WIM System Field Calibration and Validation Summary Report

Arkansas SPS-5
SHRP ID – 050200

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APPLIED RESEARCH ASSOCIATES, INC.

U.S. Department of Transportation
Federal Highway Administration

LTPP

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1 Executive Summary

A WIM validation was performed on March 20 and 21, 2012 at the Arkansas SPS-5 site located on route I-30, milepost 101.8, 2.2 miles east of US 270.

This site was installed in 2006. The in-road sensors are installed in the westbound, righthand driving lane. The site is equipped with weighpad WIM sensors and an IRD iSINC WIM controller. The LTPP lane is identified as lane 1 in the WIM controller. From a comparison between the report of the most recent validation of this equipment on March 9, 2011 and this validation visit, it appears that no changes have occurred during this time to the basic operating condition of the equipment.

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

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

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

Table 1-1 – Post-Validation Results – 21-Mar-12

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-0.1 ± 6.9%	Pass
Tandem Axles	±15 percent	-0.4 ± 6.7%	Pass
GVW	±10 percent	-1.7 ± 4.7%	Pass
Vehicle Length	±3.0 percent (2.1 ft)	-0.9 ± 0.8 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.2 ft	Pass

Truck speeds were manually collected for each test run by a radar gun and compared with the speed reported by the WIM equipment. For this site, the error in speed measurement was -0.4 ± 2.7 mph, which is greater than the ±1.0 mph tolerance established by the LTPP Field Operations Guide for SPS WIM Sites. However, since the site is measuring axle spacing length with a mean error of 0.0 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). The heavy truck misclassification rate of 0.0% is within the 2.0% acceptability criterion for LTPP SPS WIM sites. The overall misclassification rate of 3.9% from the 103 vehicle sample (Class 4 – 13) was due to the 4 cross-classifications of Class 3, 4, 5, and 8 vehicles.

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

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

- 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 concrete barriers.

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

Table 1-2 – Post-Validation Test Truck Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	77.7	10.6	16.3	16.3	17.2	17.2	19.5	4.3	37.5	4.5	65.8	70.4
2	69.4	10.2	14.5	14.5	15.2	15.2	18.8	4.5	35.7	4.3	63.3	67.8

The posted speed limit at the site is 65 mph. During the testing, the speed of the test trucks ranged from to 54 to 67 mph, a variance of 13 mph.

During test truck runs, pavement temperature was collected using a hand-held infrared temperature device. The post-validation pavement surface temperatures varied from 56.5 to 62.8 degrees Fahrenheit, a range of 6.3 degrees Fahrenheit. The rainy weather conditions prevented the desired 30 degree range in temperatures.

A review of the LTPP Standard Release Database 25 shows that there are 4 years of level "E" WIM data for this site. This site requires 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 December 19, 2011 (Data) to the most recent Comparison Data Set (CDS) from March 10, 2011. The assessments performed prior to the site visits are used to develop similar expectations for the validation. The results of further investigations performed as a result of the analyses are provided in Section 5 of this report.

2.1 LTPP WIM Data Availability

A review of the LTPP Standard Release Database 25 shows that there are 4 years of level "E" WIM data for this site. Table 2-1 provides a breakdown of the available data for years 2007 to 2011.

Table 2-1 – LTPP Data Availability

Year	Total Number of Days in Year	Number of Months
2007	330	12
2008	348	12
2009	347	12
2010	37	3
2011	231	9

As shown in the table, this site requires at least 1 additional year of data to meet the minimum of five years of research quality data. The data does not meet the 210-day minimum requirement for calendar year 2010.

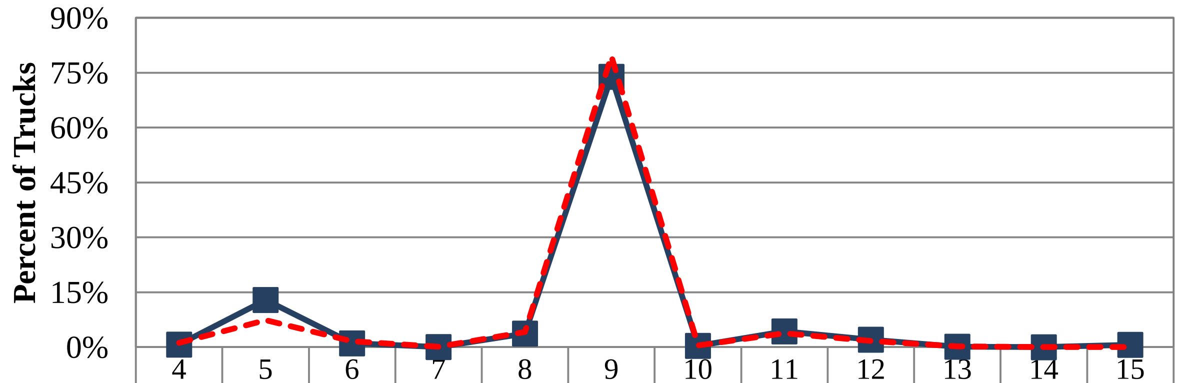
Table 2-2 provides a monthly breakdown of the available data for years 2007 through 2011.

Table 2-2 – LTPP Data Availability by Month

Year	Month												No. of Months
	1	2	3	4	5	6	7	8	9	10	11	12	
2007	17	28	31	30	31	30	31	31	30	31	18	22	12
2008	28	29	31	30	31	30	24	24	30	30	30	31	12
2009	31	28	31	30	31	19	31	31	30	31	29	25	12
2010	3										23	11	3
2011	1	28	31	30	31	30	31	31	18				9

2.2 Classification Data Analysis

The traffic data was analyzed to determine the expected truck distributions. This analysis provides a basis for the classification distribution study that was conducted on site. Figure 2-1 provides a comparison of the truck type distributions between the sample dataset from December 19, 2011 (Data) and the most recent comparison Data Set (CDS) from March 10, 2011.



	4	5	6	7	8	9	10	11	12	13	14	15
Data	0.7%	12.9%	1.1%	0.1%	3.7%	73.9%	0.4%	4.3%	2.1%	0.2%	0.0%	0.7%
CDS	1.1%	7.4%	1.6%	0.1%	4.1%	79.5%	0.4%	3.8%	1.7%	0.2%	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 (73.9%) and Class 5 (12.9%) vehicles.

Table 2-3 also provides data for vehicle Classes 14 and 15. Class 14 vehicles are vehicles that are reported by the WIM equipment as having irregular measurements and cannot be classified properly, such as negative speeds from vehicles passing in the opposite direction of a two-lane road. Class 15 vehicles are unclassified vehicles. The table indicates that 0.7 percent of the vehicles at this site are unclassified.

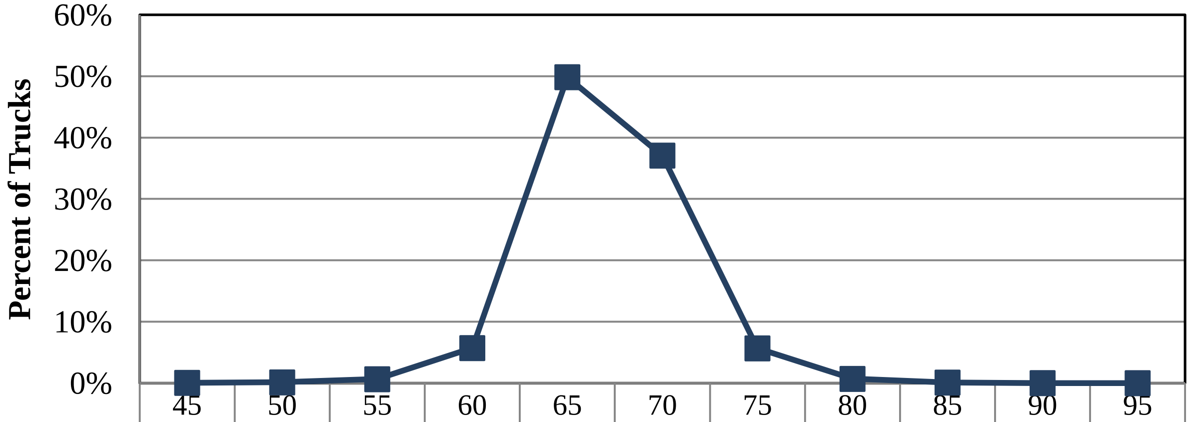
Table 2-3 – Truck Distribution from W-Card

Vehicle Classification	CDS		Data		Change
	Date				
	3/10/20011		12/19/2011		
4	737	1.1%	405	0.7%	-0.4%
5	4820	7.4%	7229	12.9%	5.5%
6	1041	1.6%	595	1.1%	-0.5%
7	74	0.1%	32	0.1%	-0.1%
8	2679	4.1%	2090	3.7%	-0.4%
9	51680	79.5%	41358	73.9%	-5.6%
10	279	0.4%	214	0.4%	0.0%
11	2452	3.8%	2426	4.3%	0.6%
12	1125	1.7%	1157	2.1%	0.3%
13	112	0.2%	85	0.2%	0.0%
14	0	0.0%	0	0.0%	0.0%
15	0	0.0%	372	0.7%	0.7%

From the table it can be seen that the percentage of Class 9 vehicles has decreased by 5.6 percent from March 2011 and December 2011. Changes in the percentage of heavier trucks may be attributed to natural and seasonal variations in truck distributions. During the same time period, the percentage of Class 5 trucks increased by 5.5 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.



