WIM System Field Calibration and Validation Summary Report

Illinois SPS-6
SHRP ID – 170600

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1 Executive Summary

A WIM validation was performed on August 5, 2013 at the Illinois SPS-6 site located on route I-57, milepost 225.6, 8.5 miles south of Interstate 72.

This site was installed on July 27, 2005. The in-road sensors are installed in the northbound, righthand driving lane. The site is equipped with bending plate WIM sensors and an IRD iSINC WIM controller. The LTPP lane is identified as lane 1 in the WIM controller. From a comparison between the report of the most recent validation of this equipment on November 2, 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. The cabinet and power service post is heavily overgrown. The leading WIM sensor has missing epoxy at the conduit exit in the shoulder. The sensors do not show signs of 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 is a bump at a pavement transition that may affect the accuracies of the WIM system. A visual observation of the trucks as they approach, traverse, and leave the sensor area indicated significant truck dyanamics at the location of the pavement transition that may affect the accuracy of the WIM system. The trucks appear to track down the center of the lane. Further pavement condition discussion is provided in Section 4.

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

Table 1-1 – Validation Results – 5-Aug-13

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	2.6 ± 3.7%	Pass
Tandem Axles	±15 percent	-0.9 ± 4.1%	Pass
GVW	±10 percent	-0.5 ± 3.2%	Pass
Vehicle Length	±3.0 percent (1.7 ft)	-0.1 ± 0.8 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.4 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 0.0 ± 1.0 mph, which is within the ±1.0 mph tolerance established by the LTPP Field Operations Guide for SPS WIM Sites. Since the site is measuring axle spacing length with a mean error of 0.0 feet, and the speed and axle spacing measurements are based on the distance between the axle detector sensors, it can be concluded that the distance factor is set correctly and that the speeds being reported by the WIM equipment are within acceptable ranges.

This site is providing research quality vehicle classification data for heavy trucks (Class 6 – 13) based on LTPP definition. The heavy truck misclassification rate of 1.3% is within the 2.0% acceptability criterion for LTPP SPS WIM sites. The overall misclassification rate of 10.0% from the 100 vehicle sample (Class 4 – 13) was due to the 9 cross-classifications of Class 3, 4, 5, and 8 vehicles. Of these misclassified vehicles, 5 lightweight vehicles (classes 3 and 5) were misclassified as heavyweight vehicles (classes 6 and 8), which increased heavy vehicle volume by 5 percent. It is recommended for Phase I contractor to evaluate vehicle classification algorithm settings for this site and make adjustments to prevent these misclassifications in the future.

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 rock.

- 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 on the trailer. The Secondary truck was loaded with rock.

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	76.2	10.8	13.5	13.5	19.2	19.2	19.4	4.3	30.5	4.1	58.3	65.0
2	67.2	9.8	12.5	12.5	16.2	16.2	14.5	4.3	15.7	4.1	38.6	45.0

The posted speed limit at the site is 65 mph. During the testing, the speed of the test trucks ranged from to 52 to 65 mph, a variance of 13 mph.

During test truck runs, pavement temperature was collected using a hand-held infrared temperature device. The validation pavement surface temperatures varied from 84.4 to 99.6 degrees Fahrenheit, a range of 15.2 degrees Fahrenheit. The mostly cloudy weather conditions prevented the desired 30 degree range in temperatures.

A review of the LTPP Standard Release Database 27 shows that there more than 5 years of level "E" WIM data for this site. This site does not require 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 July 15, 2013 (Data) to the most recent Comparison Data Set (CDS) from November 3, 2011. The assessments performed prior to the site visits are used to develop expected traffic flow characteristics for the validation. The results of further investigations performed as a result of the analyses are provided in Section 5 of this report.

2.1 LTPP WIM Data Availability

A review of the LTPP Standard Release Database 27 shows that there are 7 years of level "E" WIM data for this site. Table 2-1 provides a breakdown of the available data for years 2005 to 2012.

Table 2-1 – LTPP Data Availability

Year	Total Number of Days in Year	Number of Months
2005	135	5
2006	316	12
2007	347	12
2008	365	12
2009	365	12
2010	363	12
2011	360	12
2012	232	8

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 2005.

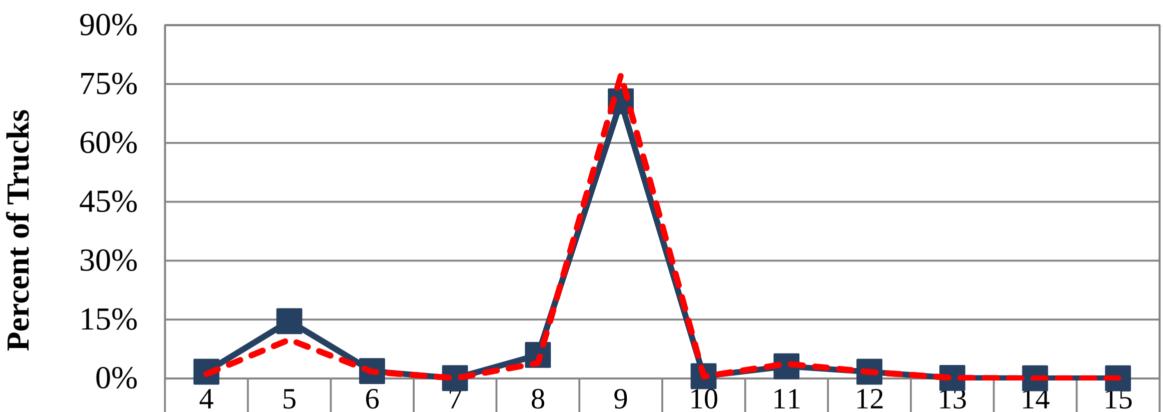
Table 2-2 provides a monthly breakdown of the available data for years 2005 through 2012.

Table 2-2 – LTPP Data Availability by Month

Year	Month												No. of Months
	1	2	3	4	5	6	7	8	9	10	11	12	
2005								17	30	30	27	31	5
2006	31	28	31	22	31	23	10	28	26	28	27	31	12
2007	27	25	31	30	25	30	31	31	30	28	28	31	12
2008	31	29	31	30	31	30	30	31	30	31	30	31	12
2009	31	28	31	30	31	30	31	31	30	31	30	31	12
2010	31	28	31	30	31	30	31	31	30	31	30	29	12
2011	29	26	31	30	31	30	31	30	30	31	30	31	12
2012	31	29	31	30	31	30	31	19					8

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 July 15, 2013 (Data) and the most recent comparison Data Set (CDS) from November 3, 2011.



	4	5	6	7	8	9	10	11	12	13	14	15
Data	1.7%	14.6%	1.8%	0.0%	5.9%	70.6%	0.6%	3.1%	1.7%	0.1%	0.0%	0.0%
CDS	1.1%	9.9%	1.7%	0.0%	3.9%	77.3%	0.5%	3.7%	1.6%	0.1%	0.0%	0.0%

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 (70.6%) and Class 5 (14.6%) 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 0.0 percent of the vehicles at this site are unclassified.

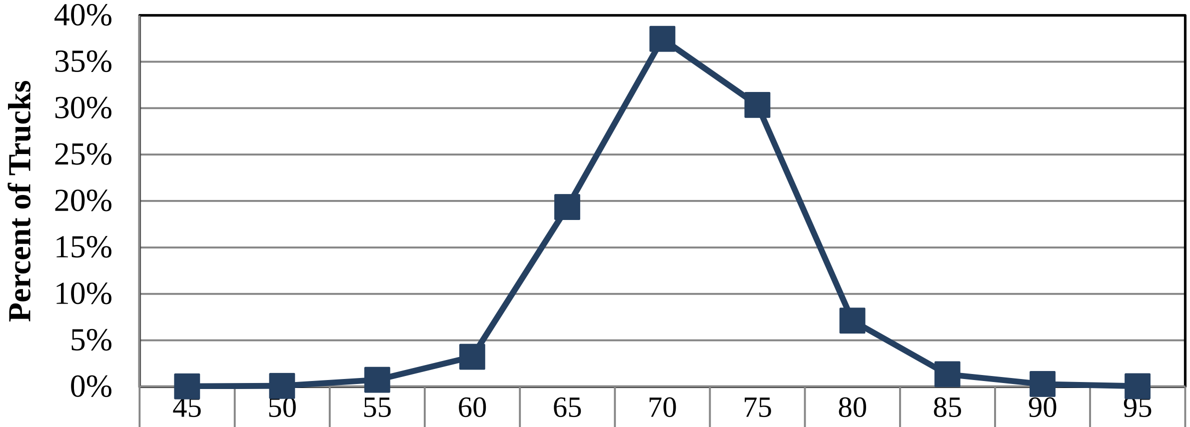
Table 2-3 – Truck Distribution from W-Card

Vehicle Classification	CDS		Data		Change
	Date				
	11/3/2011		7/15/2013		
4	456	1.1%	487	1.7%	0.6%
5	4054	9.9%	4204	14.6%	4.7%
6	691	1.7%	526	1.8%	0.1%
7	20	0.0%	12	0.0%	0.0%
8	1614	3.9%	1717	5.9%	2.0%
9	31715	77.3%	20362	70.6%	-6.7%
10	217	0.5%	159	0.6%	0.0%
11	1535	3.7%	888	3.1%	-0.7%
12	672	1.6%	478	1.7%	0.0%
13	57	0.1%	25	0.1%	-0.1%
14	0	0.0%	0	0.0%	0.0%
15	0	0.0%	0	0.0%	0.0%

From the table it can be seen that the percentage of Class 9 vehicles has decreased by 6.7 percent from November 2011 and July 2013. Changes in the percentage of heavier trucks may be attributed to natural and seasonal variations in truck distributions and an increase in goods movement during current economic cycle. During the same time period, the percentage of Class 5 trucks increased by 4.7 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.



