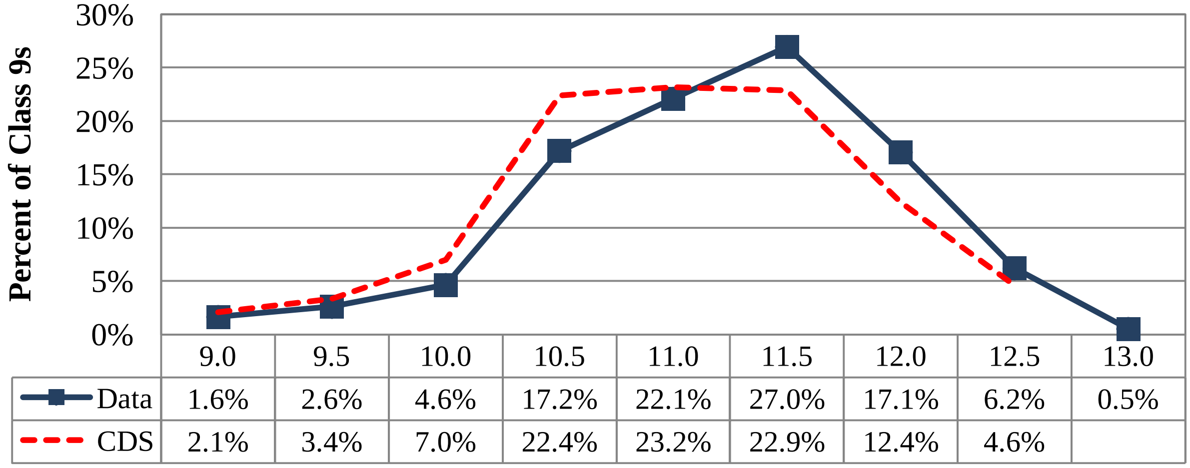


Figure 2-4 – Distribution of Class 9 Front Axle Weights

It can be seen in the figure that the greatest percentage of trucks have front axle weights measuring between 11.0 and 11.5 kips. The percentage of trucks in this range has increased between the December 2010 Comparison Data Set (CDS) and the October 2011 dataset (Data).

Table 2-5 provides the Class 9 front axle weight distribution data for the December 2010 Comparison Data Set (CDS) and the October 2011 dataset (Data).

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

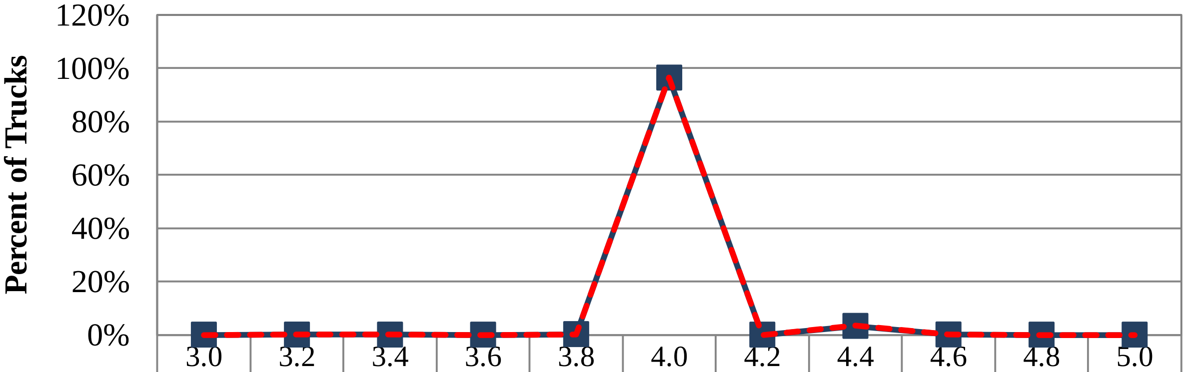
F/A weight bins (kips)	CDS		Data		Change
	Date				
	12/20/2010		10/17/2011		
9.0	187	1.8%	161	1.1%	-0.7%
9.5	216	2.1%	236	1.6%	-0.4%
10.0	350	3.4%	373	2.6%	-0.8%
10.5	729	7.0%	670	4.6%	-2.3%
11.0	2339	22.4%	2487	17.2%	-5.2%
11.5	2420	23.2%	3194	22.1%	-1.1%
12.0	2385	22.9%	3897	27.0%	4.1%
12.5	1294	12.4%	2468	17.1%	4.7%
13.0	480	4.6%	895	6.2%	1.6%
13.5	37	0.4%	74	0.5%	0.2%
Average =	11.3 kips		11.5 kips		0.2 kips

The table shows that the average front axle weight for Class 9 trucks has increased by 0.2 kips, or 1.8 percent. According to the values from the per vehicle records, the average front axle weight for Class 9 trucks is 11.5 kips. The percentages of light axles (10.0 to 10.5 kips) decreased by approximately 2.3% and the percentages of heavy axles (12.0 to 12.5 kips) increased by approximately 4.7%, indicating possible positive bias (overestimation of loads) in front axle measurement.

2.6 Class 9 Tractor Tandem Spacing Data Analysis

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

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



	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0
Data	0.0%	0.0%	0.0%	0.0%	0.2%	96.4%	0.0%	3.3%	0.1%	0.0%	0.0%
CDS	0.0%	0.0%	0.0%	0.0%	0.1%	96.5%	0.0%	3.4%	0.1%	0.0%	0.0%

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

As seen in the figure, the Class 9 tractor tandem spacings for the December 2010 Comparison Data Set and the October 2011 Data are nearly identical.

Table 2-6 shows the Class 9 axle spacings between the second and third axles. .

Table 2-6 – Class 9 Axle 2 to 3 Spacing from W-Card

Tandem 1 spacing bins (feet)	CDS		Data		Change
	Date				
	12/20/2010		10/17/2011		
3.0	0	0.0%	0	0.0%	0.0%
3.2	1	0.0%	3	0.0%	0.0%
3.4	1	0.0%	2	0.0%	0.0%

Tandem 1 spacing bins (feet)	CDS		Data		Change
	Date				
	12/20/2010		10/17/2011		
3.6	0	0.0%	0	0.0%	0.0%
3.8	6	0.1%	28	0.2%	0.1%
4.0	10102	96.5%	14027	96.4%	0.0%
4.2	0	0.0%	0	0.0%	0.0%
4.4	354	3.4%	477	3.3%	-0.1%
4.6	9	0.1%	9	0.1%	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 feet, which is identical to the expected average of 4.0 feet from the CDS per vehicle records. Further axle spacing analyses are performed during the validation analysis.

2.7 Data Analysis Summary

Historical data analysis involved the comparison of the most recent Comparison Data Set (December 2010) based on the last calibration with the most recent two-week WIM data sample from the site (October 2011). Comparison of vehicle class distribution data do not indicate a change in the number of Class 9 vehicles. Analysis of Class 9 weight data indicates that front axle weights have increased by 0.2 kips and average Class 9 GVW has increased by 2.9 percent for the October 2011 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 22, 2010 and this validation visit, it appears that no changes have occurred during this time to the basic operating condition of the equipment.

3.1 Description

This site was installed on June 08, 2006 by International Road Dynamics. It is instrumented with bending plate weighing sensors and an IRD iSINC WIM Controller. As the installation contractor, IRD also performs routine equipment maintenance and data quality checks of the WIM data.