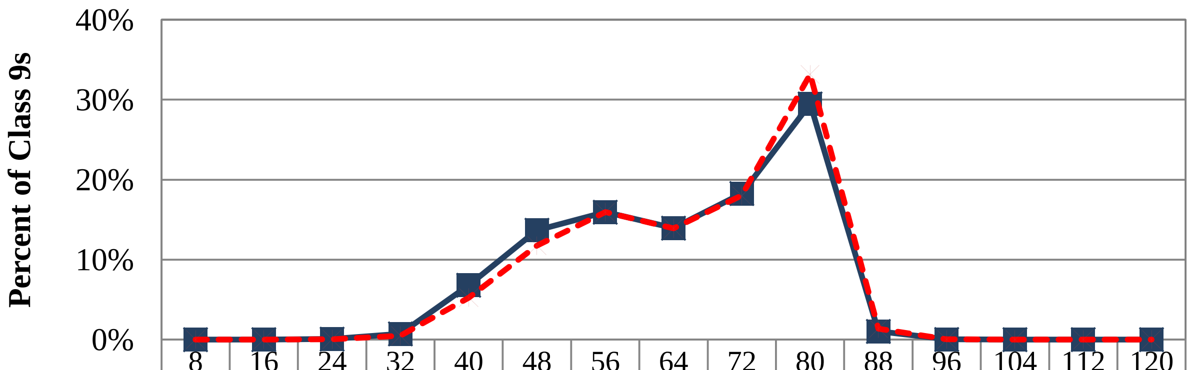
	45	50	55	60	65	70	75	80	85	90	95
Data	0.1%	0.1%	0.6%	5.7%	49.9%	37.1%	5.7%	0.7%	0.1%	0.0%	0.0%

Figure 2-2 – Truck Speed Distribution – 19-Jan-12

As shown in Figure 2-2, the majority of the trucks at this site are traveling between 60 and 75 mph. The posted speed limit at this site is 65 and the 85th percentile speed for trucks at this site is 68 mph. The range of truck speeds for the validation will be 55 to 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 December 2011 and the Comparison Data Set from March 2011.



	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
Data	0.0%	0.0%	0.1%	0.7%	6.8%	13.7	15.9	13.9	18.3	29.5	1.0%	0.0%	0.0%	0.0%	0.0%
CDS	0.0%	0.0%	0.1%	0.5%	5.2%	11.8	15.9	13.9	18.0	33.2	1.4%	0.0%	0.0%	0.0%	0.0%

Figure 2-3 – Comparison of Class 9 GVW Distribution

As shown in Figure 2-3, there is a small upward shift for the unloaded peak and a slight downward shift for the loaded peaks between the March 2011 Comparison Data Set (CDS) and the December 2011 two-week sample W-card dataset (Data). The results indicate that there may have been a small change in the pavement condition or sensor deterioration, or slight calibration drift.

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

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

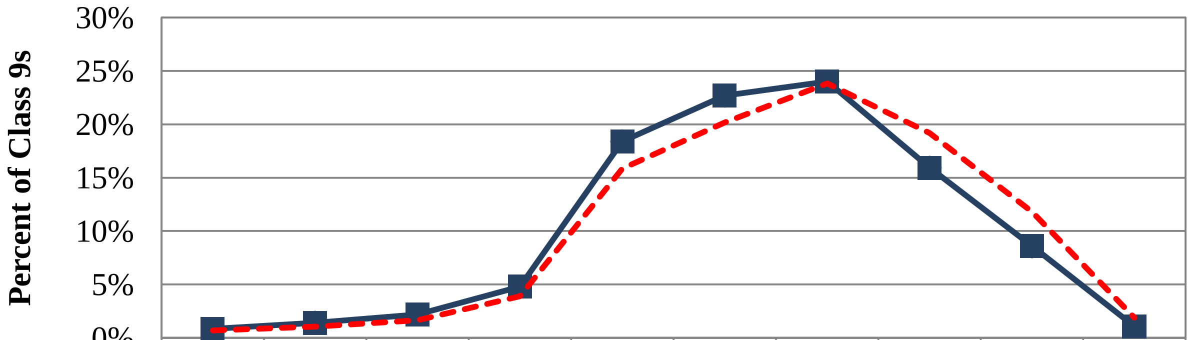
GVW weight bins (kips)	CDS		Data		Change
	Date				
	3/10/20011		12/19/2011		
8	0	0.0%	0	0.0%	0.0%
16	2	0.0%	0	0.0%	0.0%
24	26	0.1%	27	0.1%	0.0%
32	249	0.5%	299	0.7%	0.2%
40	2688	5.2%	2804	6.8%	1.6%
48	6026	11.8%	5639	13.7%	1.9%
56	8165	15.9%	6569	15.9%	0.0%
64	7124	13.9%	5747	13.9%	0.0%
72	9229	18.0%	7534	18.3%	0.3%
80	16994	33.2%	12149	29.5%	-3.7%
88	705	1.4%	425	1.0%	-0.4%
96	13	0.0%	9	0.0%	0.0%
104	6	0.0%	1	0.0%	0.0%
112	3	0.0%	2	0.0%	0.0%
120	0	0.0%	2	0.0%	0.0%
Average =	62.5 kips		61.0 kips		-1.5 kips

As shown in the table, the percentage of unloaded class 9 trucks in the 32 to 40 kips range increased by 1.6 percent while the percentage of loaded class 9 trucks in the 72 to 80 kips range decreased by 3.7 percent. During this time period the percentage of overweight trucks increased by 0.4 percent. Based on the average Class 9 GVW values from the per vehicle records, the GVW average for this site decreased by 2.4 percent, from 62.5 to 61.0 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 December 2011 and the Comparison Data Set from March 2011. The percentage of light axles (9.5 to 10.5 kips) increased by approximately 1.9 percent and the percentage of heavy axles (12.0 to 13.0 kips) decreased by approximately 6.2%, indicating possible negative bias (underestimation of loads) in front axle measurement.



	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5
Data	0.8%	1.4%	2.2%	4.8%	18.4%	22.7%	24.0%	15.9%	8.6%	1.1%
CDS	0.7%	1.0%	1.6%	3.9%	15.8%	20.2%	23.8%	19.2%	11.8%	1.9%

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 decreased between the March 2011 Comparison Data Set (CDS) and the December 2011 dataset (Data).

Table 2-5 provides the Class 9 front axle weight distribution data for the March 2011 Comparison Data Set (CDS) and the December 2011 dataset (Data). 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 11.5 kips.

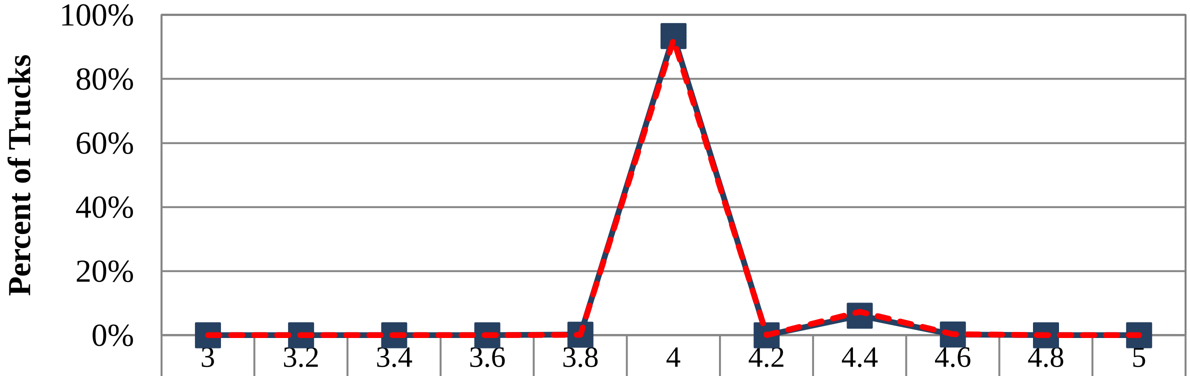
Table 2-5 – Class 9 Front Axle Weight Distribution from W-Card

F/A weight bins (kips)	CDS		Data		Change
	Date				
	3/10/20011		12/19/2011		
9.0	356	0.7%	344	0.8%	0.1%
9.5	529	1.0%	581	1.4%	0.4%
10.0	834	1.6%	902	2.2%	0.6%
10.5	1974	3.9%	1969	4.8%	0.9%
11.0	8053	15.8%	7552	18.4%	2.6%
11.5	10249	20.2%	9313	22.7%	2.5%
12.0	12119	23.8%	9854	24.0%	0.2%
12.5	9748	19.2%	6536	15.9%	-3.2%
13.0	6006	11.8%	3525	8.6%	-3.2%
13.5	965	1.9%	445	1.1%	-0.8%
Average =	11.6 kips		11.5 kips		-0.1 kips

2.6 Class 9 Tractor Tandem Spacing Data Analysis

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

The Class 9 tractor tandem spacing plot in Figure 2-5 is provided to indicate possible shifts in WIM system distance and speed measurement accuracies. As seen in the figure, the Class 9 tractor tandem spacings for the March 2011 Comparison Data Set and the December 2011 Data are nearly identical.