	45	50	55	60	65	70	75	80	85	90	95
Data	0.0%	0.1%	0.7%	3.2%	19.3%	37.5%	30.3%	7.1%	1.3%	0.3%	0.0%

Figure 2-2 – Truck Speed Distribution – 15-Jul-13

As shown in Figure 2-2, the majority of the trucks at this site are traveling between 55 and 75 mph. The posted speed limit at this site is 65 and the 85th percentile speed for trucks at this site is 74 mph. The range of truck speeds for the validation is expected to be between 55 and 65 mph.

2.4 GVW Data Analysis

The traffic CDS data received from the Regional Support Contractor was analyzed to determine the expected Class 9 GVW distributions. Figure 2-3 shows a comparison between GVW plots generated using a two-week W-card sample from July 2013 and the Comparison Data Set from November 2011.

As shown in Figure 2-3, the unloaded and loaded peaks for the November 2011 Comparison Data Set (CDS) and the July 2013 two-week sample W-card dataset (Data) are similar.

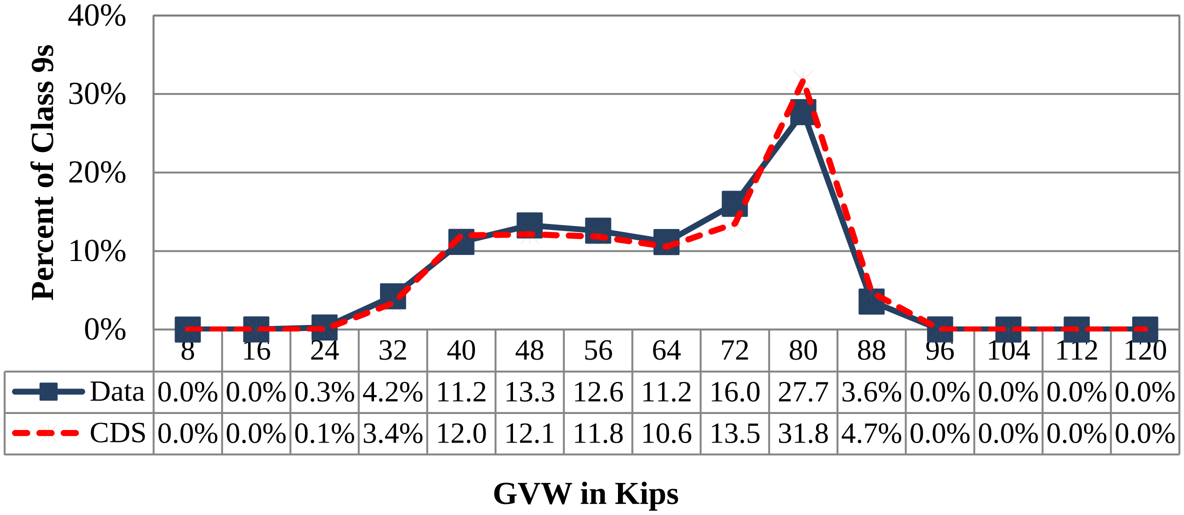


Figure 2-3 – Comparison of Class 9 GVW Distribution

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

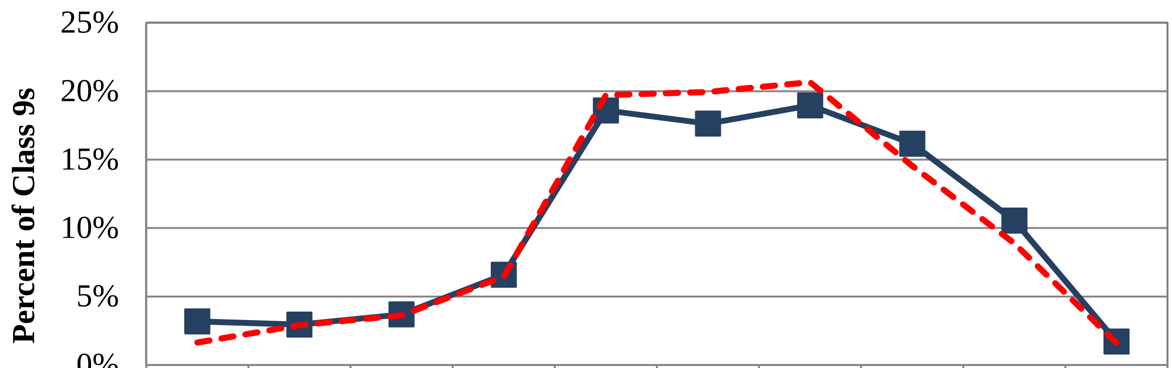
GVW weight bins (kips)	CDS		Data		Change
	Date				
	11/3/2011		7/15/2013		
8	0	0.0%	0	0.0%	0.0%
16	3	0.0%	2	0.0%	0.0%
24	23	0.1%	52	0.3%	0.2%
32	1061	3.4%	858	4.2%	0.9%
40	3784	12.0%	2264	11.2%	-0.8%
48	3830	12.1%	2689	13.3%	1.1%
56	3741	11.8%	2552	12.6%	0.7%
64	3336	10.6%	2260	11.2%	0.6%
72	4263	13.5%	3247	16.0%	2.5%
80	10027	31.8%	5614	27.7%	-4.1%
88	1494	4.7%	724	3.6%	-1.2%
96	11	0.0%	3	0.0%	0.0%
104	1	0.0%	1	0.0%	0.0%
112	0	0.0%	0	0.0%	0.0%
120	0	0.0%	0	0.0%	0.0%
Average =	60.5 kips		59.4 kips		-1.1 kips

As shown in the table, the percentage of unloaded class 9 trucks in the 32 to 40 kips range decreased by 0.8 percent while the percentage of loaded class 9 trucks in the 72 to 80 kips range decreased by 4.1 percent. During this time period the percentage of overweight trucks decreased by 1.2 percent. Based on the average Class 9 GVW values from the per vehicle records, the GVW average for this site decreased by 1.9 percent, from 60.5 to 59.4 kips. This indicates a possible underestimation of loads by the system at this site.

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 July 2013 and the Comparison Data Set from November 2011. The percentage of light axles (10.5 to 11.5 kips) decreased by approximately 3.4% and the percentage of heavy axles (12.5 to 13.5 kips) increased by approximately 1.8%.



	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5
Data	3.2%	2.9%	3.7%	6.6%	18.6%	17.6%	19.0%	16.2%	10.5%	1.7%
CDS	1.6%	2.9%	3.6%	6.5%	19.7%	20.0%	20.7%	14.5%	8.9%	1.6%

Steering Axle Weight in Kips

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

It can be seen in the figure that the greatest percentage of trucks have front axle weights measuring between 11.0 and 12.0 kips. The percentage of trucks in this range has decreased by 4.0% between the November 2011 Comparison Data Set (CDS) and the July 2013 dataset (Data).

Table 2-5 provides the Class 9 front axle weight distribution data for the November 2011 Comparison Data Set (CDS) and the July 2013 dataset (Data).

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

F/A weight bins (kips)	CDS		Data		Change
	Date				
	11/3/2011		7/15/2013		
9.0	517	1.6%	639	3.2%	1.5%
9.5	912	2.9%	592	2.9%	0.0%
10.0	1140	3.6%	742	3.7%	0.1%
10.5	2024	6.5%	1325	6.6%	0.1%
11.0	6185	19.7%	3739	18.6%	-1.1%
11.5	6259	20.0%	3546	17.6%	-2.3%
12.0	6482	20.7%	3814	19.0%	-1.7%
12.5	4562	14.5%	3251	16.2%	1.6%
13.0	2786	8.9%	2121	10.5%	1.7%
13.5	504	1.6%	344	1.7%	0.1%
Average =	11.4 kips		11.3 kips		-0.1 kips

The table shows that the average front axle weight for Class 9 trucks has decreased by 0.1 kips, or 0.9 percent. According to the values from the per vehicle records, the average front axle weight for Class 9 trucks is 11.3 kips.