3.2 Physical Inspection

Prior to the validation test truck runs, a physical inspection of all WIM equipment and support services equipment was conducted. No deficiencies were noted. Photographs of all system components were taken and are presented after Section 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 October 19, 2010 by the North Central Regional Support Contractor using a high-speed profiler, where the operator measures the pavement profile over the entire one-thousand foot long WIM Section, 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, 10.875 profile passes were made, 5 in the center of the travel lane and 6 that were shifted to the left and to the right of the center of the travel lane.

From a pre-visit review of the IRI values for the center, right, and left profile runs, the highest IRI value within the 1000 foot WIM section is 170 in/mi and is located approximately 524 feet prior to the WIM scale. The highest IRI value within the 400 foot approach section was 139 in/mi and is located approximately 333 feet prior to the WIM scale. This area of pavement was 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 3 left, 2.875 right and 5 center profiler runs are presented in Table 4-2.

Table 4-2 – WIM Index Values

Profiler Passes			**Pass 1**	**Pass 2**	**Pass 3**	**Pass 4**	**Pass5**	**Avg**
Left	LWP	LRI (m/km)	1.712	1.541	1.401			1.551
		SRI (m/km)	0.817	0.603	0.808			0.743
		Peak LRI (m/km)	2.001	1.650	1.909			1.853
		Peak SRI (m/km)	1.765	0.810	1.317			1.297
	RWP	LRI (m/km)	1.017	0.924	0.980			0.974
		SRI (m/km)	0.879	0.626	0.833			0.779
		Peak LRI (m/km)	1.036	1.019	1.010			1.022
		Peak SRI (m/km)	1.030	0.844	0.949			0.941
Center	LWP	LRI (m/km)	0.787	0.893	0.788	0.783	0.873	0.813
		SRI (m/km)	0.615	0.669	0.537	0.748	0.990	0.642
		Peak LRI (m/km)	0.811	0.923	1.000	0.917	0.949	0.913
		Peak SRI (m/km)	1.022	0.852	0.933	0.802	1.129	0.902
	RWP	LRI (m/km)	0.652	1.132	1.044	1.030	0.872	0.965
		SRI (m/km)	0.519	1.016	0.762	1.085	0.733	0.846
		Peak LRI (m/km)	0.984	1.254	1.348	1.148	1.051	1.184
		Peak SRI (m/km)	*0.654*	1.169	1.107	1.166	0.833	1.024
Right	LWP	LRI (m/km)	1.022	0.732	1.210			0.988
		SRI (m/km)	1.140	0.961	0.867			0.989
		Peak LRI (m/km)	1.185	0.954				1.070
		Peak SRI (m/km)	1.262	1.069	1.111			1.147
	RWP	LRI (m/km)	0.846	0.726	0.954			0.842
		SRI (m/km)	1.032	0.942	0.881			0.952
		Peak LRI (m/km)	0.981	1.106	1.029			1.039
		Peak SRI (m/km)	1.189	0.945	1.041			1.058

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

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 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 November 15, 2011, beginning at approximately 9:24 AM and continuing until 3:54 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with grain, 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 grain, 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	74.7	11.0	16.5	15.8	15.7	15.8	18.2	4.3	32.3	4.0	58.8	63.4
2	64.7	10.9	14.6	14.7	12.1	12.3	19.5	4.3	31.5	4.0	59.3	63.9

Test truck speeds varied by 21 mph, from 54 to 75 mph. The measured validation pavement temperatures varied 28.1 degrees Fahrenheit, from 40.6 to 68.7. The sunny weather conditions enabled to almost attain the desired 30 degree temperature range. Table 5-2 provides a summary of the validation results.

Table 5-2 – Validation Overall Results – 15-Nov-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-0.9 ± 5.9%	Pass
Tandem Axles	±15 percent	-2.1 ± 7.1%	Pass
GVW	±10 percent	-1.9 ± 5.9%	Pass
Vehicle Length	±3.0 percent (1.9 ft)	-0.4 ± 1.0 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.1 ft	Pass

Truck speed was manually collected for each test run using a radar gun and compared with the speed reported by the WIM equipment. For this site, the average error in speed measurement over all speeds was 0.5 ± 1.6 mph, which is greater than the ±1.0 mph tolerance established by the LTPP Field Guide. However, since the site is measuring axle spacing length with a mean error of 0.0 feet, and the speed and axle spacing measurements are based on the distance between the axle detector sensors, it can be concluded that the distance factor is set correctly and that the speeds being reported by the WIM equipment are within acceptable ranges.

5.1.1 Statistical Speed Analysis

Statistical analysis was conducted on the test truck run data to investigate whether a relationship exists between speed and WIM equipment weight and distance measurement accuracy. The posted speed limit at this site is 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 – 15-Nov-11

Parameter	95% Confidence Limit of Error	Low	Medium	High
		54.0 to 61.0 mph	61.1 to 68.1 mph	68.2 to 75.0 mph
Steering Axles	±20 percent	-4.0 ± 3.8%	0.5 ± 2.4%	1.0 ± 6.4%
Tandem Axles	±15 percent	-5.9 ± 2.8%	-0.3 ± 4.0%	0.3 ± 5.7%
GVW	±10 percent	-5.5 ± 1.5%	-0.2 ± 2.3%	0.4 ± 3.9%
Vehicle Length	±3.0 percent (1.9 ft)	-0.7 ± 1.2 ft	-0.1 ± 0.6 ft	-0.2 ± 1.1 ft
Vehicle Speed	± 1.0 mph	0.4 ± 1.6 mph	0.3 ± 1.5 mph	1.0 ± 1.8 mph
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.1 ft	0.0 ± 0.1 ft	0.0 ± 0.1 ft

From the table, it can be seen that, on average, the WIM equipment underestimated all weights at low speeds and estimated weights without any apparent bias at the medium and high speeds. The range of errors is generally higher at higher speeds. It appears that there is a relationship between weight estimates and speed at this site.

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

5.1.1.1 GVW Errors by Speed

As shown in Figure 5-1, the equipment underestimated GVW at the low speeds and estimated GVW without any apparent bias at the medium and high speeds. The range in error was similar throughout the entire speed range. There appears to be a correlation between speed and weight estimates at this site.

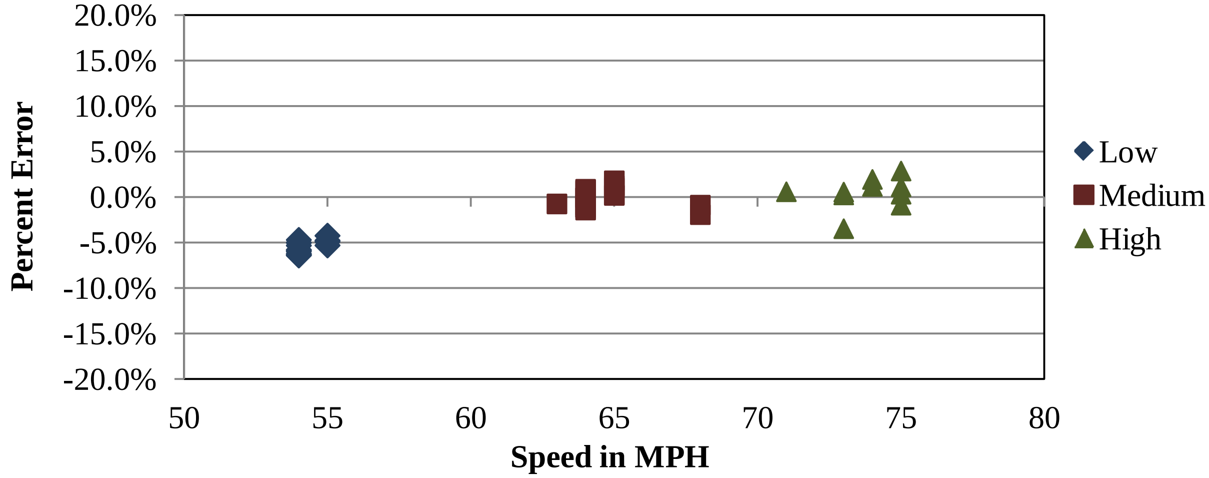


Figure 5-1 – Validation GVW Error by Speed – 15-Nov-11

5.1.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-2, the equipment underestimated steering axle weights at the low speeds and estimated steering axle weights without any apparent bias at the medium and high speeds. The range in error appears to be slightly lower at medium speeds when compared with low and high speeds.