	3	3.2	3.4	3.6	3.8	4	4.2	4.4	4.6	4.8	5
Data	0.0%	0.0%	0.0%	0.0%	0.2%	93.4%	0.0%	6.1%	0.2%	0.0%	0.0%
CDS	0.0%	0.0%	0.0%	0.0%	0.1%	92.3%	0.0%	7.3%	0.3%	0.0%	0.0%

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

Table 2-6 shows the Class 9 axle spacings between the second and third axles. From the table it can be seen that the drive tandem spacing of Class 9 trucks at this site is between 3.8 and 4.6 feet. Based on the average Class 9 drive tandem spacing values from the per vehicle records, the average tractor tandem spacing is 4.0, which is identical to the expected average of 4.0 from the CDS per vehicle records. Further axle spacing analyses are performed during the validation and post-validation analysis.   .

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

Tandem 1 spacing bins (feet)	CDS		Data		Change
	Date				
	3/10/20011		12/19/2011		
3.0	0	0.0%	2	0.0%	0.0%
3.2	0	0.0%	3	0.0%	0.0%
3.4	2	0.0%	5	0.0%	0.0%
3.6	0	0.0%	0	0.0%	0.0%
3.8	36	0.1%	74	0.2%	0.1%
4.0	47272	92.3%	38498	93.4%	1.2%
4.2	0	0.0%	0	0.0%	0.0%
4.4	3744	7.3%	2517	6.1%	-1.2%
4.6	168	0.3%	100	0.2%	-0.1%
4.8	0	0.0%	0	0.0%	0.0%
5.0	9	0.0%	8	0.0%	0.0%
Average =	4.0 feet		4.0 feet		0.0 feet

2.7 Data Analysis Summary

Historical data analysis involved the comparison of the most recent Comparison Data Set (March 2011) based on the last calibration with the most recent two-week WIM data sample from the site (December 2011). Comparison of vehicle class distribution data indicates a 5.6 percent decrease in the number 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 2.4 percent for the December 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 March 9, 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 in 2006 by International Road Dynamics. It is instrumented with weighpad weighing sensors and an IRD iSINC WIM Controller. As the installation contractor, IRD also performs routine equipment maintenance and data quality checks of the WIM data.

3.2 Physical Inspection

Prior to the pre-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.

Photo 3-1 – Leading Loop Sealant Condition

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

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, There were no pavement distresses noted that may affect the accuracies of the WIM system.

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)	1.152	1.042	1.046			1.080
		SRI (m/km)	0.967	0.971	0.810			0.916
		Peak LRI (m/km)	1.292	1.222	1.242			1.252
		Peak SRI (m/km)	1.180	1.379	1.311			1.290
	RWP	LRI (m/km)	1.058	0.881	1.089			1.009
		SRI (m/km)	0.967	0.980	0.814			0.920
		Peak LRI (m/km)	1.130	1.160	1.187			1.159
		Peak SRI (m/km)	1.074	1.285	1.029			1.129
Center	LWP	LRI (m/km)	1.087	1.001	0.984	0.984	0.947	1.001
		SRI (m/km)	0.931	0.638	0.613	0.613	1.024	0.764
		Peak LRI (m/km)	1.224	1.185	1.159	1.159	1.105	1.166
		Peak SRI (m/km)	0.988	0.997	0.949	0.949	1.252	1.027
	RWP	LRI (m/km)	1.116	1.097	1.089	1.089	1.053	1.089
		SRI (m/km)	1.163	1.583	1.409	1.409	1.096	1.332
		Peak LRI (m/km)	1.336	1.271	1.298	1.298	1.175	1.276
		Peak SRI (m/km)	**1.319**	**1.902**	**1.876**	**1.876**	**1.190**	**1.633**
Right	LWP	LRI (m/km)	0.971	0.972	0.987			0.977
		SRI (m/km)	0.779	1.012	0.724			0.838
		Peak LRI (m/km)	1.223	1.126	1.127			1.159
		Peak SRI (m/km)	1.062	1.065	0.829			0.985
	RWP	LRI (m/km)	0.951	1.000	0.956			0.969
		SRI (m/km)	1.350	1.263	1.290			1.301
		Peak LRI (m/km)	1.165	1.153	1.176			1.165
		Peak SRI (m/km)	1.491	1.468	1.479			1.479

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

4.3 Profile and Vehicle Interaction

Profile data was collected on January 19, 2012 by the Southern 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 is 126 in/mi and is located approximately 844 feet prior to the WIM scale. The highest IRI value within the 400 foot approach section was 114 in/mi and is located approximately 154 feet prior to the WIM scale. These areas of the pavement were closely investigated during the validation visit, and truck dynamics in this area were closely observed. There were no distresses observed at these locations that would influence truck dynamics in the WIM scale area.

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

4.4 Recommended Pavement Remediation

No pavement remediation is recommended.

5 Statistical Reliability of the WIM Equipment

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

5.1 Pre-Validation

The first set of test runs provides a general overview of system performance prior to any calibration adjustments for the given environmental, vehicle speed and other conditions.

The 40 pre-validation test truck runs were conducted on March 20, 2012, beginning at approximately 11:21 AM and continuing until 4:49 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with concrete barriers, 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 concrete barriers, 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 pre-validation and were re-weighed at the conclusion of the pre-validation. The average test truck weights and measurements are provided in Table 5-1.

Table 5-1 – Pre-Validation Test Truck Weights and Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	77.9	10.9	16.3	16.3	17.2	17.2	19.5	4.3	37.5	4.5	65.8	70.4
2	69.6	10.4	14.5	14.5	15.1	15.1	18.8	4.5	35.7	4.3	63.3	67.8

Test truck speeds varied by 13 mph, from 53 to 66 mph. The measured pre-validation pavement temperatures varied 14.7 degrees Fahrenheit, from 64.6 to 79.3. The rainy weather conditions prevented the desired 30 degree temperature range. Table 5-2 provides a summary of the pre-validation results.

As shown in Table 5-2, the site met all LTPP requirements for loading measurement, but failed for truck overall length measurement as a result of the pre-validation test truck runs. High positive bias was observed for the steering axle measurements; however, overall error was with the allowable tolerances.

Table 5-2 – Pre-Validation Overall Results – 21-Mar-12

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	4.9 ± 7.4%	Pass
Tandem Axles	±15 percent	1.6 ± 7.0%	Pass
GVW	±10 percent	2.2 ± 4.8%	Pass
Vehicle Length	±3.0 percent (2.1 ft)	2.3 ± 2.1 ft	FAIL
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 over all speeds was -0.4 ± 2.7 mph, which is greater than the ±1.0 mph tolerance established by the LTPP Field Guide. However, since the site is measuring axle spacing length with a mean error of 0.0 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 similar acceptable ranges.

5.1.1 Statistical Speed Analysis

Statistical analysis was conducted on the test truck run data to investigate whether a relationship exists between speed and WIM equipment weight and distance measurement accuracy. The posted speed limit at this site is 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 – Pre-Validation Results by Speed – 21-Mar-12

Parameter	95% Confidence Limit of Error	Low	Medium	High
		53.0 to 57.3 mph	57.4 to 61.8 mph	61.9 to 66.0 mph
Steering Axles	±20 percent	7.6 ± 5.8%	5.1 ± 6.1%	1.4 ± 5.6%
Tandem Axles	±15 percent	1.6 ± 8.9%	1.8 ± 6.3%	2.0 ± 6.2%
GVW	±10 percent	2.4 ± 6.0%	2.2 ± 4.7%	1.9 ± 5.0%
Vehicle Length	±3.0 percent (2.1 ft)	2.4 ± 2.2 ft	2.4 ± 2.4 ft	2.2 ± 2.5 ft
Vehicle Speed	± 1.0 mph	0.1 ± 0.2 mph	0.0 ± 0.2 mph	0.0 ± 0.2 mph
Axle Length	± 0.5 ft [150mm]	0.0 ± 1.4 ft	0.8 ± 4.1 ft	0.5 ± 2.0 ft

From the table, it can be seen that, on average, the WIM equipment overestimates all weights at all speeds. The range in errors and the mean errors seem to be independent of speed, with the exception of the mean error for the steering axles that decreased as speed increased.

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 generally overestimates GVW at all speeds. The range in error and bias are similar at all speeds.

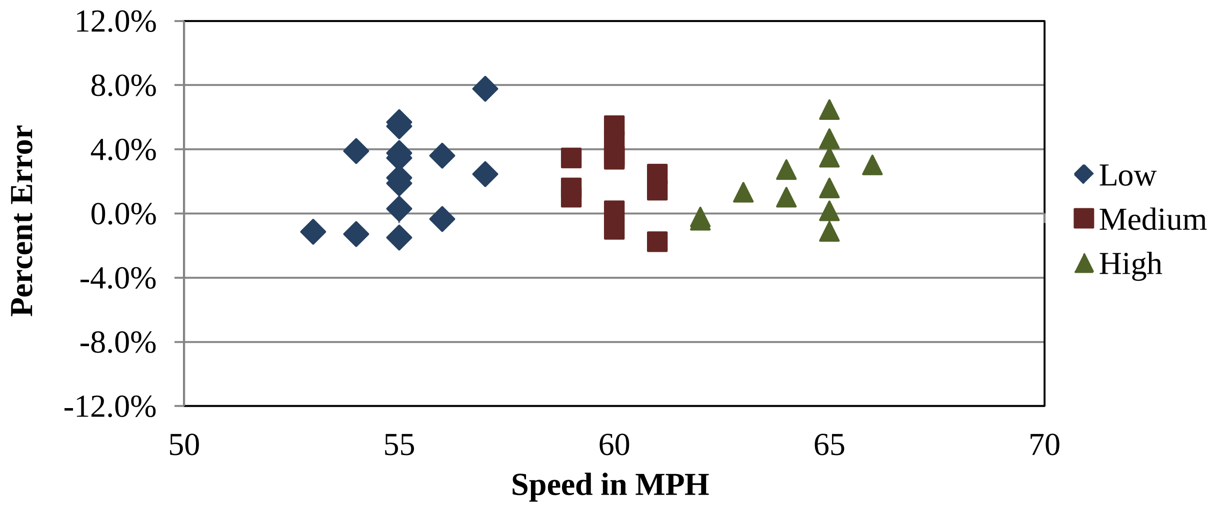


Figure 5-1 – Pre-Validation GVW Error by Speed – 21-Mar-12

5.1.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-2, the equipment overestimates steering axle weights at low and medium speeds. There is positive bias at the low and medium speeds. Bias is near zero at the higher speeds. The range in error is lower at high speeds when compared to low and medium speeds.