2.6 Class 9 Tractor Tandem Spacing Data Analysis

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

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

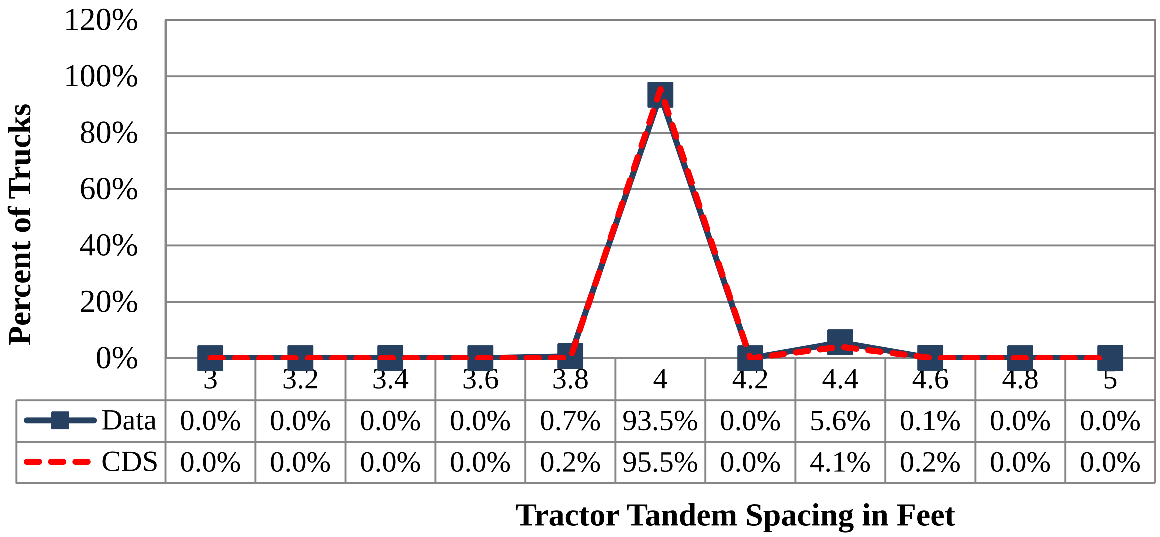


Figure 2-5 – Comparison of Class 9 Tractor Tandem Spacing

As seen in the figure, the Class 9 tractor tandem spacings for the November 2011 Comparison Data Set and the July 2013 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				
	11/3/2011		7/15/2013		
3.0	0	0.0%	0	0.0%	0.0%
3.2	0	0.0%	1	0.0%	0.0%
3.4	1	0.0%	4	0.0%	0.0%
3.6	0	0.0%	0	0.0%	0.0%
3.8	74	0.2%	144	0.7%	0.5%
4.0	30144	95.5%	18944	93.5%	-2.0%
4.2	0	0.0%	0	0.0%	0.0%
4.4	1300	4.1%	1142	5.6%	1.5%
4.6	51	0.2%	27	0.1%	0.0%
4.8	0	0.0%	0	0.0%	0.0%
5.0	4	0.0%	4	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 4.4 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 (November 2011) based on the last calibration with the most recent two-week WIM data sample from the site (July 2013). Comparison of vehicle class distribution data indicates a 6.7 percent decrease in the percentage of Class 9 vehicles. Analysis of Class 9 weight data indicates that front axle weights have decreased by 0.9 percent and average Class 9 GVW has decreased by 1.9 percent for the July 2013 data. The data indicates an average truck tandem spacing of 4.0 feet, which is identical to the expected average of 4.0 feet.

3 WIM Equipment Discussion

From a comparison between the report of the most recent validation of this equipment on November 2, 2011 and this validation visit, it appears that no changes have occurred during this time to the basic operating condition of the equipment.

3.1 Description

This site was installed on July 27, 2005 by International Road Dynamics. It is instrumented with bending plate weighing sensors and an IRD iSINC WIM Controller. As the installation contractor, IRD also performs routine equipment maintenance and data quality checks of the WIM data.

3.2 Physical Inspection

Prior to the pre-validation test truck runs, a physical inspection of all WIM equipment and support services equipment was carried out. Missing epoxy at the conduit exit for the leading WIM sensor was noted and is shown in Photo 3-1 – Missing Epoxy at Leading No other deficiencies were noted. Photographs of all system components were taken and are presented after Section 7.

Photo 3-1 – Missing Epoxy at Leading Weighpad

It appears that ants have infested the cabinet interior, as shown in Photo 3-2.

Photo 3-2 Cabinet Interior Infestation

It was also noted that the cabinet and power meter service mast are densely overgrown, as shown in Photo 3-3 and Photo 3-4 below.

Photo 3-3 – Overgrowth at Cabinet

Photo 3-4 – Overgrowth at Power Meter Mast

No other deficiencies were noted. Photographs of all system components were taken and are presented after Section 7.

3.3 Electronic and Electrical Testing

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

3.4 Equipment Troubleshooting and Diagnostics

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

3.5 Recommended Equipment Maintenance

The missing epoxy at the leading WIM sensor needs to be replaced. Pest control in the cabinet and vegetation control at the cabinet and at the power meter service mast are recommended.

4 Pavement Discussion

4.1 Pavement Condition Survey

During a visual distress survey of the pavement conducted from the shoulder, the distress shown in Photo 4-1 was noted at a location 392 feet prior to the WIM scales. Adverse truck dynamics were noted in this area. The distress may affect the accuracy of the WIM sensors.

Photo 4-1 – Pavement Distress 392 Feet Prior to WIM

4.2 LTPP Pavement Profile Data Analysis

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

Table 4-1 – Recommended WIM Smoothness Index Thresholds

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

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

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

Table 4-2 – WIM Index Values

Profiler Passes			**Pass 1**	**Pass 2**	**Pass 3**	**Pass 4**	**Pass 5**	**Avg**
Left	LWP	LRI (m/km)	0.658	0.654	0.620			0.644
		SRI (m/km)	0.560	0.604	*0.309*			*0.491*
		Peak LRI (m/km)	0.893	0.829	0.901			0.874
		Peak SRI (m/km)	*0.585*	*0.613*	*0.464*			*0.554*
	RWP	LRI (m/km)	0.597	0.672	0.563			0.611
		SRI (m/km)	1.112	1.210	0.606			0.976
		Peak LRI (m/km)	0.822	0.753	0.832			0.802
		Peak SRI (m/km)	**1.164**	**1.213**	***0.674***			**1.017**
Center	LWP	LRI (m/km)	*0.462*	*0.455*	*0.451*	*0.444*	*0.425*	*0.447*
		SRI (m/km)	*0.348*	*0.461*	*0.405*	*0.409*	*0.395*	*0.404*
		Peak LRI (m/km)	0.713	0.801	0.758	0.778	0.714	0.753
		Peak SRI (m/km)	*0.546*	*0.589*	*0.608*	*0.619*	*0.567*	*0.586*
	RWP	LRI (m/km)	0.594	0.510	0.551	0.530	0.573	0.552
		SRI (m/km)	1.235	0.758	0.821	0.896	1.049	0.952
		Peak LRI (m/km)	0.753	0.730	0.784	0.830	0.865	0.792
		Peak SRI (m/km)	1.250	0.786	0.842	0.950	1.059	0.977
Right	LWP	LRI (m/km)	0.515	0.595	0.598			0.569
		SRI (m/km)	*0.266*	0.541	0.627			*0.478*
		Peak LRI (m/km)	0.746	0.813	0.752			0.770
		Peak SRI (m/km)	*0.495*	*0.680*	*0.645*			*0.607*
	RWP	LRI (m/km)	0.817	0.603	0.579			0.666
		SRI (m/km)	1.385	0.589	0.560			0.845
		Peak LRI (m/km)	0.871	0.781	0.749			0.800
		Peak SRI (m/km)	1.390	*0.641*	*0.611*			0.881

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. Indices that are below the lower thresholds are shown in italics. The highest values, on average, are the Peak SRI values in the right wheel path of the left shift passes (shown in bold).

4.3 Profile and Vehicle Interaction

Profile data was collected on June 26, 2012 by the North Central Regional Support Contractor using a high-speed profiler, where the operator measures the pavement profile over the entire one-thousand foot long WIM Section, beginning 900 feet prior to WIM scales and ending 100 feet after the WIM scales. Each pass collects International Roughness Index (IRI) values in both the left and right wheel paths. For this site, 11 profile passes were made, 5 in the center of the travel lane and 6 that were shifted to the left and to the right of the center of the travel lane.

From a pre-visit review of the IRI values for the center, right, and left profile runs, the highest IRI value within the 1000 foot WIM section and the 400-foot approach section is 745 in/mi and is located approximately 392 feet prior to the WIM scale. This area of the pavement was closely investigated during the validation visit, and truck dynamics in this area were closely observed. The bump noted at this location indicates adverse truck dynamics and may influence WIM accuracy. The dynamics appear to diminish as the trucks approach the sensor area.

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.

4.4 Recommended Pavement Remediation

Pavement remediation at the location of the distress 392 feet prior to the WIM scales 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.

5.3 Validation

The 40 validation test truck runs were conducted on August 5, 2013, beginning at approximately 10:00 AM and continuing until 5:23 PM.

The two test trucks consisted of:

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

The test trucks were weighed prior to the validation and 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 Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	76.2	10.8	13.5	13.5	19.2	19.2	19.4	4.3	30.5	4.1	58.3	65.0
2	67.2	9.8	12.5	12.5	16.2	16.2	14.5	4.3	15.7	4.1	38.6	45.0

Test truck speeds varied by 13 mph, from 52 to 65 mph. The measured validation pavement temperatures varied 15.2 degrees Fahrenheit, from 84.4 to 99.6. The mostly cloudy weather conditions prevented the desired minimum 30 degree temperature range. Table 5-2 is a summary of validation results.

Table 5-2 – Validation Overall Results – 5-Aug-13

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	2.6 ± 3.7%	Pass
Tandem Axles	±15 percent	-0.9 ± 4.0%	Pass
GVW	±10 percent	-0.5 ± 3.2%	Pass
Vehicle Length	±3.0 percent (1.7 ft)	-0.1 ± 0.8 ft	Pass
Vehicle Speed	± 1.0 mph	0.0 ± 1.0 mph	Pass
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.2 ft	Pass

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

5.3.1 Statistical Speed Analysis

Statistical analysis was conducted on the test truck run data to investigate whether a relationship exists between speed and WIM equipment weight and distance measurement accuracy. The posted speed limit at this site is 65 mph. The test runs were divided into three speed groups - low, medium and high speeds, as shown in Table 5-3.

Table 5-3 – Validation Results by Speed – 5-Aug-13

Parameter	95% Confidence Limit of Error	Low	Medium	High
		52.0 to 56.3 mph	56.4 to 60.8 mph	60.9 to 65.0 mph
Steering Axles	±20 percent	3.9 ± 3.3%	2.6 ± 3.2%	1.5 ± 3.6%
Tandem Axles	±15 percent	1.0 ± 3.2%	-1.3 ± 2.4%	-2.1 ± 3.8%
GVW	±10 percent	1.3 ± 2.0%	-0.8 ± 1.2%	-1.6 ± 2.9%
Vehicle Length	±3.0 percent (1.7 ft)	-0.2 ± 0.9 ft	-0.2 ± 0.8 ft	-0.1 ± 1.0 ft
Vehicle Speed	± 1.0 mph	-0.1 ± 1.5 mph	0.1 ± 0.6 mph	0.0 ± 1.1 mph
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.2 ft	-0.1 ± 0.2 ft	0.0 ± 0.2 ft

From the table, it can be seen that the WIM equipment increasingly overestimates steering axle weights as speed decreases. For GVW and tandem axle weights, the system transitions from an overestimation at low speeds to an underestimation at high speeds. The range in error for each parameter appears to be consistent throughout the range of 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 paragraphs.