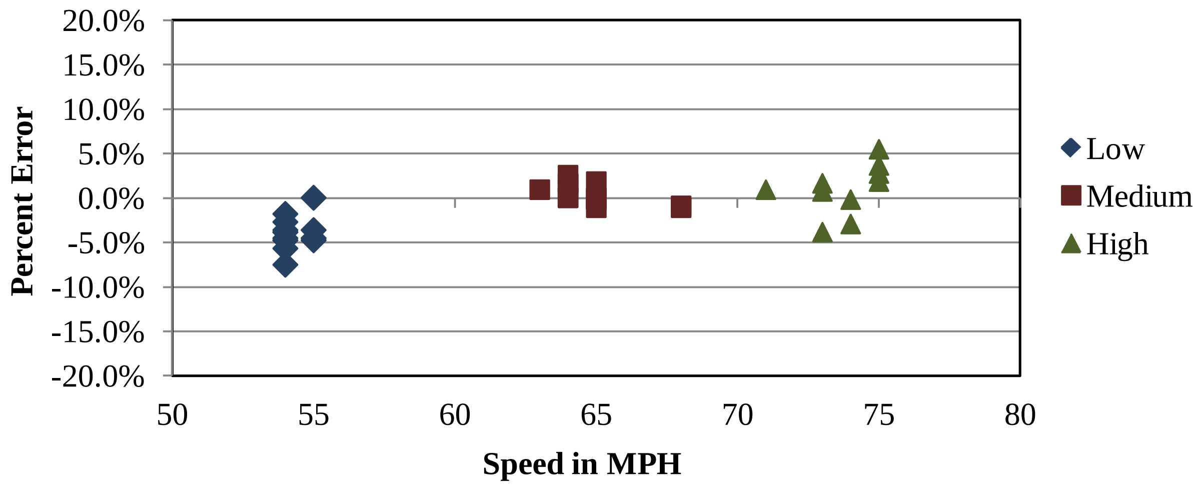


Figure 5-2 – Validation Steering Axle Weight Errors by Speed – 15-Nov-11

5.1.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 5-3, the equipment underestimated tandem axle weights at low speeds and estimated tandem axle weights without any apparent bias at medium and high speeds. The range in error is similar throughout the entire speed range.