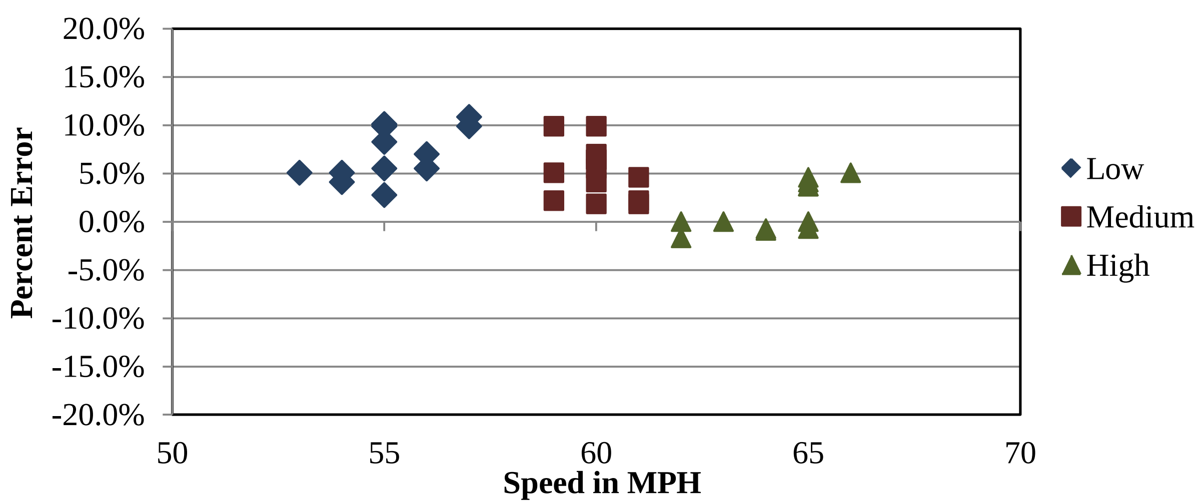


Figure 5-2 – Pre-Validation Steering Axle Weight Errors by Speed – 21-Mar-12

5.1.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 5-3, the equipment estimates tandem axle weights with similar accuracy at all speeds. The range in error is slightly lower at high speeds when compared to low and medium speeds.

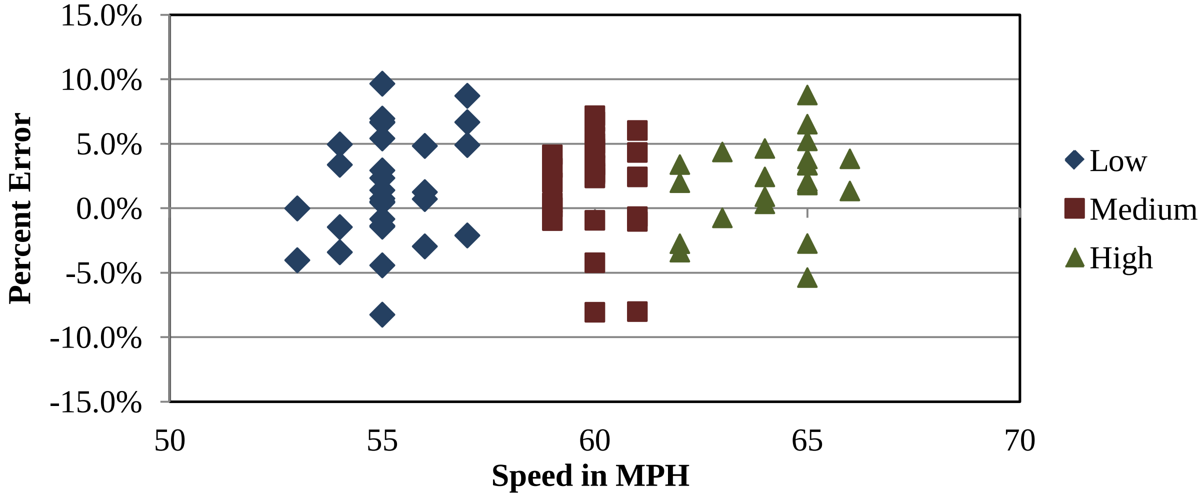


Figure 5-3 – Pre-Validation Tandem Axle Weight Errors by Speed – 21-Mar-12

5.1.1.4 GVW Errors by Speed and Truck Type

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

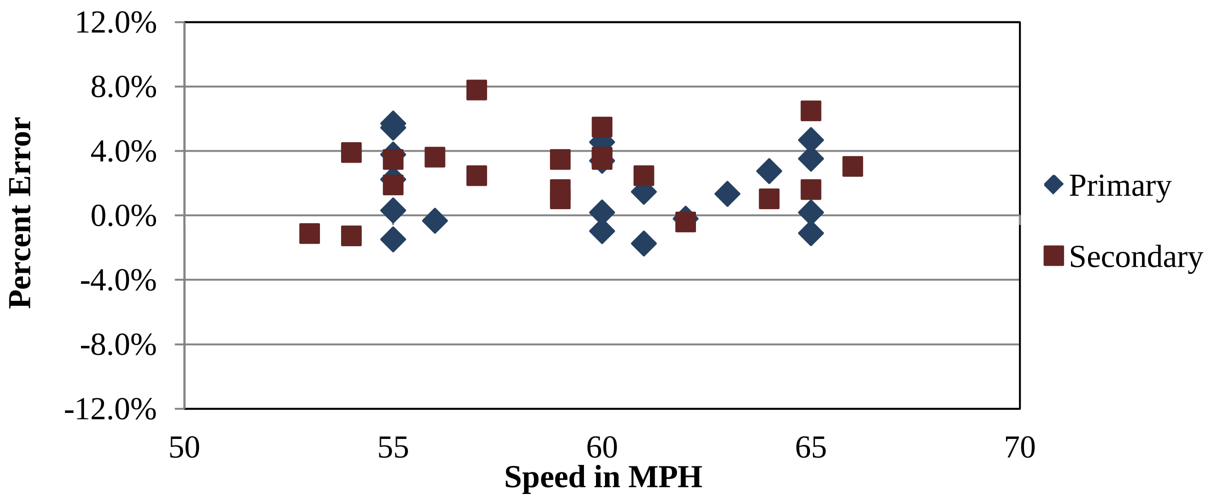


Figure 5-4 – Pre-Validation GVW Errors by Truck and Speed – 21-Mar-12

5.1.1.5 Axle Length Errors by Speed

For this site, the error in axle length measurement was consistent at all speeds. The range in axle length measurement error ranged from -0.1 feet to 0.3 feet. Distribution of errors is shown graphically in Figure 5-5.

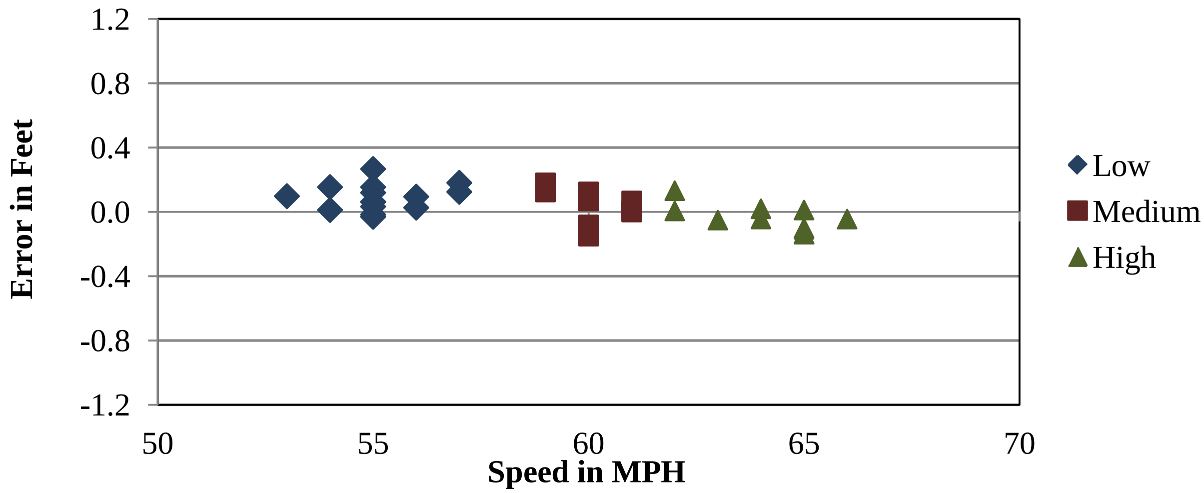


Figure 5-5 – Pre-Validation Axle Length Errors by Speed – 21-Mar-12

5.1.1.6 Overall Length Errors by Speed

For this system, the WIM equipment overestimated overall vehicle length consistently over the entire range of speeds, with an error range of 0.6 to 4.3 feet. Distribution of errors is shown graphically in Figure 5-6.