5.3.1.1 GVW Errors by Speed

As shown in Figure 5-1, the equipment transitions from a slight overestimation at low speeds, to a slight underestimation at high speeds. The range in error is reasonably similar for each of the speed groups.

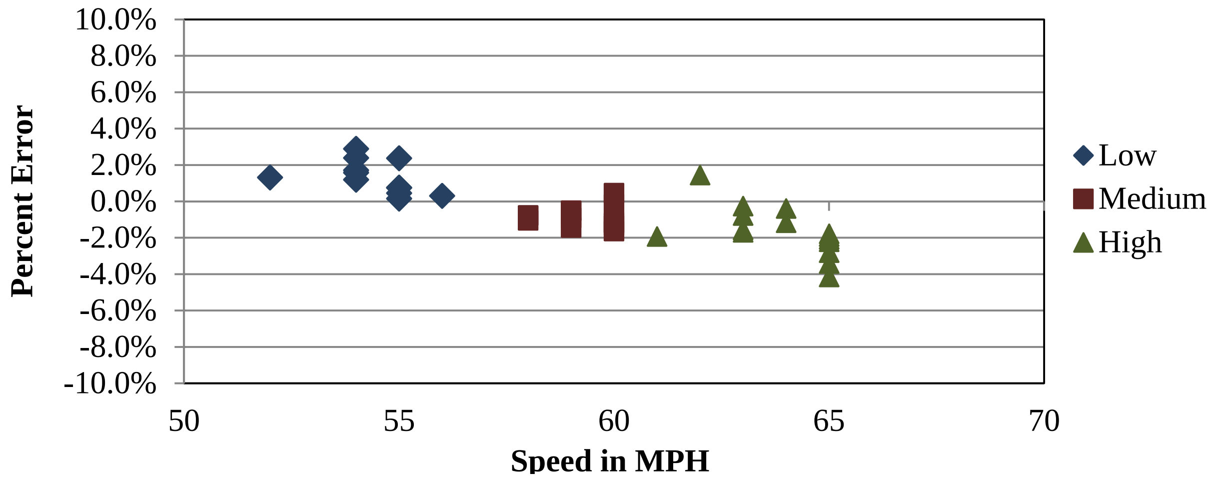


Figure 5-1 – Validation GVW Errors by Speed – 5-Aug-13

5.3.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-2, the equipment generally yields lower errors with increasing speed. The figure illustrates a slight negative correlation between speed and steering axle weight error. The range in error is similar for each of the speed groups.

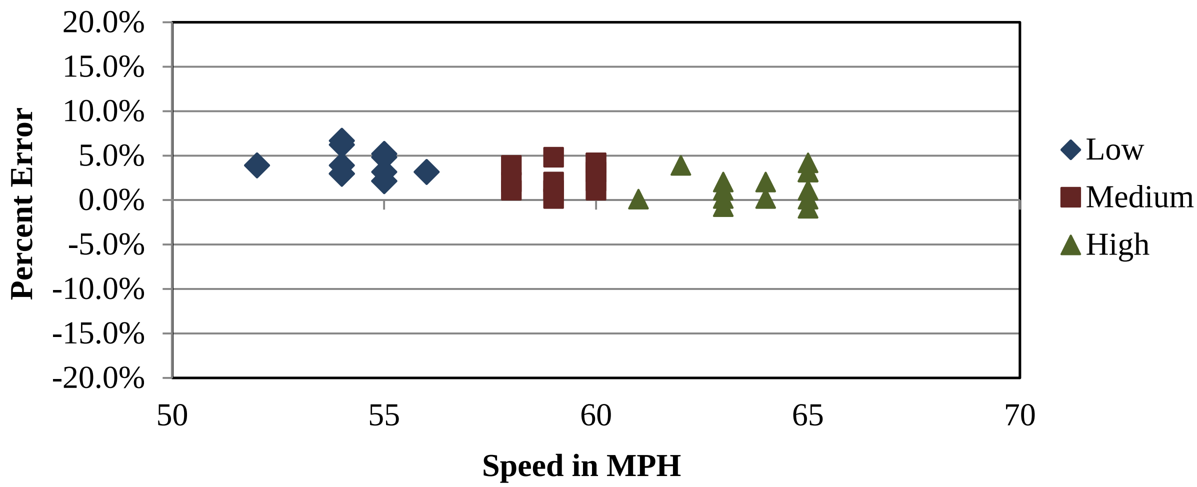


Figure 5-2 – Validation Steering Axle Weight Errors by Speed – 5-Aug-13

5.3.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 5-3, equipment transitions from a slight overestimation at low speeds, to a slight underestimation at high speeds. The range in error is similar for each of the speed groups.

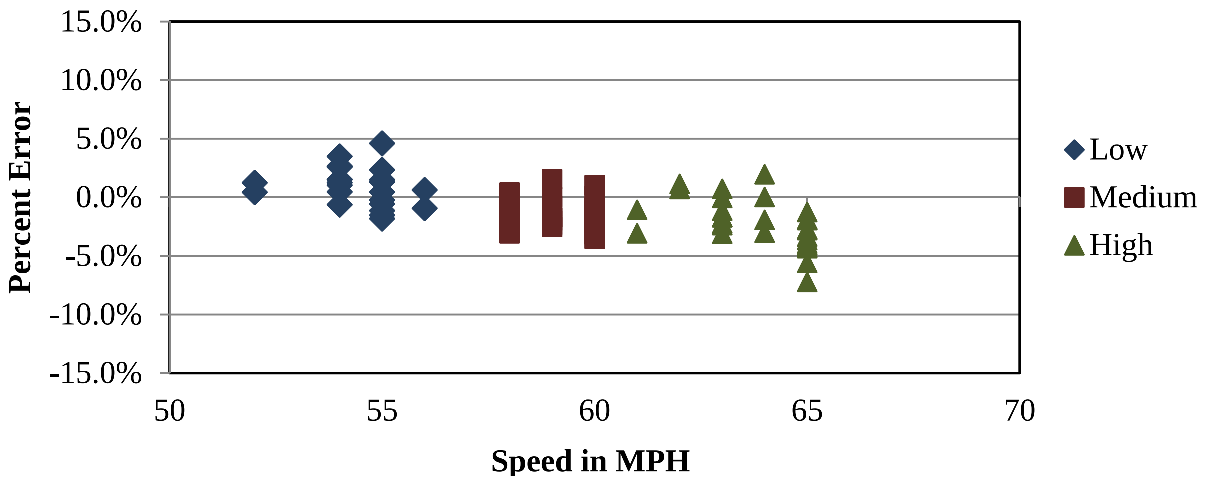


Figure 5-3 – Validation Tandem Axle Weight Errors by Speed – 5-Aug-13

5.3.1.4 GVW Errors by Speed and Truck Type

It can be seen in Figure 5-4 that when the GVW errors are analyzed by truck type, the WIM equipment precision and bias is similar for both the heavily loaded (Primary) truck and the partially loaded (Secondary) truck at low and medium speeds. The range in error is similar for both trucks for each of the speed groups.

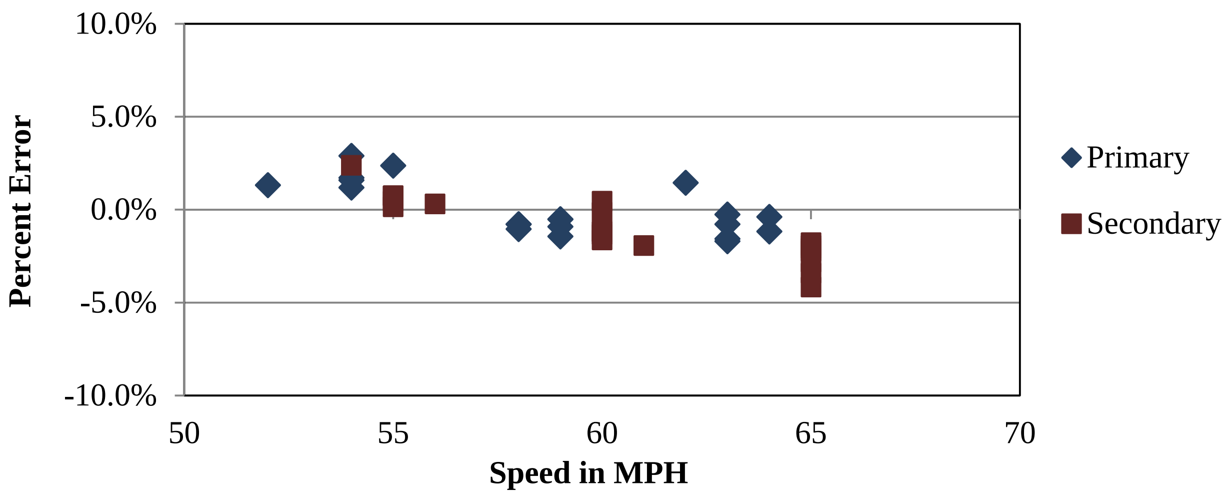


Figure 5-4 – Validation GVW Error by Truck and Speed – 5-Aug-13

5.3.1.5 Axle Length Errors by Speed

For this site, the error in axle length measurement was consistent at all speeds with the exception of one outlier at the high speed range. The range of the axle length measurement error was from -0.2 feet to 0.9 feet. Distribution of errors is shown graphically in Figure 5-5.