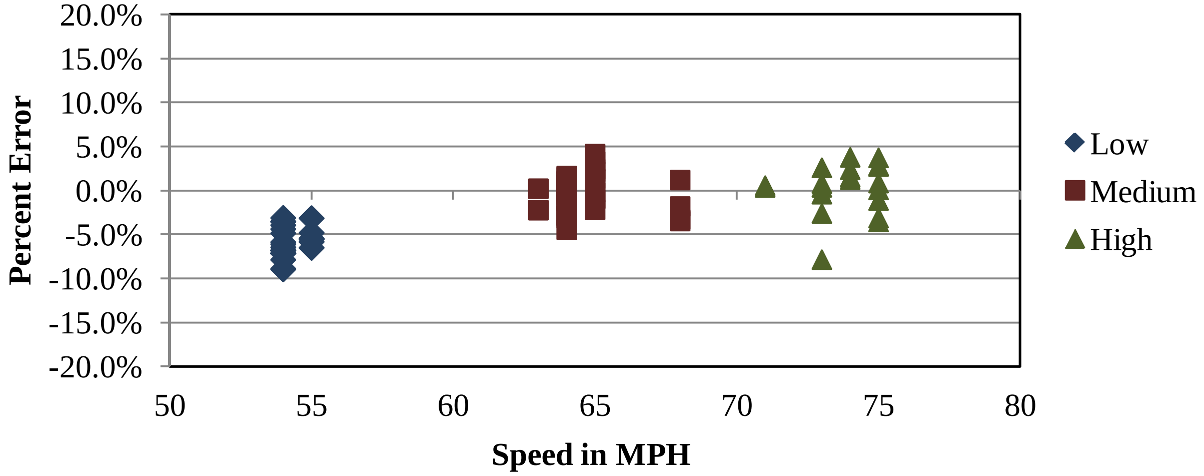


Figure 5-3 – Validation Tandem Axle Weight Errors by Speed – 15-Nov-11

5.1.1.4 GVW Errors by Speed and Truck Type

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

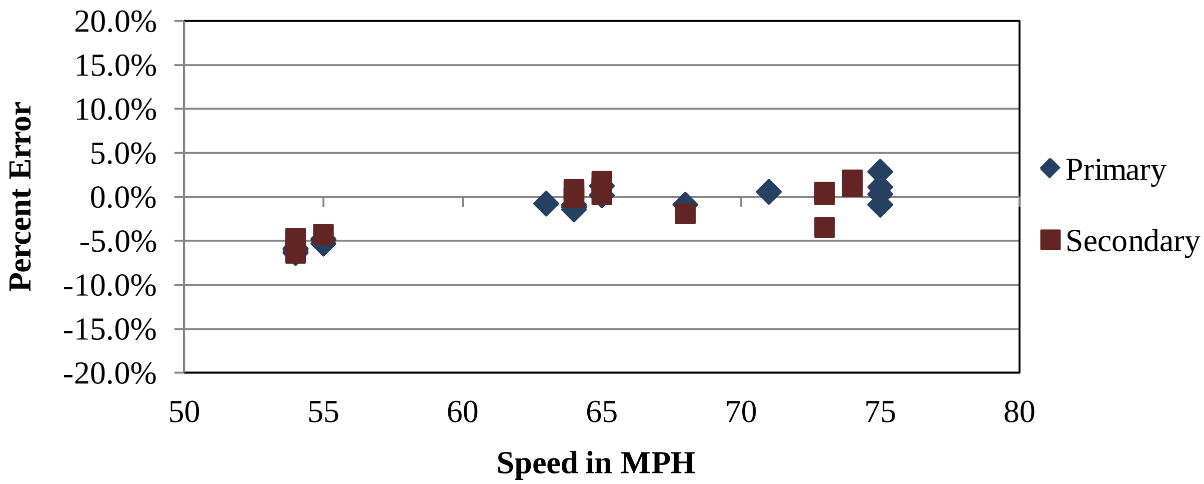


Figure 5-4 – Validation GVW Errors by Truck and Speed – 15-Nov-11

5.1.1.5 Axle Length Errors by Speed

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

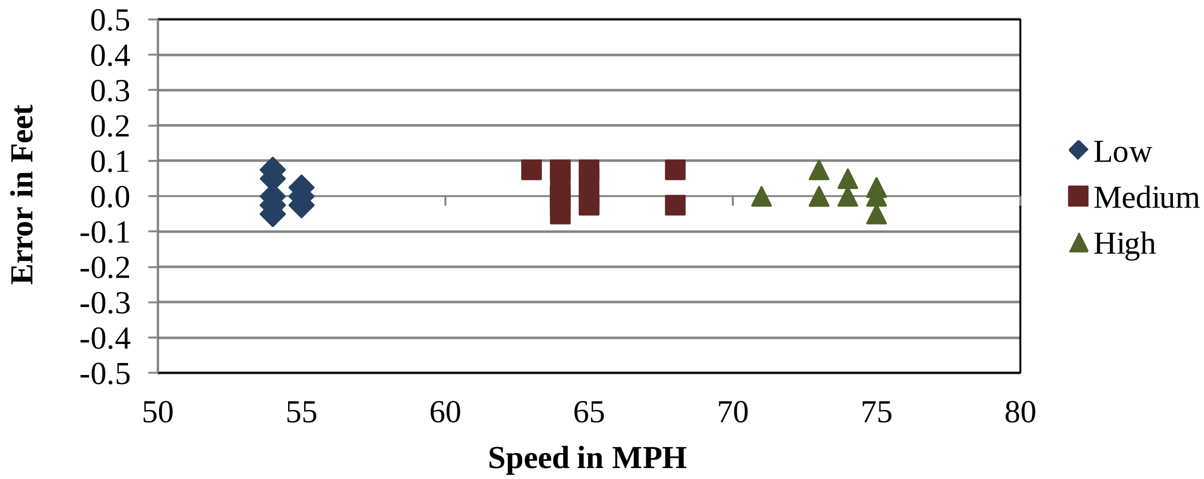


Figure 5-5 – Validation Axle Length Errors by Speed – 15-Nov-11

5.1.1.6 Overall Length Errors by Speed

For this system, the WIM equipment underestimated overall vehicle length with slightly higher bias at the lower and higher speeds when compared with the medium speeds, with an error range of -1.4 to 0.1 feet. Distribution of errors is shown graphically in Figure 5-6.

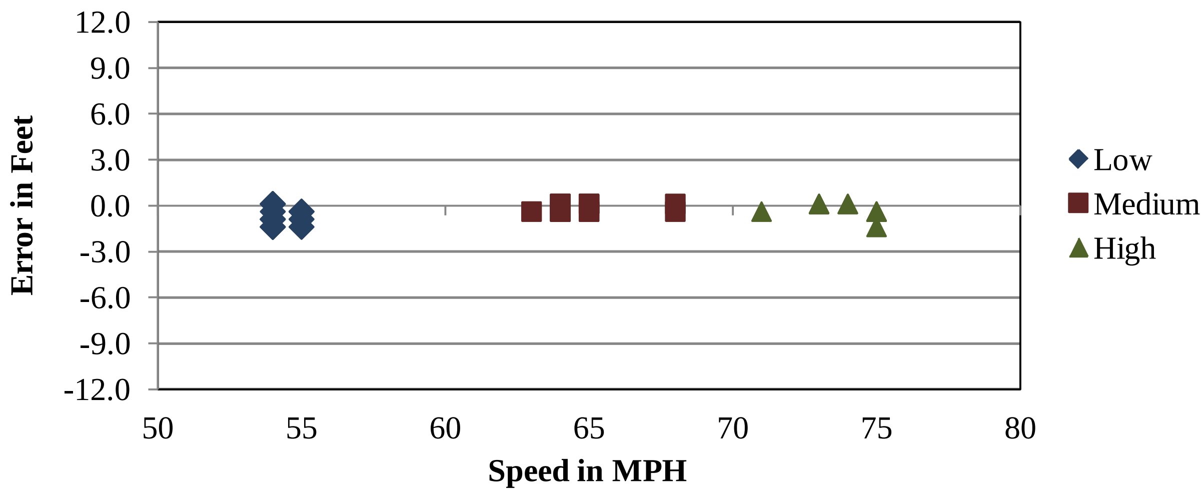


Figure 5-6 – Validation Overall Length Error by Speed – 15-Nov-11

5.1.2 Statistical Temperature Analysis

Statistical analysis was performed for the test truck run data to investigate whether a relationship exists between pavement temperature and WIM equipment weight and distance measurement accuracy. The range of pavement temperatures varied 28.1 degrees, from 40.6 to 68.7 degrees Fahrenheit. Although the preferred 30 degree temperature range was nearly met, the validation test runs are being reported under two temperature groups – low and high, as shown in Table 5-4.

Table 5-4 – Validation Results by Temperature – 15-Nov-11

Parameter	**95% Confidence Limit of Error**	**Low**	**High**
		40.6 to 54.7 degF	**54.8 to 68.7 degF**
Steering Axles	±20 percent	-0.6 ± 7.3%	-1.1 ± 5.9%
Tandem Axles	±15 percent	-1.9 ± 8.6%	-2.2 ± 7.1%
GVW	±10 percent	-1.6 ± 7.7%	-2.0 ± 5.8%
Vehicle Length	±3.0 percent (1.9 ft)	-0.5 ± 1.5 ft	-0.3 ± 0.9 ft
Vehicle Speed	± 1.0 mph	0.4 ± 1.9 mph	0.5 ± 1.6 mph
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.1 ft	0.0 ± 0.1 ft