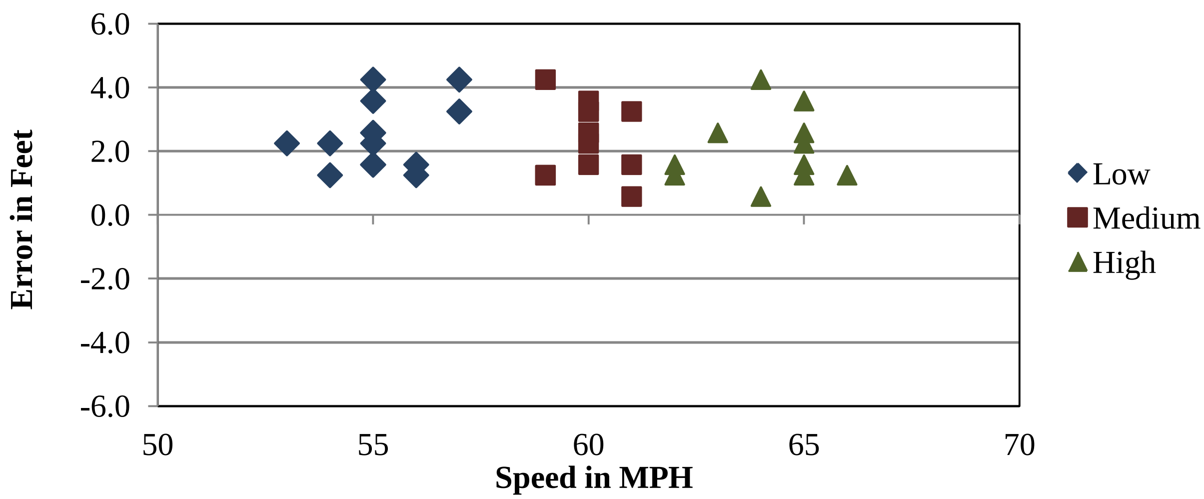


Figure 5-6 – Pre-Validation Overall Length Error by Speed – 21-Mar-12

5.1.2 Statistical Temperature Analysis

Statistical analysis was performed for the test truck run data to investigate whether a relationship exists between pavement temperature and WIM equipment weight and distance measurement accuracy. The range of pavement temperatures varied 14.7 degrees, from 64.6 to 79.3 degrees Fahrenheit. Since the desired 30 degree temperature range was met, the pre-validation test runs are being reported under two temperature groups – low and high, as shown in Table 5-4.

Table 5-4 – Pre-Validation Results by Temperature – 21-Mar-12

Parameter	**95% Confidence Limit of Error**	**Low**	**High**
		64.6 to 70 degF	**70.1 to 80.0 degF**
Steering Axles	±20 percent	3.3 ± 5.3%	6.3 ± 8.2%
Tandem Axles	±15 percent	1.5 ± 6.9%	2.1 ± 7.4%
GVW	±10 percent	1.6 ± 4.9%	2.6 ± 5.0%
Vehicle Length	±3.0 percent (2.1 ft)	1.5 ± 1.1 ft	3.0 ± 1.9 ft
Vehicle Speed	± 1.0 mph	0.0 ± 0.2 mph	0.0 ± 0.3 mph
Axle Length	± 0.5 ft [150mm]	0.8 ± 3.6 ft	0.1 ± 1.3 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 generally overestimates GVW across the range of temperatures observed in the field. The range in error is similar for the two temperature groups. Mean error is higher for the group of measurements obtained at higher temperatures.

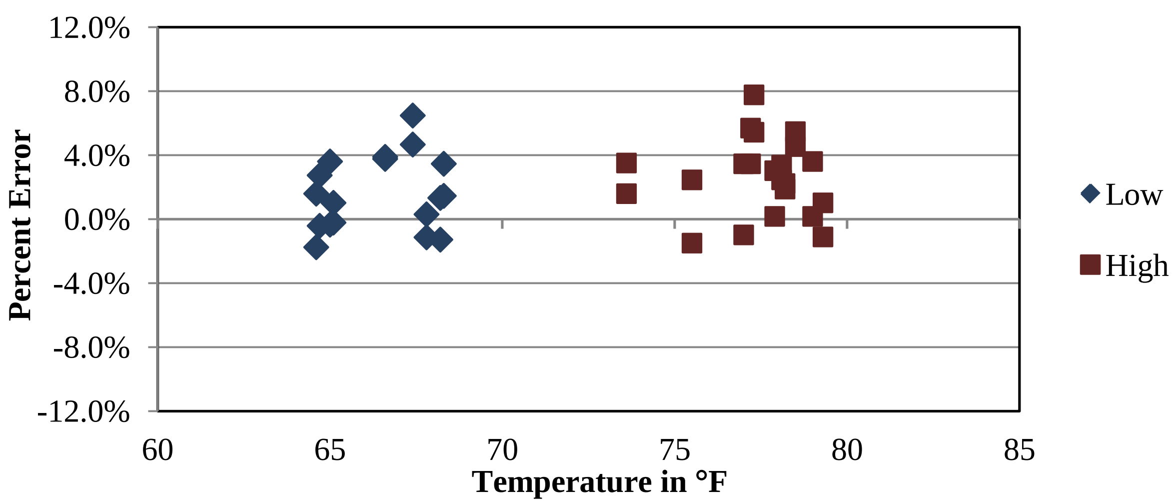


Figure 5-7 – Pre-Validation GVW Errors by Temperature – 21-Mar-12

5.1.2.2 Steering Axle Weight Errors by Temperature

Figure 5-8 illustrates that for steering axles, the WIM equipment overestimates steering axle weights at all temperatures. The bias and range in error is greater at the higher temperatures.

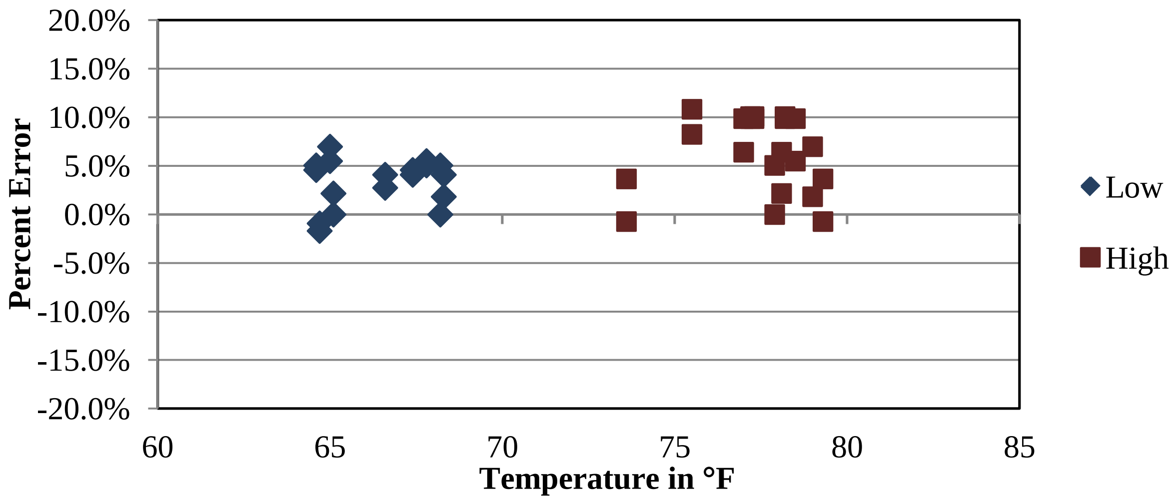


Figure 5-8 – Pre-Validation Steering Axle Weight Errors by Temperature – 21-Mar-12

5.1.2.3 Tandem Axle Weight Errors by Temperature

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

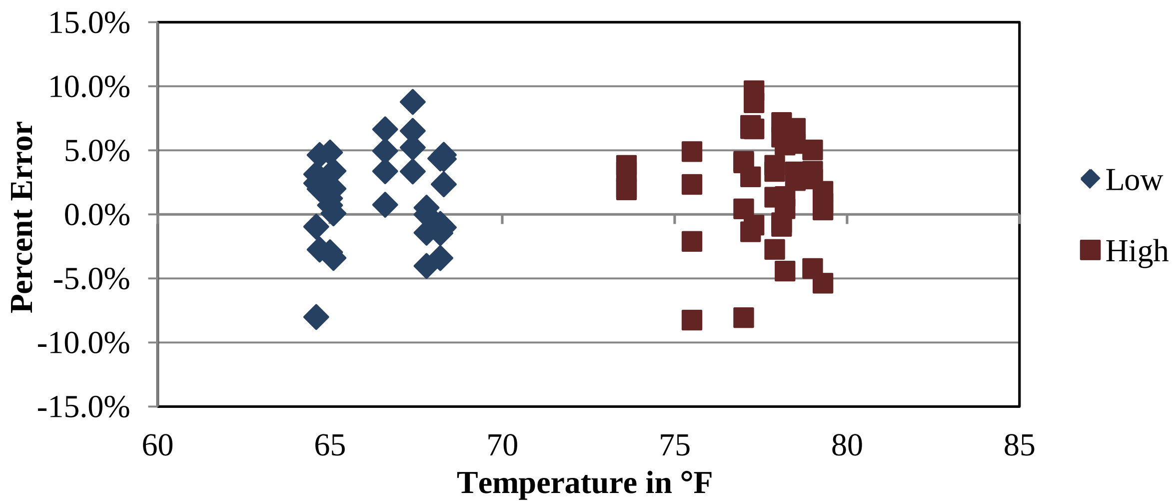


Figure 5-9 – Pre-Validation Tandem Axle Weight Errors by Temperature – 21-Mar-12

5.1.2.4 GVW Errors by Temperature and Truck Type

When analyzed for each test truck, it can be seen that the WIM equipment precision and bias are similar for both the heavily loaded (Primary) truck and the partially loaded (Secondary) truck. 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.