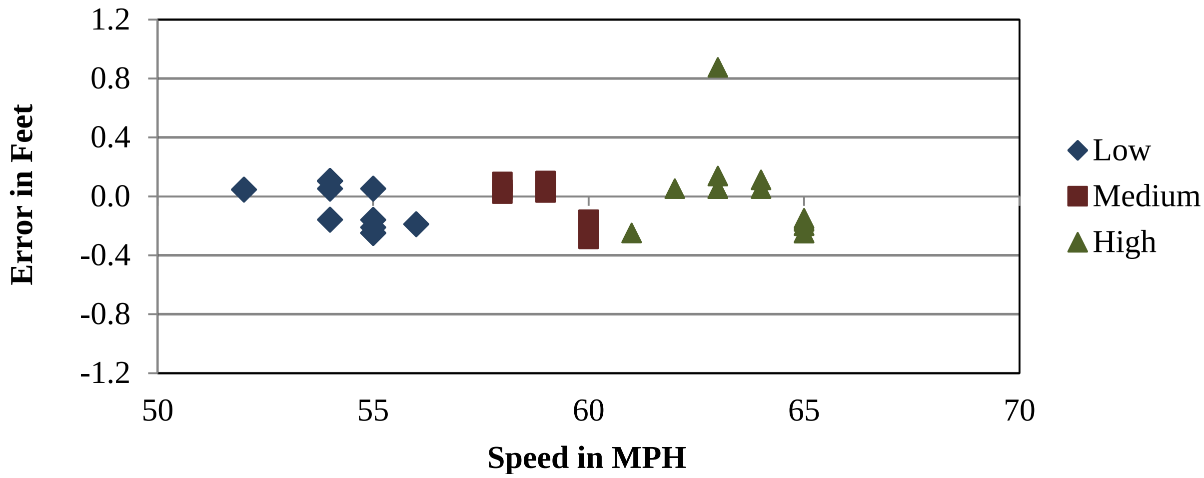


Figure 5-5 – Validation Axle Length Error by Speed – 5-Aug-13

5.3.1.6 Overall Length Errors by Speed

For this system, the WIM equipment measures overall length consistently over the entire range of speeds, with errors ranging from -1.0 to 1.0 feet. Distribution of errors is shown graphically in Figure 5-6.

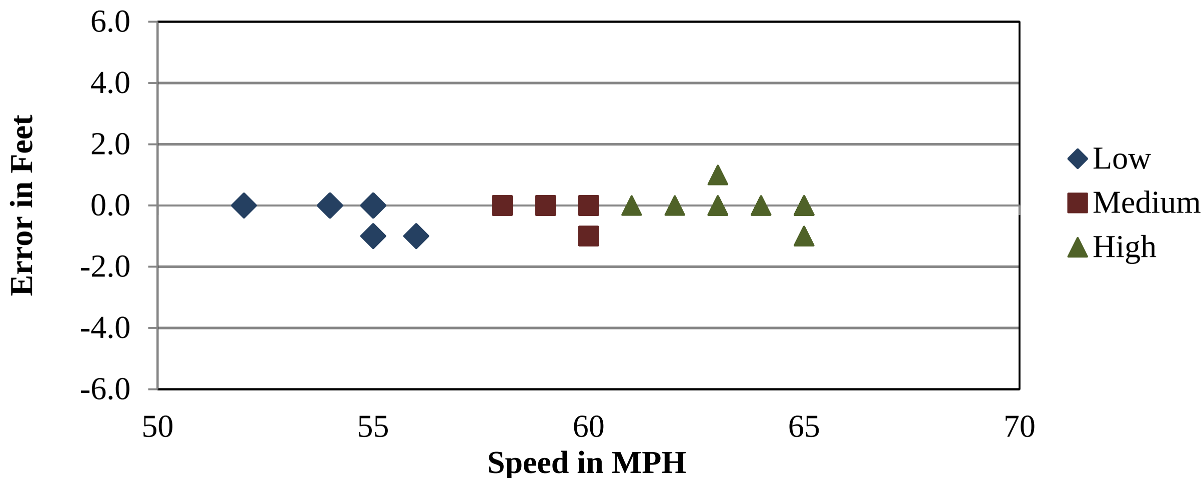


Figure 5-6 – Validation Overall Length Error by Speed – 5-Aug-13

5.3.2 Statistical Temperature Analysis

Statistical analysis was performed for the test truck run data to investigate whether a relationship exists between pavement temperature and WIM equipment weight and distance measurement accuracy. The range of pavement temperatures was 15.2 degrees, from 84.4 to 99.6 degrees Fahrenheit. The validation test runs are reported under one temperature group – medium as shown in Table 5-4 below.

Table 5-4 – Validation Results by Temperature – 5-Aug-13

Parameter	**95% Confidence Limit of Error**	**Medium**
		84.4 to 99.6 degF
Steering Axles	±20 percent	2.6 ± 3.7%
Tandem Axles	±15 percent	-0.9 ± 4.0%
GVW	±10 percent	-0.5 ± 3.2%
Vehicle Length	±3.0 percent (1.7 ft)	-0.1 ± 0.8 ft
Vehicle Speed	± 1.0 mph	0.0 ± 1.0 mph
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.2 ft

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

5.3.2.1 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 GVW estimates at this site.

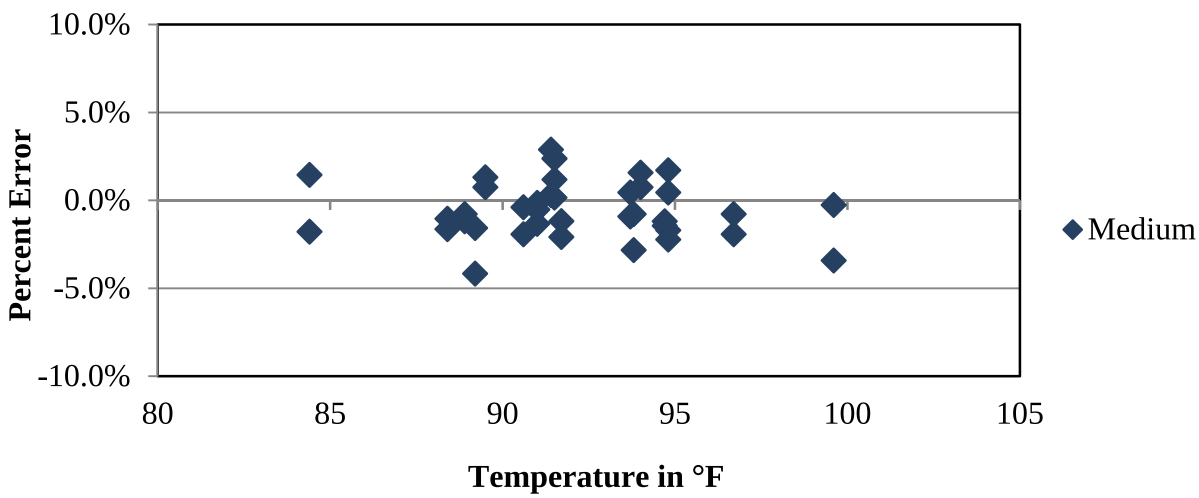


Figure 5-7 – Validation GVW Errors by Temperature – 5-Aug-13

5.3.2.2 Steering Axle Weight Errors by Temperature

Figure 5-8 demonstrates that for steering axles, the WIM equipment appears to estimate weights with similar positive bias across the range of temperatures observed in the field. There does not appear to be a correlation between temperature and steering axle weight estimates at this site.

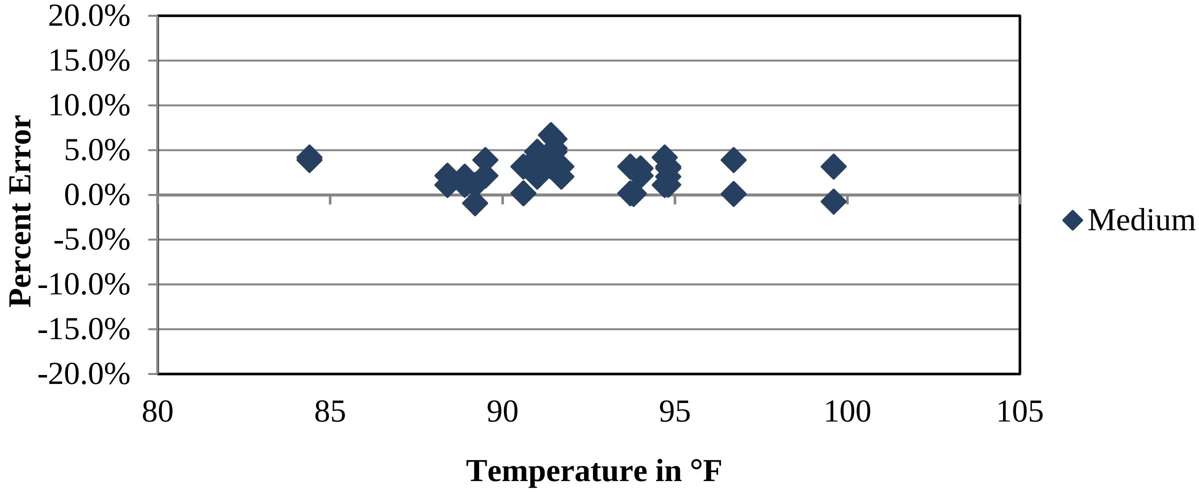


Figure 5-8 – Validation Steering Axle Weight Errors by Temperature – 5-Aug-13

5.3.2.3 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. The range in tandem axle errors is consistent for all temperatures observed in the field.