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

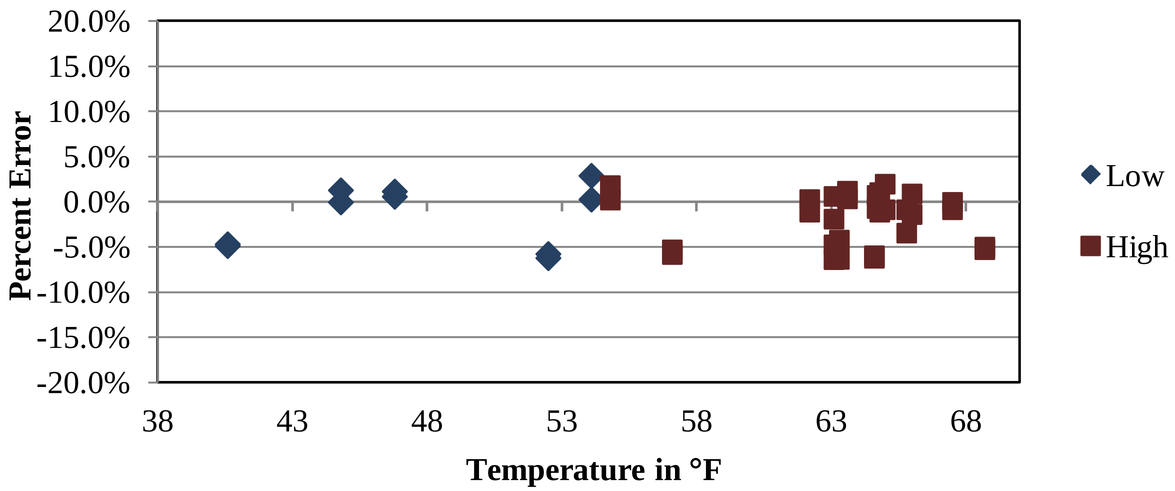


Figure 5-7 – Validation GVW Errors by Temperature – 15-Nov-11

5.1.2.2 Steering Axle Weight Errors by Temperature

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

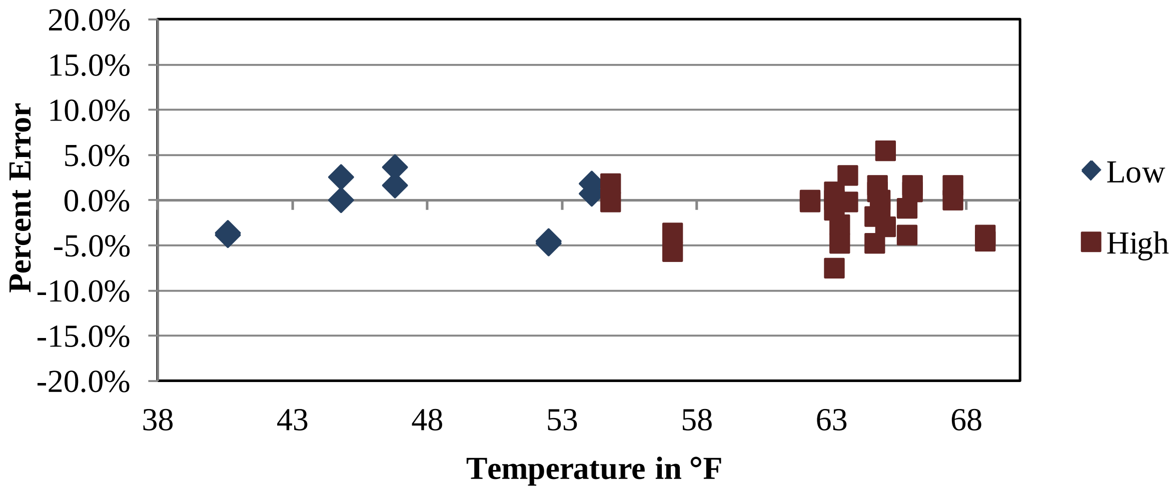


Figure 5-8 – Validation Steering Axle Weight Errors by Temperature – 15-Nov-11

5.1.2.3 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-9, the WIM equipment appears to estimate tandem axle weights with similar accuracy across the range of temperatures observed in the field. The range in tandem axle errors is consistent for the two temperature groups.

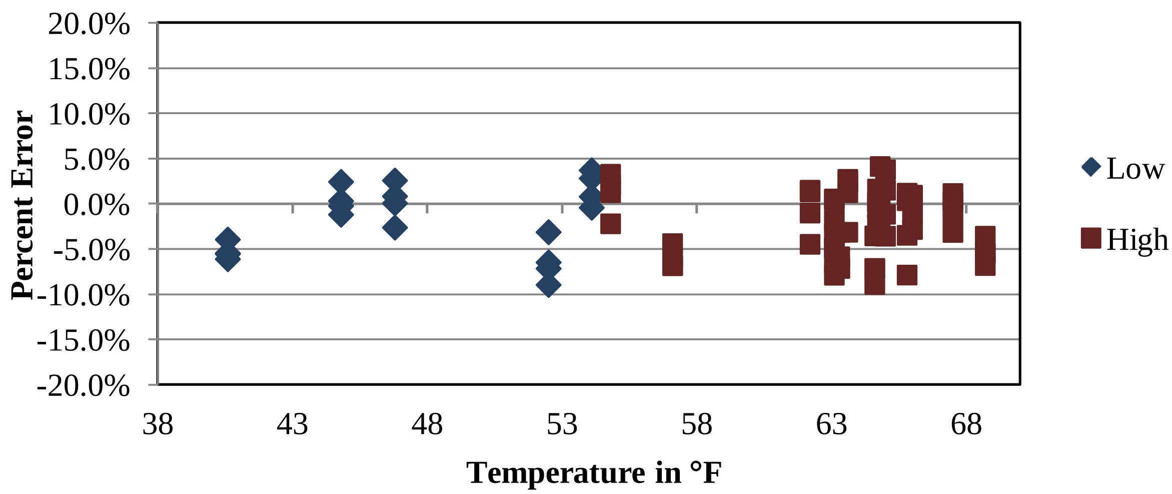


Figure 5-9 – Validation Tandem Axle Weight Errors by Temperature – 15-Nov-11

5.1.2.4 GVW Errors by Temperature and Truck Type

When analyzed for each test truck, GVW measurement errors for both trucks follow similar patterns where estimates for GVW error for both trucks are reasonably accurate at all temperatures. For both trucks, the range of errors and bias are consistent over the range of temperatures. Distribution of errors is shown graphically in Figure 5-10.