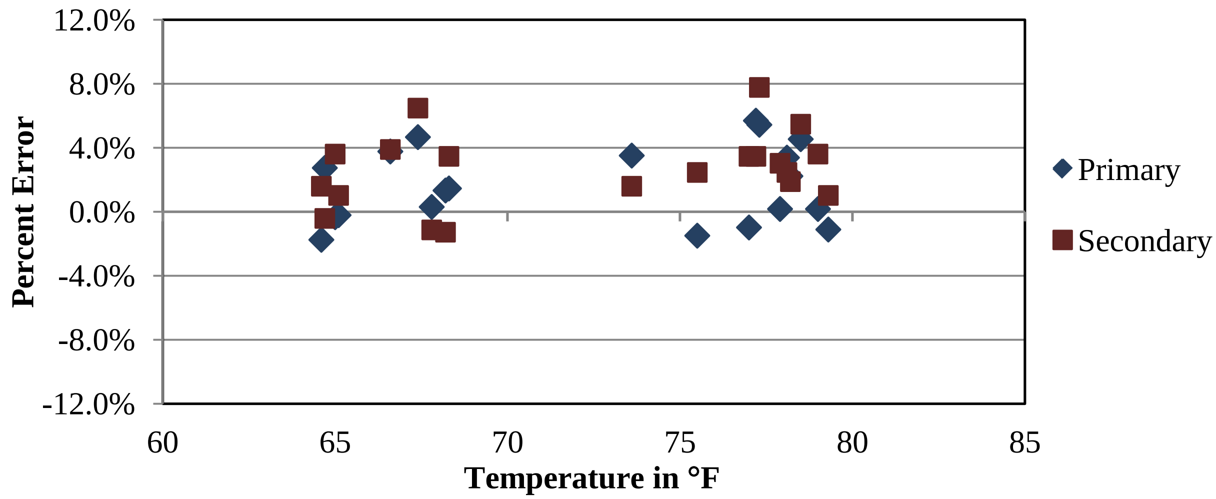


Figure 5-10 – Pre-Validation GVW Error by Truck and Temperature – 21-Mar-12

5.1.3 Classification and Speed Evaluation

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

For the pre-validation classification study at this site, a manual sample of 102 vehicles including 100 trucks (Class 4 through 13) was collected. Video was collected during the study to provide a means for further analysis of misclassifications and vehicles whose classifications could not be determined with a high degree of certainty in the field.

Misclassified vehicles are defined as those vehicles that are manually classified by observation as one class of vehicle but identified by the WIM equipment as another class 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, one Class 3 vehicle was misclassified as a Class 5 vehicle, a total of two Class 5 vehicles were misclassified as Class 8 and Class 14 vehicles respectively, and two Class 10 vehicles were misclassified as Class 13 vehicles by the equipment.

Table 5-5 – Pre-Validation Misclassifications by Pair – 21-Mar-12

		WIM											
		3	4	5	6	7	8	9	10	11	12	13	14
Observed	3	-		1									
	4		-										
	5			-			1						1
	6				-								
	7					-							
	8						-						
	9							-					
	10								-			2	
	11									-			
	12										-		
	13											-	-

As shown in the table, a total of 5 vehicles, including 2 heavy trucks (vehicle classes 6 – 13) were misclassified by the equipment. Based on the vehicles observed during the pre-validation study, the misclassification percentage is 2.1% for heavy trucks (6 – 13), which is greater than the 2.0% acceptability criteria for LTPP SPS WIM sites. The overall misclassification rate for all vehicles (3 – 15) is 4.9%, primarily due to misclassifications of lightweight vehicles in Class 3 and Class 5. One Class 5 vehicle was reported by the system as a Class 14. This is typically the result of irregular presence measurements by the loops in the event of a vehicle changing lanes during detection and analysis by the WIM system. The causes for the misclassifications were not investigated in the field.

The combined results produced an undercount of one Class 3 vehicle, one class 5 vehicle, and two Class 10 vehicles and an overcount of one Class 8 vehicle, and two class 13 vehicles, as shown in Table 5-6. The misclassified percentage represents the percentage of the misclassified vehicles in the manual sample.

Table 5-6 – Pre-Validation Classification Study Results – 21-Mar-12

Class	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Observed Count	2	0	5	3	0	0	83	3	4	2	0
WIM Count	1	0	4	3	0	1	83	1	4	2	2
Observed Percent	2.0	0.0	4.9	2.9	0.0	0.0	81.4	2.9	3.9	2.0	0.0
WIM Percent	1.0	0.0	3.9	2.9	0.0	1.0	81.4	1.0	3.9	2.0	2.0
Misclassified Count	1	0	2	0	0	0	0	2	0	0	0
Misclassified Percent	50.0	0.0	40.0	0.0	0.0	0.0	0.0	66.7	0.0	0.0	0.0
Unclassified Count	0	0	0	0	0	0	0	0	0	0	0
Unclassified Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Unclassified vehicles are defined as those vehicles that cannot be identified by the WIM equipment algorithm. These are typically trucks with unusual trailer tandem configurations and are identified as Class 15 by the WIM equipment. The unclassified vehicles by pair are provided in Table 5-7.

Table 5-7 – Pre-Validation Unclassified Trucks by Pair – 21-Mar-12

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

Based on the manually collected sample of the 100 trucks, 0.0 percent of the vehicles at this site were reported as unclassified during the study. This is within the established criteria of 2.0% for LTTP SPS WIM sites.

For speed, the mean error for WIM equipment speed measurement was -0.5 mph; the range of errors was 1.4 mph.

5.2 Calibration

The WIM equipment required one calibration iteration between the pre- and post-validations. Information regarding the basis for changing equipment compensation factors, supporting data for the changes, and the resulting WIM accuracies from the calibrations are provided in this section.

The operating system weight compensation parameters that were in place prior to the pre-validation are shown in Table 5-8.

Table 5-8 – Initial System Parameters – 21-Mar-12

Speed Point	MPH	Right	Left
		1	2
80	50	3143	3070
88	55	3235	3159
96	60	3145	3071
104	65	3044	2973
112	70	3038	2967
Axle Distance (cm)		373	
Dynamic Comp (%)		109	
Loop Width (cm)		140	

5.2.1 Equipment Adjustments

For GVW, the pre-validation test truck runs produced an overall error of 2.2% and errors of 2.4%, 1.8%, and 2.4% at the 55, 60 and 65 mph speed points respectively. To compensate for these errors, the changes in Table 5-9 were made to the compensation factors.

Table 5-9 – Calibration Equipment Factor Changes – 21-Mar-12

Speed Points	Old Factors		New Factors	
	Right	Left	Right	Left
	1	2	1	2
80	3143	3070	3082	3011
88	3235	3159	3172	3098
96	3145	3071	3102	3029
104	3044	2973	2987	2918
112	3038	2967	2981	2912
Axle Distance (cm)	373		373	
Dynamic Comp (%)	109		106	
Loop Width (cm)	140		211	

5.2.2 Calibration Results

The results of the 12 calibration verification runs are provided in Table 5-10 and Figure 5-11. As can be seen in the table, the mean error of all weight estimates was reduced as a result of the calibration.

Table 5-10 – Calibration Results – 21-Mar-12

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-1.7 ± 6.1%	Pass
Tandem Axles	±15 percent	-0.8 ± 6.7%	Pass
GVW	±10 percent	-2.1 ± 4.3%	Pass
Vehicle Length	±3.0 percent (2.1 ft)	-1.0 ± 1.0 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.3 ft	Pass

Figure 5-11 shows that the WIM equipment is estimating GVW with similar bias at all speeds.