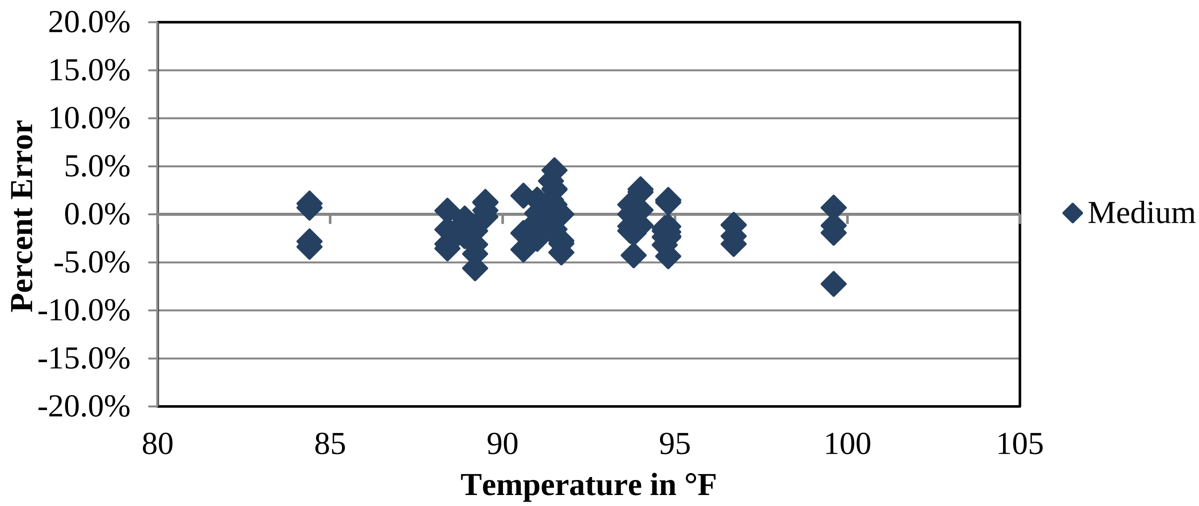


Figure 5-9 – Validation Tandem Axle Weight Errors by Temperature – 5-Aug-13

5.3.2.4 GVW Errors by Temperature and Truck Type

As shown in Figure 5-10, when analyzed by truck type, GVW measurement errors for both trucks are similar at all temperatures observed in the field. For both trucks, bias and precision are similar for the two trucks across the range of temperatures observed in the field.

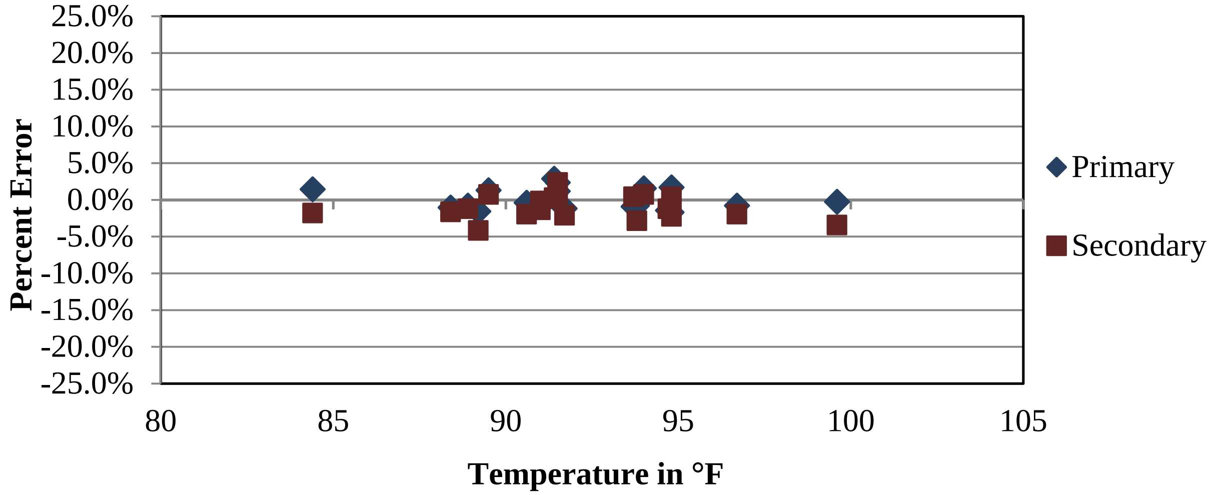


Figure 5-10 – Validation GVW Error by Truck and Temperature – 5-Aug-13

5.3.3 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 100 vehicles, classified as trucks by WIM system (FHWA classes 4-13), 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 5-5. The table illustrates the breakdown of vehicles observed and identified by the equipment for the manual classification study. As shown in Table 5-5, four Class 3 vehicles were misclassified as Class 5 vehicles, one Class 3 vehicle was misclassified as a Class 8 vehicle, one Class 4 vehicle was misclassified as a Class 6 vehicle, and three Class 5 vehicles were misclassified as Class 8 vehicles by the equipment.

Table 5-5 – Validation Misclassifications by Pair – 5-Aug-13

		WIM												
		3	4	5	6	7	8	9	10	11	12	13	14	15
Observed	3	-		4			1							
	4		-		1									
	5			-			3							
	6				-									
	7					-								
	8						-							
	9							-						1
	10								-					
	11									-				
	12										-			
	13											-	-	

As shown in the table, a total of 9 vehicles, including 0 heavy trucks (6 – 13) were misclassified by the equipment. One Class 9 vehicle was not classified by the equipment. Based on the vehicles observed during the validation study, the misclassification percentage is 1.3% for heavy trucks (vehicle classes 6 – 13), which is within the 2.0% acceptability criteria for LTPP SPS WIM sites. The overall misclassification rate for all vehicles (3 – 15) is 10.0 percent due to misclassification of lightweight vehicles in Classes 3, 4 and 5. Of these vehicles, 5 were misclassified as heavyweight vehicles, which increased heavy vehicle volume by 5 percent. It is recommended for Phase I contractor to evaluate vehicle classification algorithm settings for this site and to make adjustments to prevent these misclassifications in the future.

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 results of the investigation are provided in Section 6.2.

The combined results of the misclassifications resulted in an undercount of five Class 3s, one Class 4, and one Class 9, and an overcount of one Class 5, one Class 6, and four Class 8 vehicles, as shown in Table 5-6. The misclassified percentage represents the percentage of the misclassified vehicles in the manual sample.

Table 5-6 – Validation Classification Study Results – 5-Aug-13

Class	3	4	5	6	7	8	9	10	11	12	13
Observed Count	5	1	14	2	0	1	75	1	1	0	0
WIM Count	0	0	15	3	0	5	74	1	1	0	0
Observed Percent	5.0	1.0	14.0	2.0	0.0	1.0	75.0	1.0	1.0	0.0	0.0
WIM Percent	0.0	0.0	15.0	3.0	0.0	5.0	74.0	1.0	1.0	0.0	0.0
Misclassified Count	5	1	3	0	0	0	1	0	0	0	0
Misclassified Percent	100	100	21.4	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0
Unclassified Count	0	0	0	0	0	0	1	0	0	0	0
Unclassified Percent	0.0	0.0	0.0	0.0	0.0	0.0	1.4	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 5-7.

Table 5-7 – Validation Unclassified Trucks by Pair – 5-Aug-13

Observed Class	Unclassified	Observed Class	Unclassified	Observed Class	Unclassifie d
3	0	7	0	11	0
4	0	8	0	12	0
5	0	9	1	13	0
6	0	10	0		

Based on the manually collected sample of the 95 trucks, 1.0 percent of the vehicles at this site were reported as unclassified during the study. This is within the established criteria of 2.0% for LTTP SPS WIM sites.

For speed, the mean error for WIM equipment speed measurement was 0.0 mph; the range of errors was 0.7 mph.

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 -0.5 percent), a calibration of the system was not required and therefore was not carried out.

5.3.4 Final WIM System Compensation Factors

The final factors left in place at the conclusion of the validation are provided in Table 5-8.

Table 5-8 – Final Factors

Speed Point	MPH	Left	Right
		1	2
80	50	3437	3866
88	55	3633	4087
96	60	3618	4071
104	65	3628	4080
112	70	3437	3863
Axle Distance (cm)		306	
Dynamic Comp (%)		105	
Loop Width (cm)		277	

6 Post-Visit Data Analysis

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

If necessary, a traffic data sample from the days immediately following the validation to the date of the report submission may be conducted to further investigate anomalies in the traffic data that may have resulted from the calibration of the system or any other changes to the WIM system

6.1 Regression Analysis

This section provides additional results for the analysis carried out to determine the influence of truck type, speed and pavement temperature on WIM measurement errors. Multivariable linear regression analysis was applied to WIM data collected during calibration procedures. The same calibration data analyzed and discussed previously was used for this analysis; however a more comprehensive statistical methodology was applied. The objective of the additional analysis is to investigate if the trends identified using previous analyses are statistically significant, and to quantify these trends.

Multivariable analysis provides additional insight on how factors such as 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.

6.1.1 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 52 to 65 mph.
- Pavement temperature. Pavement temperature ranged from 84.4 to 99.6 degrees Fahrenheit.

6.1.2 Results

For analysis of GVW weights, the value of regression coefficients and their statistical properties are summarized in Table 6-1. The value of regression coefficients defines the slope of the relationship between the % error in GVW and the predictor variables (speed, temperature, and truck type). The values of the t-distribution (for the regression coefficients) given in Table 6-1 are for the null hypothesis that assumes that the regression coefficients are equal to zero. The p-value reported in Table 6-1 is for the probability that the regression coefficient, given in Table 5-5, occur by chance alone.

Table 6-1 – Table of Regression Coefficients for Measurement Error of GVW

Parameter	Regression coefficients	Standard error	Value of t-distribution	Probability value (p-value)
Intercept	22.1779	4.6043	4.8168	2.63E-05
Speed	-0.3034	0.0370	-8.2055	9.23E-10
Temp	-0.0469	0.0445	-1.0536	0.2991
Truck	-0.5894	0.2957	-1.9930	0.0539

The lowest probability value given in Table 5-15 was 9.23E-10 for speed. This means that there is about 0 percent chance that the value of regression coefficient for speed (-0.3034) can occur by chance alone. Overall, speed have the most significant effect on the GVW measurement errors.