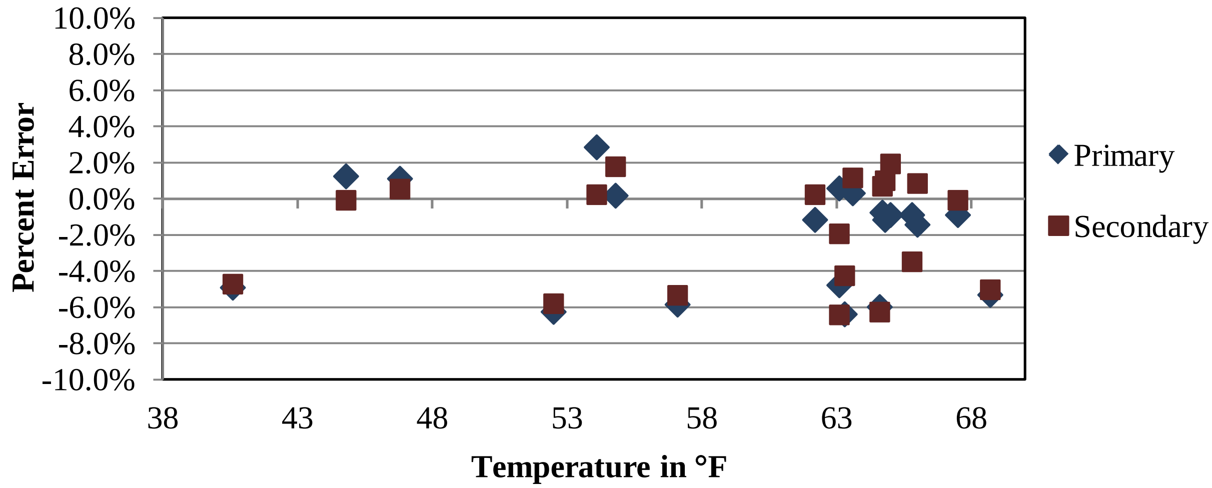


Figure 5-10 – Validation GVW Error by Truck and Temperature – 15-Nov-11

5.1.3 GVW and Steering Axle Trends

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

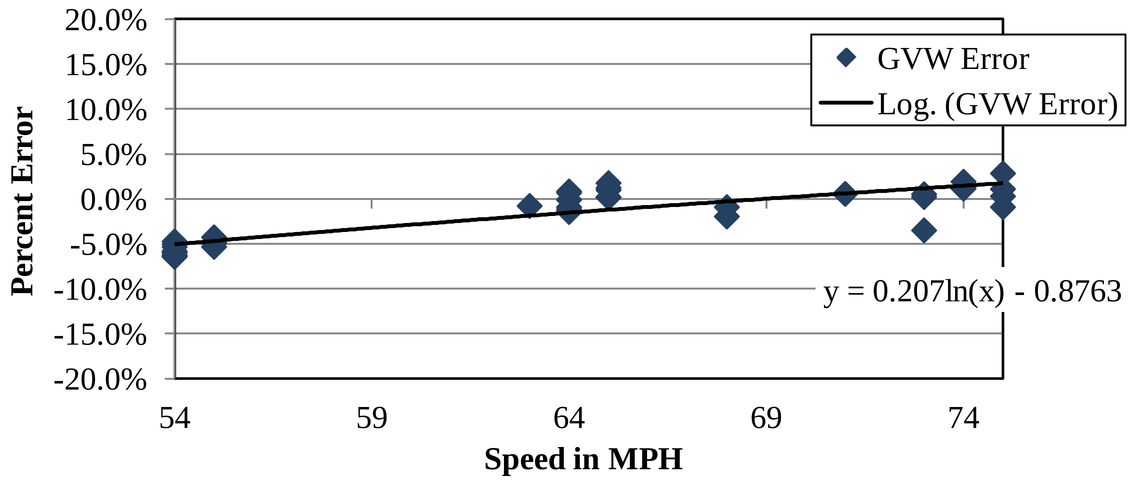


Figure 5-11 – GVW Error Trend by Speed

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

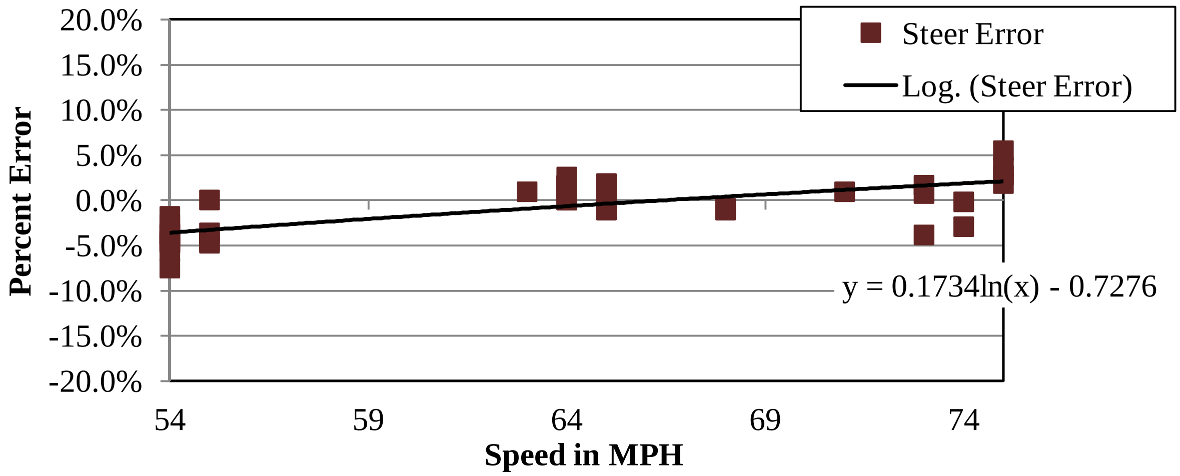


Figure 5-12 – Steering Axle Trend by Speed

5.1.4 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.

5.1.4.1 Data

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

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

- Truck type. Primary truck and secondary truck.

- Truck test speed. Truck test speed ranged from 54 to 75 mph.

- Pavement temperature. Pavement temperature ranged from 40.6 to 68.7 degrees Fahrenheit.

- Interaction between the factors such as the interaction between speed and pavement temperature.

5.1.4.2 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 coefficient, given in Table 5-5, is equal to zero.

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	-21.1341	2.8641	-7.3789	0.0000
Speed	0.3226	0.0337	9.5771	0.0000
Temp	-0.0229	0.0325	-0.7058	0.4849
Truck	0.3368	0.5129	0.6567	0.5156

Only the effect of speed was found to be statistically significant based on reported low probability value (less than 1%).

The relationship between speed and 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.

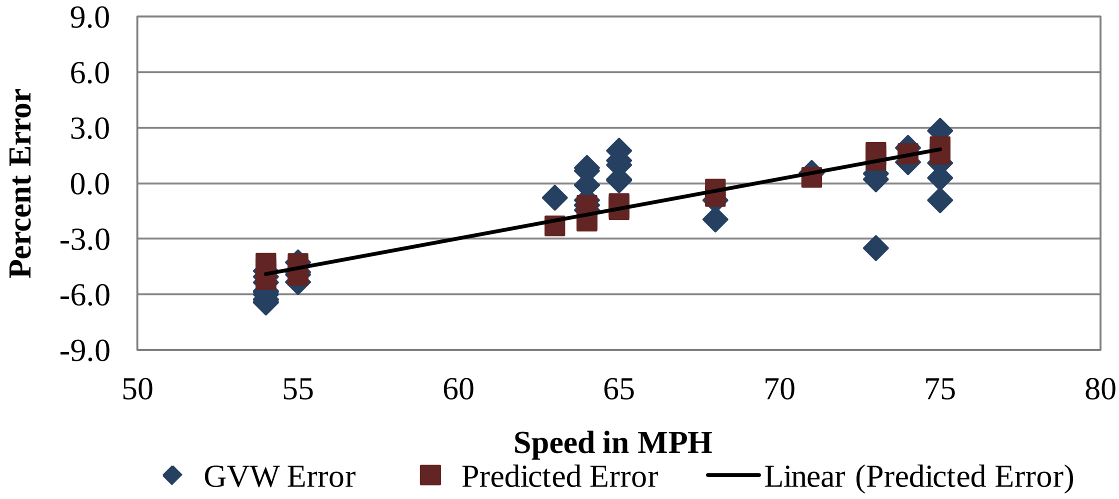


Figure 5-13 – Influence of Speed on the Measurement Error of GVW

The significance of the relationship is assessed with the value of the regression coefficient, in this case 0.3226 (in Table 5-5). This means, for example, that for a 10 mph increase in speed, the % error is increased by about 3.2 % (0.3226 x 10). The statistical assessment of the relationship is provided by the probability value of the regression coefficient.

The probability that the regression coefficient for speed (0.3226 in Table 5-5) is zero was extremely small (p-value = 1.95 E-11). In other words, the probability that the value of the regression coefficient is due to the chance alone was much less than 1% percent.

The interaction between speed, temperature, and truck type was also investigated by adding an interactive variable (or variables) such as the product of speed and temperature. No interactive variables were statistically significant.

5.1.4.3 Summary Results

Table 5-6 lists regression coefficients and their associated p-values for all combinations of factors and weight parameters evaluated for WIM measurement errors. 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 5-6 indicates that the relationship was not statistically significant (the probability that the relationship can occur by chance alone was greater than 20 percent).

Table 5-6 – Summary of Regression Analysis

Parameter	Factor					
	Speed		Temperature		Truck type	
	Regression coefficient	Probability (p-value)	Regression coefficient	Probability (p-value)	Regression coefficient	Probability (p-value)
GVW	0.3226	0.0000	–	–	–	–
Steering axle	0.2891	0.0000	-	_	-1.5270	0.0192
Tractor Tandem	0.4455	0.0000	-	_	_	-
Trailer Tandem	0.2220	0.0001	–	–	2.0732	0.0099

5.1.4.4 Conclusions

1. Speed had statistically significant effect on measurement errors of all weight parameters (GVW, steering axle weight, and tandem axle weights).

2. Temperature did not have statistically significant effect on measurement errors of any weight parameters.

3. Truck type had statistically significant effect on the measurement errors of steering axle weights and weights of tandem axles on trailers. The regression coefficient 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.) For example, the mean error for steering axle weights for the Secondary truck was about 1.5 % smaller than the error for the Primary truck.

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

5.1.5 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 117 vehicles including 106 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 5-7 illustrates the breakdown of vehicles observed and identified by the WIM equipment for the manual classification study. Misclassified vehicles are defined as those vehicles that are manually classified by observation as one class of vehicle but identified by the WIM equipment as another class of vehicle. As shown in Table 5-8, four Class 3 vehicles were identified as Class 5 vehicles and one Class 5 vehicle was identified as a Class 4 vehicle (bus) by the equipment. Additionally, two Class 5 vehicles and two Class 3 vehicles were identified as Class 8 vehicles. The WIM equipment reported two class 9 vehicles as Class 14 vehicles, indicating that the vehicles either were not fully in the lane or did not trigger the loops properly.