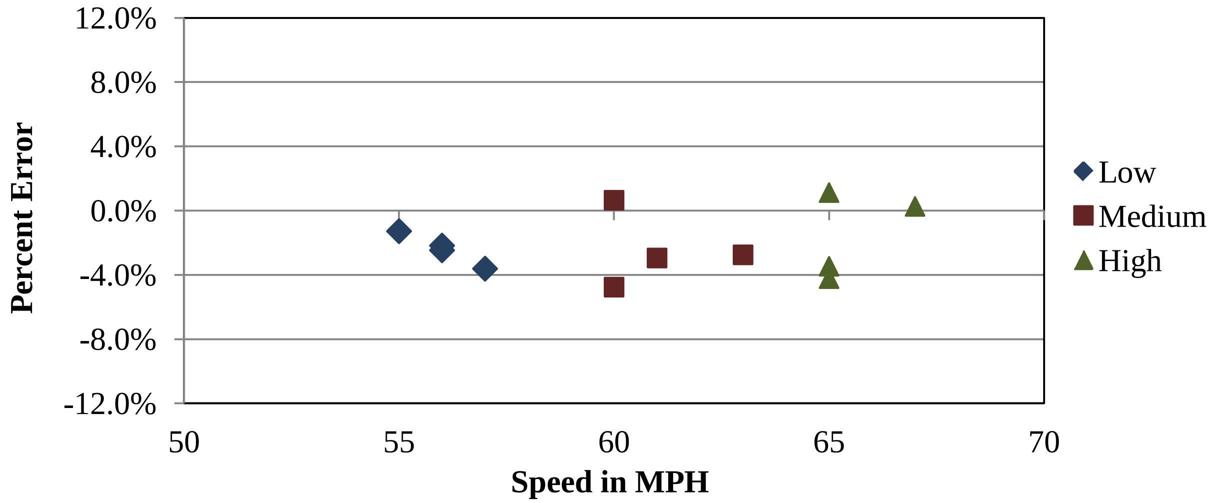


Figure 5-11 – Calibration GVW Error by Speed – 21-Mar-12

Based on the results of the calibration, where GVW weight estimate is -2.1 percent, a second calibration was not considered to be necessary. The 12 calibration runs were combined with 31 additional post-validation runs to complete the WIM system validation.

5.3 Post-Validation

The 43 post-validation test truck runs were conducted on March 21, 2012, beginning at approximately 7:43 AM and continuing until 2:34 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with concrete barriers, 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 concrete barriers, 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 post-validation and re-weighed at the conclusion of the post-validation. The average test truck weights and measurements are provided in Table 5-11.

Table 5-11 – Post-Validation Test Truck Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	77.7	10.6	16.3	16.3	17.2	17.2	19.5	4.3	37.5	4.5	65.8	70.4
2	69.4	10.2	14.5	14.5	15.2	15.2	18.8	4.5	35.7	4.3	63.3	67.8

Test truck speeds varied by 13 mph, from 54 to 67 mph. The measured post-validation pavement temperatures varied 6.3 degrees Fahrenheit, from 56.5 to 62.8. The rainy weather conditions prevented the desired minimum 30 degree temperature range. Table 5-12 is a summary of post validation results.

Table 5-12 – Post-Validation Overall Results – 21-Mar-12

Parameter	**95% Confidence Limit of Error**	**Site Values**	**Pass/Fail**
Steering Axles	±20 percent	-0.1 ± 6.9%	Pass
Tandem Axles	±15 percent	-0.4 ± 6.7%	Pass
GVW	±10 percent	-1.7 ± 4.7%	Pass
Vehicle Length	±3.0 percent (2.1 ft)	-0.9 ± 0.8 ft	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 -0.4 ± 2.7 mph, which is greater than the ±1.0 mph tolerance established by the LTPP Field Guide. However, since the site is measuring axle spacing length with a mean error of 0.0 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 5-13.

Table 5-13 – Post-Validation Results by Speed – 21-Mar-12

Parameter	95% Confidence Limit of Error	Low	Medium	High
		54.0 to 58.3 mph	58.4 to 62.8 mph	62.9 to 67.0 mph
Steering Axles	+20 percent	2.4 ± 5.7%	-0.3 ± 5.5%	-2.9 ± 5.3%
Tandem Axles	+15 percent	-2.9 ± 7.1%	-3.0 ± 5.6%	-0.3 ± 6.6%
GVW	+10 percent	-2.1 ± 4.5%	-2.6 ± 4.8%	-0.7 ± 5.4%
Vehicle Length	±3.0 percent (2.1 ft)	-0.6 ± 0.4 ft	-1.2 ± 0.8 ft	-1.1 ± 0.8 ft
Vehicle Speed	± 1.0 mph	0.1 ± 0.2 mph	0.0 ± 0.3 mph	0.0 ± 0.2 mph
Axle Length	+ 0.5 ft [150mm]	-0.6 ± 3.3 ft	-0.2 ± 3.0 ft	-0.3 ± 2.1 ft

From the table, it can be seen that the WIM equipment estimates all weights with similar precision at all speeds. There is some evidence of the relationship between weight measurement bias and speed, especially for the steering axles.

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 5-12, the equipment estimated GVW with similar accuracy at low and medium speeds. The bias is close to zero at high speeds. The range in error is lower at medium speeds when compared to low and high speeds.

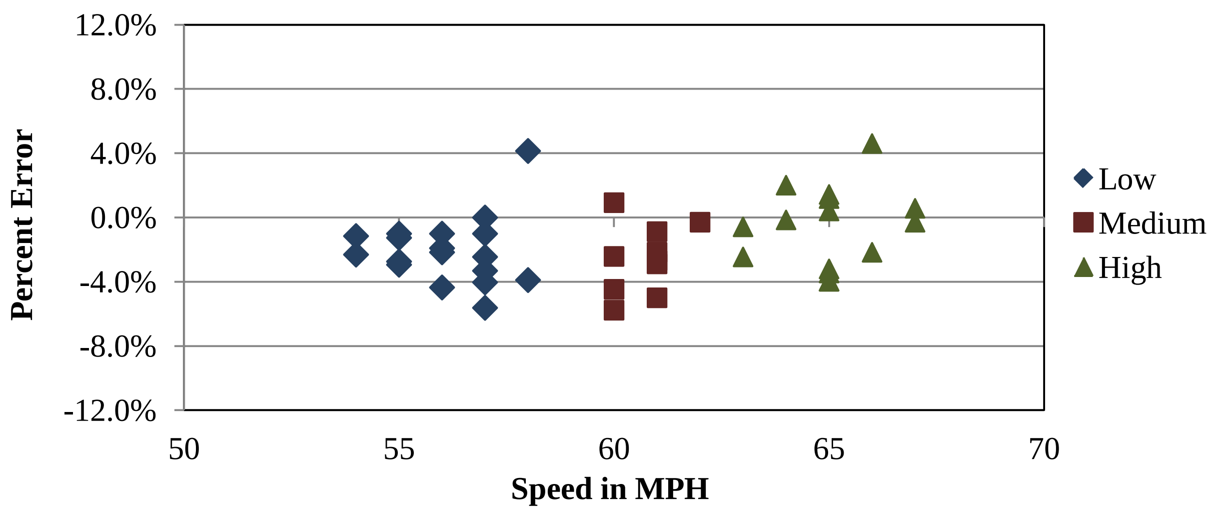


Figure 5-12 – Post-Validation GVW Errors by Speed – 21-Mar-12

5.3.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-13, the WIM equipment bias transitions from a positive bias to a negative bias as speed increases. The range in error is lower at medium speeds when compared to low and high speeds.

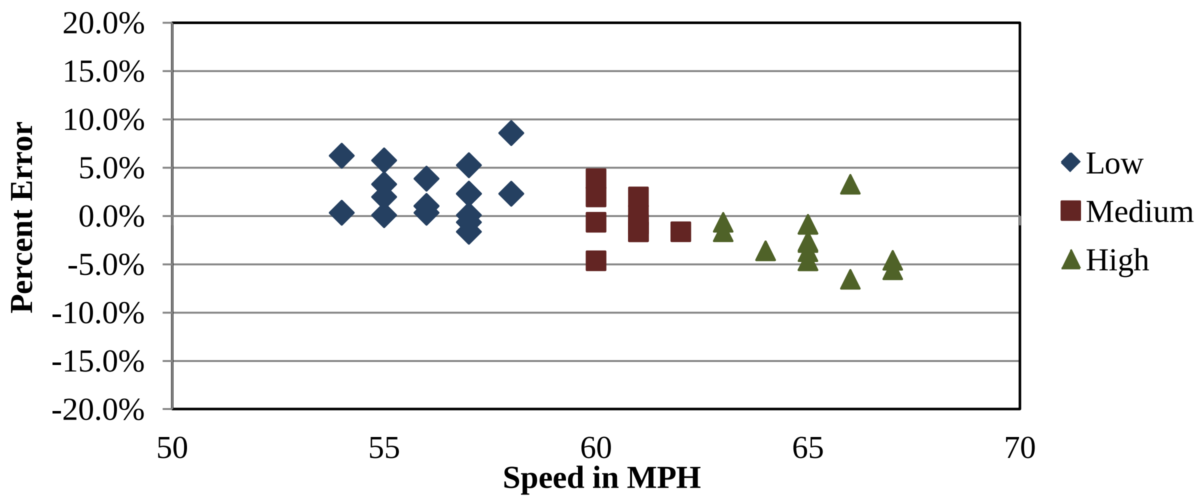


Figure 5-13 – Post-Validation Steering Axle Weight Errors by Speed – 21-Mar-12

5.3.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 5-15, the equipment estimated tandem axle weights with similar accuracy at low and medium speeds. The bias changes from negative to positive when the speed range changes from medium to high. The range in error is similar at all speeds.