The relationship between speed and measurement errors is shown in Figure 6-1. The figure includes a trend line for the predicted percent error. Besides the visual assessment of the relationship, Figure 6-1 provides quantification and statistical assessment of the relationship.

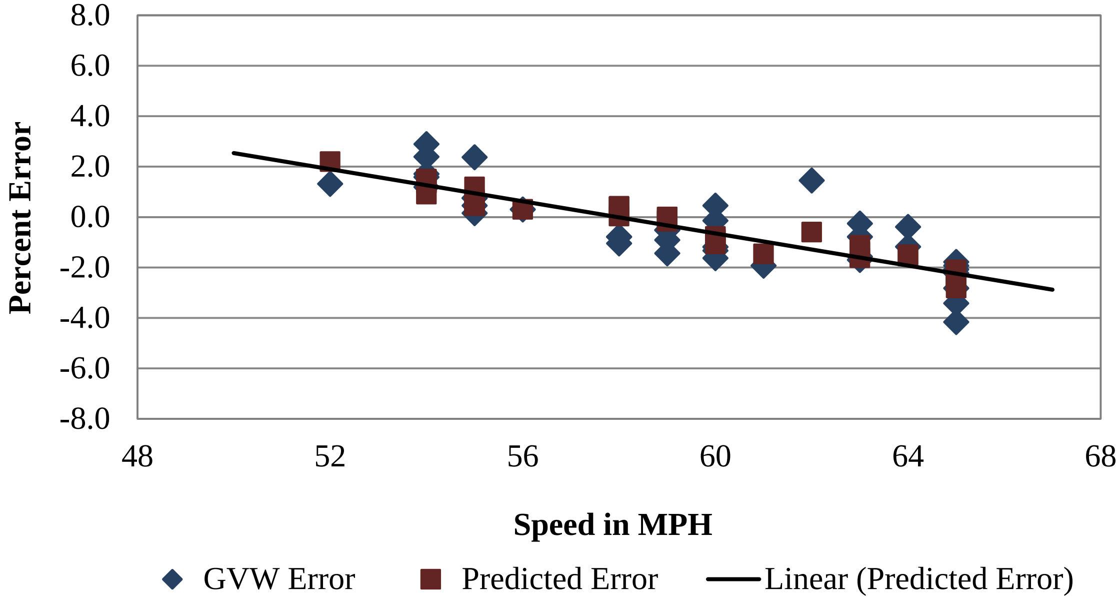


Figure 6-1 – Influence of Speed on the Measurement Error of GVW

The quantification of the relationship is provided by the value of the regression coefficient, in this case -0.3034 (in Table 6-1). This means, for example, that for a 10 mph increase in speed, the measurement error is changed by about 3 percent (-0.3034 x 10). The statistical assessment of the relationship is provided by the probability value of the regression coefficient (-0.3034) and is statistically significant.

6.1.3 Summary Results

Table 6-2 lists regression coefficients and their probability values for all combinations of factors and % errors evaluated. Entries in the table are provided only if the probability value was smaller than 0.20. The dash in Table 6-2 indicates that the relationship was not statistically significant (the probability that the relationship can occur by chance alone was greater than 20 percent).

Table 6-2 – Summary of Regression Analysis

Parameter	Factor					
	Speed		Temperature		Truck type	
	Regression coefficient	Probability value (p-value)	Regression coefficient	Probability value (p-value)	Regression coefficient	Probability value (p-value)
GVW	-0.3034	9.23E-10	-	-	-0.5894	0.0539
Steering axle	-0.2420	0.0005	-0.1052	0.1737	-	-
Tandem axle tractor	-0.2778	0.0001	-	-	-1.3045	0.0140
Tandem axle trailer	-0.3625	2.49E-08	-0.0828	0.1873	-	-

6.1.4 Conclusions

1. According to Table 6-2, speed had statistically significant effect on the measurement errors of all loads.

2. Temperature had a statistically significant effect on steering axle and trailer tandem measurement errors.

3. Truck type had statistically significant effect on GVW measurement errors at 0.0539 probability value. The regression coefficients for truck type in Table 6-2 represent the difference between the mean errors for the Primary and Secondary trucks. (Truck type is an indicator variable with values of 0 or 1.).

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.

6.1.5 Contribution of Two Trucks to Calibration

Calibration of WIM systems installed in LTPP lanes is carried out by adjusting calibration factors based on measurement errors of GVW obtained for calibration trucks. During the calibration process, the GVW measurement errors obtained for two calibration trucks are combined when calculating and setting calibration factors. Different calibration factors are used for different speed points (truck speeds). The question addressed in this section is: What would be the calibration factors (calibration results) if only one truck (either Primary or Secondary) was used?

The contribution of using Primary and Secondary trucks for the calibration of the WIM system is illustrated using Figure 6-2 and supported by the associated statistical analysis. It is noted that the influence of pavement temperature is not directly used in the calibration process and thus not considered in this analysis.

Figure 6-2 shows that speed had similar influences on the GVW measurement for each truck, with both trucks showing increasingly negative bias as speed increases. The trend lines for the two trucks are statistically significant. Combined, the overall GVW error dependency on speed was statistically significant for 5 percent (by chance alone) level of significance (p-value was 9.23E-10). The difference between GVW measurement errors for 2 trucks was found statistically significant for 6 percent (by chance alone) level of significance (p-value was 0.0539) but the difference value is about 0.6 percent and considered small from the practical perspective.

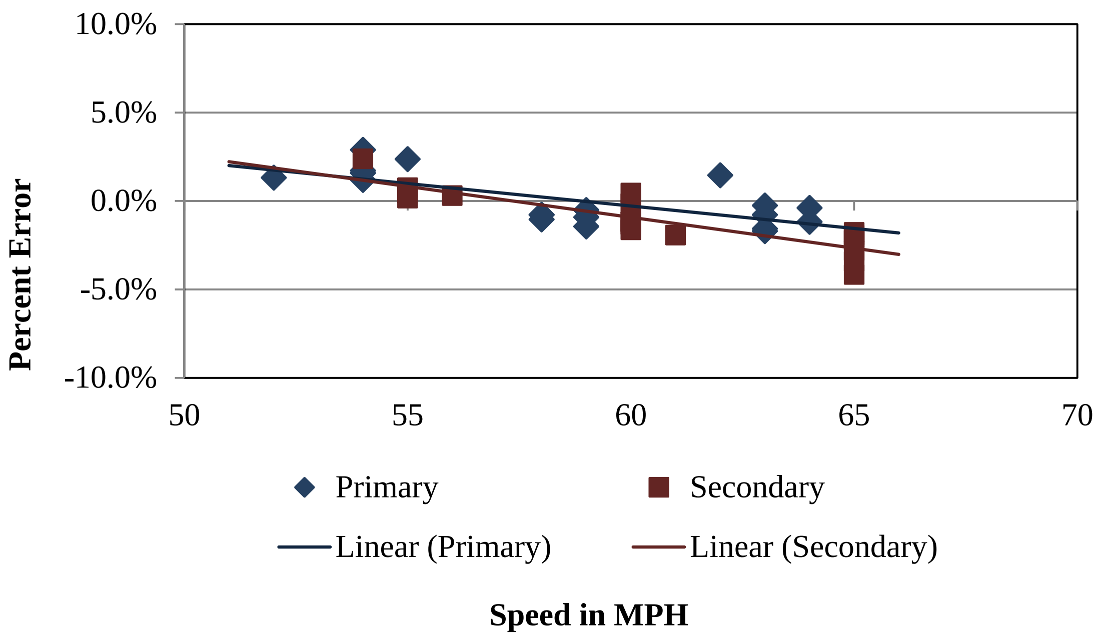


Figure 6-2– Influence of Speed on the GVW Measurement Error of Primary and Secondary Trucks

The use of two calibration trucks provided verification of the trends and speeded up the time required to obtain 40 pre-validation runs. For this site, the use of only one of the trucks (Primary or Secondary) would have resulted in similar verification and calibration results.

6.2 Misclassification Analysis

A post-visit analysis was conducted on the truck misclassifications identified during the validation conducted in the field. For this site, a total of 10 vehicles, including no heavy trucks (6 – 13) were misclassified by the equipment. The single unclassified truck was a Class 9 which was identified by the WIM system as a Class 15 vehicle. According to the Sheet 20, this vehicle was vehicle number 23377. The capture of the real-time record for vehicle 23377 is provided in **Error! Reference source not found.**.

(23377)	LANE #1	CLASS 15	GVW 53.0 kips	LENGTH 74 ft	
SPEED 69 mph	MAX GVW 0.0 kips	Mon Aug 5 2013 12:32:48 (2004)			
AXLE	SEPARATION (ft)	LEFT WT (kips)	RIGHT WT (kips)	TOTAL WT (kips)	ALLOWABLE (kips)
1 S		0.6	4.3	4.9	
2 D	16.6	7.4	4.8	12.1	
3 D	4.3	8.0	4.5	12.5	
4 D	34.9	5.3	6.6	11.9	
5 D	4.0	5.5	6.1	11.6	

Figure 6-3 – Vehicle Record 23377

As shown in the figure above the weights of the left and right sides of the first three axles are significantly different, indicating that the vehicle may have not been driving fully within the lane or changing lanes.

6.3 Traffic Data Analysis

Since there was no calibration of the WIM system operating parameters performed during this validation, the post-visit data analysis was not performed.

7 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.

7.1 Classification

The information in Table 7-1 data was extracted from the most recent previous validation and was updated to include the results of this validation.