When combined, the misclassifications resulted in an undercount of six class 3 vehicles and two class 9 vehicles and an overcount of one class 4, one class 5 and four class 8 vehicles. There were no unclassified vehicles reported by the equipment.

Table 5-7 – Validation Classification Study Results – 15-Nov-11

Class	3	4	5	6	7	8	9	10	11	12	13
Observed Count	11	0	14	2	1	3	76	3	4	3	0
WIM Count	5	1	15	2	1	7	74	3	4	3	0
Observed Percent	9.4	0.0	12.0	1.7	0.9	2.6	65.0	2.6	3.4	2.6	0.0
WIM Percent	4.3	0.9	12.8	1.7	0.9	6.0	63.2	2.6	3.4	2.6	0.0
Misclassified Count	2	0	3	0	0	0	0	0	0	0	0
Misclassified Percent	18.2	0.0	21.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unclassified Count	0	0	0	0	0	0	0	0	0	0	0
Unclassified Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

The misclassified percentage represents the percentage of the misclassified vehicles in the manual sample. The misclassifications by pair are provided in Table 5-8.

Table 5-8 – Validation Misclassifications by Pair – 15-Nov-11

Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs
3/5	4	6/4	0	9/5	0
3/8	2	6/7	0	9/8	0
4/6	0	6/8	0	9/10	0
5/3	0	6/9	0	9/14	2
5/4	1	6/10	0	10/13	0
5/6	0	7/6	0	11/12	0
5/7	0	8/3	0	12/11	0
5/8	2	8/5	0	13/10	0
5/9	0	8/9	0	13/11	0

As shown in the table, a total of 9 vehicles, including 2 heavy trucks (6 – 13) were misclassified by the equipment and two Class 9 vehicles were identified as Class 14 vehicles. Based on the vehicles observed during the validation study, the misclassification percentage is 2.2% for heavy trucks (6 – 13), which is not within the 2.0% acceptability criteria for LTPP SPS WIM sites. The overall misclassification rate for all vehicles (3 – 15) is 4.7%.

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 – 15-Nov-11

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

Based on the manually collected sample of the 106 trucks, 0.0% of the vehicles at this site were reported as unclassified during the study. This is within the established criteria of 2.0% for LTTP SPS WIM sites.

For speed, the mean error for WIM equipment speed measurement was -0.4 mph; the range of errors was 6.5 mph.

5.2 Calibration

The validation study demonstrated that the site is currently providing high-quality research type traffic loading data. The mean measurement error for GVW of the two test trucks was 0.4% at the truck traffic flow speed. Consequently, no calibration of the equipment compensation factors was recommended. The operating system weight compensation parameters that were in place prior to the validation and left in place at the conclusion are shown in Table 5-10.

Table 5-10 – Initial and Final System Parameters – 15-Nov-11

Speed Point	MPH	Left	Right
		1	2
88	55	3156	3654
96	60	3385	3923
104	65	3344	3874
112	70	3370	3905
120	75	3437	3981
Axle Distance (cm)		370	
Dynamic Comp (%)		101	
Loop Width (cm)		320	

6 Previous WIM Site Validation Information

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

6.1 Sheet 16s

This site has validation information from five previous visits as well as the current one as summarized in the tables below and provided on the Traffic Sheet 16. Table 6-1 data was extracted from 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
	4	5	6	7	8	9	10	11	12	13	
31-Oct-06	75	50	0	N/A	18	3	N/A	25	0	100	0
1-Nov-06	50	33	0	0	0	1	0	33	0	N/A	0
17-Apr-07	N/A	N/A	N/A	N/A	0	1	N/A	14	0	N/A	2
18-Apr-07	N/A	0	0	N/A	0	0	0	0	0	N/A	0
29-Jul-08	N/A	18	0	N/A	38	0	N/A	0	N/A	N/A	0
30-Jul-08	0	21	0	N/A	50	1	N/A	0	N/A	N/A	0
21-Dec-10	N/A	0	0	N/A	11	0	0	0	0	N/A	0
22-Dec-10	0	8	0	0	0	0	0	0	0	N/A	0
15-Nov-11	18	0	21	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 post-validations as reported on the LTPP Traffic Sheet 16s.

Table 6-2 – Weight Validation History

Date	Mean Error and SD		
	GVW	Single Axles	Tandem
31-Oct-06	-1.2 ± 3.2	-3.8 ± 4.7	-1.8 ± 6.7
1-Nov-06	-1.6 ± 2.3	-4.8 ± 3.8	-1.1 ± 2.9
17-Apr-07	-1.5 ± 3.9	-3.0 ± 8.7	-1.2 ± 5.5
18-Apr-07	0.5 ± 3.1	-0.3 ± 5.3	0.6 ± 4.6
29-Jul-08	-2.4 ± 1.3	-1.3 ± 2.4	-2.6 ± 2.0
30-Jul-08	0.8 ± 1.4	2.5 ± 2.4	0.5 ± 2.1
21-Dec-10	2.5 ± 1.1	1.6 ± 2.5	2.7 ± 1.5
22-Dec-10	-0.3 ± 1.2	-0.2 ± 2.5	-0.4 ± 1.7
15-Nov-11	-1.9 ± 2.9	-0.9 ± 2.9	-2.1 ± 3.5

The variability of the weight errors appears to have been reduced for the 2008 and 2010 validations. From this information, it appears that the system demonstrates a tendency for the equipment to move toward an underestimation for all weights over time. The table also demonstrates the effectiveness of the validations in keeping the weight estimations within LTPP SPS WIM equipment tolerances.

6.2 Comparison of Past Validation Results

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

Table 6-3 – Comparison of Post-Validation Results

Parameter	95 %Confidence Limit of Error	Site Values (Mean Error and 95% Confidence Interval)				
		1-Nov-06	18-Apr-07	30-Jul-08	22-Dec-10	15-Nov-11
Steering Axles	±20 percent	-4.8 ± 7.7	-0.3 ± 10.7	2.5 ± 6.2	-0.2 ± 5.1	-0.9 ± 5.9
Tandem Axles	±15 percent	-1.1 ± 5.8	0.6 ± 9.2	0.5 ± 4.2	-0.4 ± 3.4	-2.1 ± 7.1
GVW	±10 percent	-1.6 ± 4.6	0.5 ± 6.3	0.8 ± 2.9	-0.3 ± 2.4	-1.9 ± 5.9

From Table 6-3, it appears that the mean error and the 95% confidence interval were reduced for the 2008 and 2010 validations.

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

Table 6-4 – Final Factors

Speed Points	**New Factors**	
	Left	**Right**
	1	**2**
88	3156	3654
96	3385	3923
104	3344	3874
112	3370	3905
120	3437	3981
Axle Distance (cm)	370	
Dynamic Comp (%)	101	
Loop Width (cm)	320	

A review of the LTPP Standard Release Database 25 shows that there are 4 years of level "E" WIM data for this site. This site requires 1 additional year 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 – Site Photograph Logs
- Updated Handout Guide

WIM System Field Calibration and Validation - Photos

Kansas, SPS-2
SHRP ID: 200200

Validation Date: November 16, 2011

APPLIED RESEARCH ASSOCIATES, INC.