Table 7-1 – Classification Validation History

Date	Misclassification Percentage by Class											Pct Unclass
	3	4	5	6	7	8	9	10	11	12	13	
7-Sep-05	-	75	67	0	-	0	0	0	0	0	-	0.0
8-Sep-05	-	67	25	25	-	0	0	-	-	-	-	0.0
20-Sep-06	-	50	20	44	0	0	0	0	0	0	0	0.0
21-Sep-06	-	67	20	0	-	0	0	0	0	0	-	0.0
28-Mar-07	-	-	0	0	-	0	0	0	0	0	0	0.0
29-Mar-07	-	-	0	0	-	-	0	-	-	-	-	0.0
8-Jun-08	-	-	13	-	-	33	0	0	-	-	-	0.0
10-Jun-08	-	100	13	0	-	0	1	100	0	0	100	2.0
7-Dec-10	-	-	0	0	-	0	0	100	0	0	0	0.0
8-Dec-10	-	-	0	0	-	0	0	-	0	0	0	1.0
1-Nov-11	11	0	13	0	0	0	0	0	0	0	0	0.0
2-Nov-11	58	0	17	0	0	0	0	0	0	0	0	0.0
5-Aug-13	100	100	21	0	0	0	1	0	0	0	0	10.0

7.2 Weight

Table 7-2 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, steering and single axles and tandems for prior pre- and validations.

Table 7-2 – Weight Validation History

Date	Mean Error and 2SD		
	GVW	Single Axles	Tandem
7-Sep-05	1.6 ± 5.2	-3.5 ± 10.6	2.6 ± 7.1
8-Sep-05	1.5 ± 5.8	-3.0 ± 13.2	2.4 ± 6.9
20-Sep-06	-0.4 ± 5.1	-3.4 ± 8.9	0.1 ± 7.4
21-Sep-06	-0.7 ± 5.0	-4.8 ± 10.4	0.0 ± 6.9
28-Mar-07	-1.6 ± 5.7	-6.6 ± 12.7	-0.3 ± 7.7
29-Mar-07	0.2 ± 4.9	-3.1 ± 11.3	1.0 ± 7.2
8-Jun-08	-0.8 ± 4.0	-2.7 ± 3.6	-0.5 ± 5.7
10-Jun-08	0.5 ± 3.2	-2.0 ± 5.0	0.9 ± 4.4
7-Dec-10	6.2 ± 5.3	1.8 ± 5.4	7.2 ± 6.2
8-Dec-10	-0.8 ± 5.9	-2.2 ± 5.4	-0.8 ± 5.9
1-Nov-11	-2.4 ± 3.9	-3.6 ± 6.7	-2.3 ± 5.0
2-Nov-11	1.0 ± 3.8	0.8 ± 5.5	1.1 ± 5.2
5-Aug-13	-0.5 ± 3.2	2.6 ± 3.7	-0.9 ± 4.0

The variability of the weight errors appears to have remained reasonably consistent since the site was first validated and even slightly decreased in the last 5 years. From this information, it appears that the system generally demonstrates a tendency for the equipment to move toward an underestimation of GVW between calibration visits, with the exception of the period between the June, 2008 and December 2010 validations. The table also demonstrates the effectiveness of the validations in bringing the weight estimations within LTPP SPS WIM equipment tolerances.

8 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

Illinois, SPS-6
SHRP ID: 170600

Validation Date: August 5, 2013

Photo 1 – Cabinet Exterior

Photo 2 – Cabinet Interior (Front)

Photo 3 – Cabinet Interior Second

Photo 4 – Leading Loop

Photo 5 – Leading WIM Sensor

Photo 6 – Trailing WIM Sensor

Photo 7 – Trailing Loop Sensor

Photo 8 – Telephone Pedestal

Photo 9 – Downstream

Photo 10 – Upstream

Photo 11 – Truck 1

Photo 12 – Truck 1 Tractor

Photo 13 – Truck 1 Trailer

Photo 14 – Truck 1 Suspension 1

Photo 15 – Truck 1 Suspension 2

Photo 16 – Truck 1 Suspension 3

Photo 17 – Truck 1 Suspension 4

Photo 18 – Truck 1 Suspension 5

Photo 19 – Truck 2

Photo 20 – Truck 2 Tractor

Photo 21 – Truck 2 Trailer and Load

Photo 22 – Truck 2 Suspension 1

Photo 23 – Truck 2 Suspension 2

Photo 24 – Truck 2 Suspension 3

Photo 25 – Truck 2 Suspension 4

Photo 26 – Truck 2 Suspension 5

Traffic Sheet 16	STATE CODE:	17
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	170600
SITE CALIBRATION SUMMARY	DATE (mm/dd/yyyy)	8/5/2013

SITE CALIBRATION INFORMATION

1. DATE OF CALIBRATION {mm/dd/yy} 8/5/13

2. TYPE OF EQUIPMENT CALIBRATED: Both

3. REASON FOR CALIBRATION: LTPP Validation

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

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

5. EQUIPMENT MANUFACTURER: IRD iSINC

WIM SYSTEM CALIBRATION SPECIFICS

6. CALIBRATION TECHNIQUE USED: Test Trucks

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

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

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

Mean Difference Between -

Dynamic and Static GVW:	-0.5%	Standard Deviation:	1.6%
Dynamic and Static Single Axle:	2.6%	Standard Deviation:	1.8%
Dynamic and Static Double Axles:	-0.9%	Standard Deviation:	2.0%

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

9. DEFINE SPEED RANGES IN MPH:

			Low		High	Runs
a.	Low	-	52.0	to	56.3	12
b.	Medium	-	56.4	to	60.8	13
c.	High	-	60.9	to	65.0	15
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: SPS WIM ID: DATE (mm/dd/yyyy)	17 170600 8/5/2013

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3437 | 3863

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

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

CLASSIFIER TEST SPECIFICS

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

Manual

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

14. MEAN DIFFERENCE IN VOLUMES BY VEHICLES CLASSIFICATION:

FHWA Class 9:	-1.0	FHWA Class	5	-	7.0
FHWA Class 8:	400.0	FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 1.0%

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: SPS WIM ID: DATE (mm/dd/yyyy)			17 170600 8/5/2013	

Count - 100 Time = 1:57:54 Trucks (4-15) - 95 Class 3s - 5

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
63	9	23327	63	9	65	9	23395	65	9
65	9	23331	65	9	65	9	23396	65	9
64	9	23333	64	9	65	9	23398	65	9
65	9	23334	65	9	**62**	**8**	**23400**	**62**	**5**
65	9	23348	65	9	68	5	23403	67	5
61	**8**	**23349**	**61**	**3**	65	9	23404	65	9
64	9	23351	64	9	64	5	23411	64	5
60	9	23353	60	9	62	5	23412	62	5
72	8	23354	71	8	62	9	23414	62	9
71	9	23356	71	9	65	9	23427	66	9
65	9	23359	65	9	64	9	23428	64	9
69	9	23360	69	9	56	9	23429	55	9
60	9	23371	60	9	64	9	23445	63	9
59	9	23372	60	9	64	9	23446	65	9
67	9	23375	67	9	64	9	23452	64	9
62	9	23376	64	9	64	9	23453	64	9
69	**15**	**23377**	**69**	**9**	62	11	23461	62	11
65	5	23378	65	5	63	9	23465	64	9
60	9	23379	60	9	67	9	23467	67	9
64	9	23384	64	9	66	5	23470	66	5
63	9	23385	62	9	63	5	23471	63	5
62	10	23388	64	10	63	9	23473	62	9
67	9	23389	66	9	63	9	23478	64	9
55	**5**	**23391**	**55**	**3**	61	9	23480	61	9
68	9	23393	68	9	63	9	23481	62	9

Sheet 1 - 1 to 50 Start: 12:18:23 Stop: 13:06:43

Recorded By: djw Verified By: ar

Validation Test Truck Run Set - Pre

Traffic Sheet 20 **LTPP MONITORED TRAFFIC DATA** **SPEED AND CLASSIFICATION STUDIES**	STATE CODE: 17 SPS WIM ID: 170600 DATE (mm/dd/yyyy) 8/5/2013

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
61	9	23482	61	9	62	6	23605	62	6
55	**6**	**23495**	**55**	**4**	64	9	23607	65	9
65	9	23503	66	9	67	9	23608	66	9
66	9	23504	66	9	66	9	23609	66	9
64	**5**	**23516**	**64**	**3**	67	9	23613	66	9
68	9	23517	68	9	65	9	23614	64	9
62	9	23522	62	9	57	9	23615	56	9
57	9	23526	57	9	56	9	23616	55	9
67	9	23546	67	9	61	9	23617	60	9
65	9	23548	65	9	64	9	23618	64	9
64	9	23551	65	9	64	9	23621	64	9
64	9	23554	64	9	65	9	23624	64	9
57	9	23556	57	9	62	9	23625	62	9
63	9	23559	63	9	65	9	23630	64	9
63	9	23560	64	9	59	5	23634	60	5
62	9	23566	62	9	63	9	23638	65	9
63	5	23573	63	5	**59**	**8**	**23645**	**59**	**5**
68	5	23574	67	5	**63**	**5**	**23648**	**63**	**3**
67	9	23577	67	9	**59**	**8**	**23645**	**59**	**5**
64	**5**	**23578**	**64**	**3**	63	5	23648	63	5
64	9	23580	65	9	66	9	23658	66	9
65	9	23585	65	9	66	9	23668	65	9
67	6	23597	66	6	63	9	23674	63	9
65	9	23600	65	9	70	5	23680	70	5
64	9	23601	64	9	65	9	23681	65	9

Sheet 2 - 51 to 100 Start: 13:06:43 Stop: 14:16:17

Recorded By: djw ar