Photo 1 – Cabinet Exterior

Photo 2 – Cabinet Interior (Front)

Photo 3 – Cabinet Interior (Back)

Photo 4 – Leading Loop

Photo 5 – Leading WIM Sensor

Photo 6 – Trailing WIM Sensor

Photo 7 - Trailing Loop

Photo 8 – Power Service Box

Photo 9 – Telephone Service Box

Photo 10 – Downstream

Photo 11 – Upstream

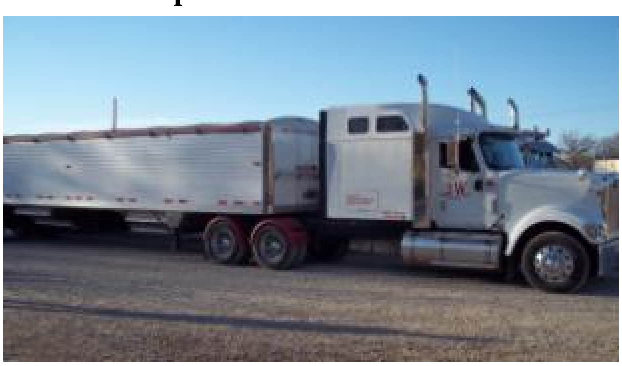


Photo 12 – Truck 1

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 4

Photo 27 – Truck 2 Suspension 5

Traffic Sheet 16	STATE CODE:	20
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	200200
SITE CALIBRATION SUMMARY	DATE (mm/dd/yyyy)	11/15/2011

SITE CALIBRATION INFORMATION

1. DATE OF CALIBRATION {mm/dd/yy} 11/15/11

2. TYPE OF EQUIPMENT CALIBRATED: Both

3. REASON FOR CALIBRATION: LTPP Validation

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

a. Inductance Loops   c. ______

b. Bending Plates   d. ______

5. EQUIPMENT MANUFACTURER: IRD iSINC

WIM SYSTEM CALIBRATION SPECIFICS

6. CALIBRATION TECHNIQUE USED: Test Trucks

Number of Trucks Compared: ______

Number of Test Trucks Used: 2

Passes Per Truck: 20

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

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

Mean Difference Between -

	Mean		
Dynamic and Static GVW:	-1.9%	Standard Deviation:	2.9%
Dynamic and Static Single Axle:	-0.9%	Standard Deviation:	2.9%
Dynamic and Static Double Axles:	-2.1%	Standard Deviation:	3.5%

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

9. DEFINE SPEED RANGES IN MPH:

			Low		High	Runs
a.	Low	-	54.0	to	61.0	14
b.	Medium	-	61.1	to	68.1	16
c.	High	-	68.2	to	75.0	10
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: SPS WIM ID: DATE (mm/dd/yyyy)	20 200200 11/15/2011

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3344 | 3874

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:		FHWA Class	5	-	
FHWA Class 8:		FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 0.0%

Validation Test Truck Run Set - Pre

Person Leading Calibration Effort: **Kevin Trousdale**

Contact Information: Phone: 717-975-3550

E-mail: ktrousdale@ara.com

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 20 SPS WIM ID: 200200 DATE (mm/dd/yyyy) 11/15/2011

Count - 117 Time = 1:56:13 Trucks (4-15) - 106 Class 3s - 11

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
68	7	11919	67	7	64	9	12026	64	9
62	9	11923	64	9	67	9	12098	67	9
69	9	11925	68	9	70	9	12100	68	9
72	**14**	**11929**	**74**	**9**	64	3	12101	62	3
5	**14**	**11931**	**72**	**9**	71	9	12103	70	9
73	9	11933	73	9	75	5	12143	74	5
72	**5**	**11938**	**71**	**3**	62	6	12147	62	6
67	9	11940	66	9	69	5	12148	69	5
76	9	11945	75	9	63	9	12149	63	9
68	9	11946	68	9	65	10	12153	65	10
77	5	11951	75	5	67	12	12156	67	12
69	9	11952	68	9	69	5	12159	70	5
66	9	11953	65	9	68	9	12163	69	9
73	9	11955	72	9	66	11	12164	65	11
74	5	11956	74	5	62	9	12174	63	9
72	9	11957	73	9	65	9	12178	68	9
67	9	11960	66	9	68	9	12180	69	9
66	**5**	**12006**	**64**	**3**	70	9	12181	69	9
64	3	12007	64	3	70	3	12185	73	3
69	9	12010	72	9	70	9	12188	70	9
70	9	12012	73	9	66	9	12190	65	9
69	9	12013	69	9	68	9	12192	67	9
70	12	12017	67	12	64	9	12195	66	9
70	9	12019	69	9	70	9	12219	69	9
62	11	12020	62	11	70	9	12222	69	9

Sheet 1 - 0 to 50 Start: 10:35:49 Stop: 11:32:04

Recorded By: ar Verified By: djw

Validation Test Truck Run Set - Pre

Traffic Sheet 20	
LTPP MONITORED TRAFFIC DATA	STATE CODE: 20
SPEED AND CLASSIFICATION STUDIES	SPS WIM ID: 200200
	DATE (mm/dd/yyyy) 11/15/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
74	**5**	**12227**	**68**	**3**	67	9	12305	67	9
65	**4**	**12228**	**65**	**5**	62	9	12306	62	9
75	5	12229	74	5	**70**	**5**	**12308**	**76**	**3**
65	12	12234	64	12	64	9	12309	64	9
73	**8**	**12235**	**74**	**3**	73	5	12310	73	5
71	9	12238	69	9	75	5	12313	74	5
60	3	12243	58	3	72	9	12315	71	9
69	8	12245	67	8	72	9	12322	72	9
67	5	12248	67	5	68	9	12330	68	9
61	9	12250	61	9	59	9	12335	60	9
74	8	12256	76	8	68	9	12336	67	9
67	**8**	**12257**	**66**	**3**	73	9	12341	71	9
65	11	12260	69	11	59	9	12343	57	9
60	9	12262	60	9	70	8	12344	67	8
70	9	12263	69	9	62	9	12347	62	9
65	11	12264	64	11	70	6	12353	69	6
67	9	12292	67	9	60	9	12356	61	9
65	9	12293	70	9	64	9	12358	64	9
65	5	12294	65	5	64	9	12359	63	9
65	9	12295	67	9	65	9	12360	64	9
64	9	12296	69	9	65	9	12361	64	9
65	9	12298	64	9	73	9	12363	74	9
65	9	12299	68	9	**66**	**8**	**12368**	**66**	**5**
67	9	12300	63	9	57	9	12370	55	9
60	**8**	**12301**	**60**	**5**	58	10	12371	56	10

Sheet 2 - 51 to 100 Start: 11:33:45 Stop: 12:00:42

Recorded By: ar Verified By: djw

Validation Test Truck Run Set - Pre

Traffic Sheet 20	STATE CODE: 20
LTPP MONITORED TRAFFIC DATA	SPS WIM ID: 200200
SPEED AND CLASSIFICATION STUDIES	DATE (mm/dd/yyyy) 11/15/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
70	9	12372	69	9					
74	9	12373	70	9					
65	9	12383	65	9					
65	9	12384	65	9					
61	9	12387	61	9					
67	10	12389	66	10					
70	5	12390	69	5					
71	9	12396	71	9					
67	9	12397	67	9					
60	9	12407	60	9					
70	9	12469	70	9					
78	3	12475	79	3					
71	9	12483	75	9					
61	9	12488	61	9					
68	9	12521	68	9					
74	9	12522	73	9					
68	9	12533	68	9					

Sheet 3 - 101 - 150 Start: 12:00:46 Stop: 12:32:02

Recorded By: ar Verified By: djw