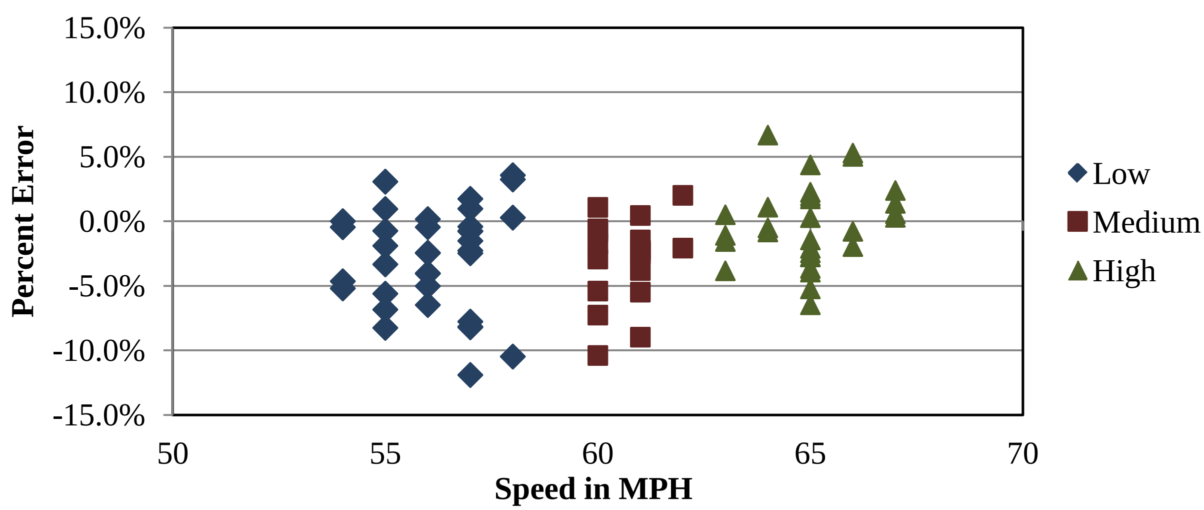


Figure 5-14 – Post-Validation Tandem Axle Weight Errors by Speed – 21-Mar-12

5.3.1.4 GVW Errors by Speed and Truck Type

It can be seen in Figure 5-17 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 all speeds.

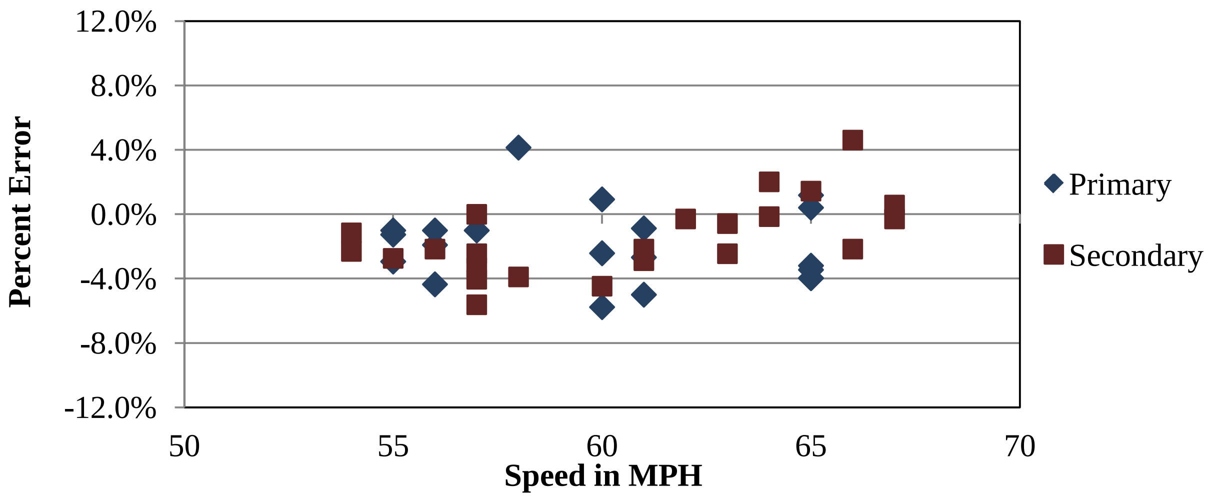


Figure 5-15 – Post-Validation GVW Error by Truck and Speed – 21-Mar-12

5.3.1.5 Axle Length Errors by Speed

For this site, the error in axle length measurement was consistent at all speeds. The range in axle length measurement error was from -0.1 feet to 0.3 feet. Distribution of errors is shown graphically in Figure 5-18.

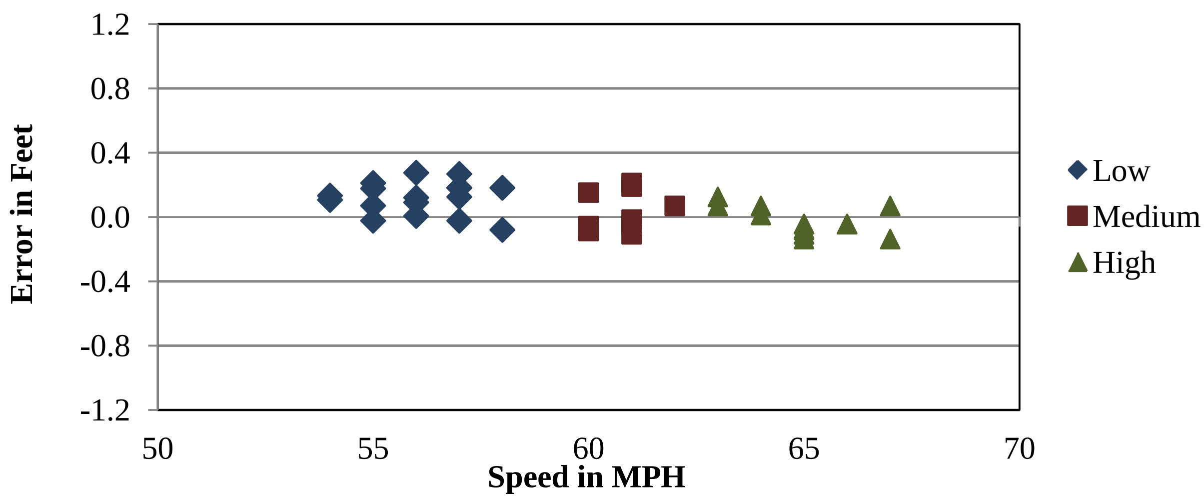


Figure 5-16 – Post-Validation Axle Length Error by Speed – 21-Mar-12

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 -1.8 to -0.4 feet. Distribution of errors is shown graphically in Figure 5-19.

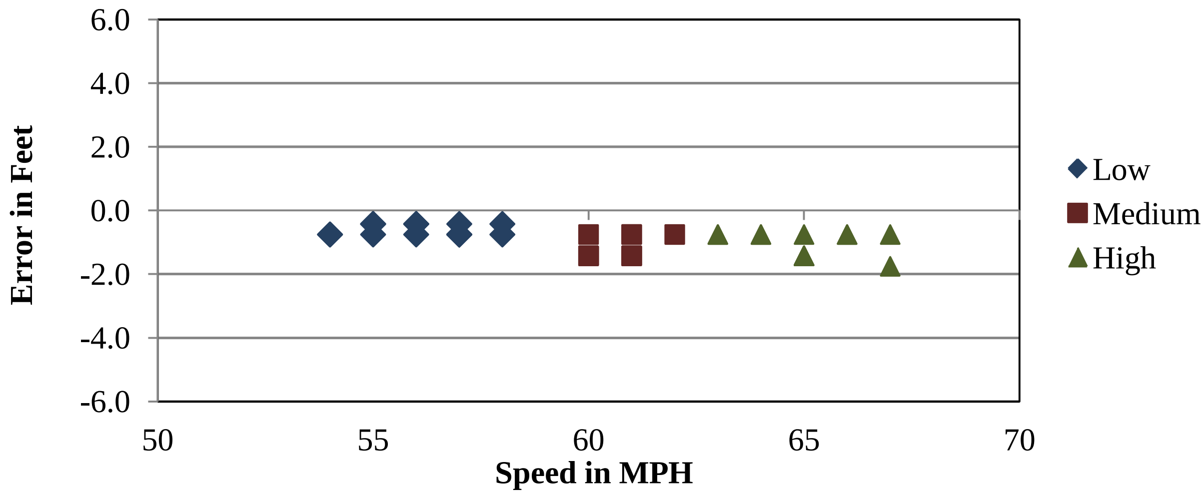


Figure 5-17 – Post-Validation Overall Length Error by Speed – 21-Mar-12

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 6.3 degrees, from 56.5 to 62.8 degrees Fahrenheit. The post-validation test runs are reported under one temperature group – medium, as shown in Table 5-14 below.

Table 5-14 – Post-Validation Results by Temperature – 21-Mar-12

Parameter	95% Confidence Limit of Error	Medium 56.5 to 62.8 degF
Steering Axles	+20 percent	-0.1 ± 6.9%
Tandem Axles	+15 percent	-2.0 ± 6.7%
GVW	+10 percent	-1.7 ± 4.7%
Vehicle Length	±3.0 percent (2.1 ft)	-0.9 ± 0.8 ft
Vehicle Speed	± 1.0 mph	0.0 ± 0.2 mph
Axle Length	+ 0.5 ft [150mm]	-0.4 ± 2.7 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 5-20, it can be seen that the equipment appears to estimate GVW with similar accuracy across the range of temperatures observed in the field. There does not appear to be a correlation between temperature and weight estimates at this site.

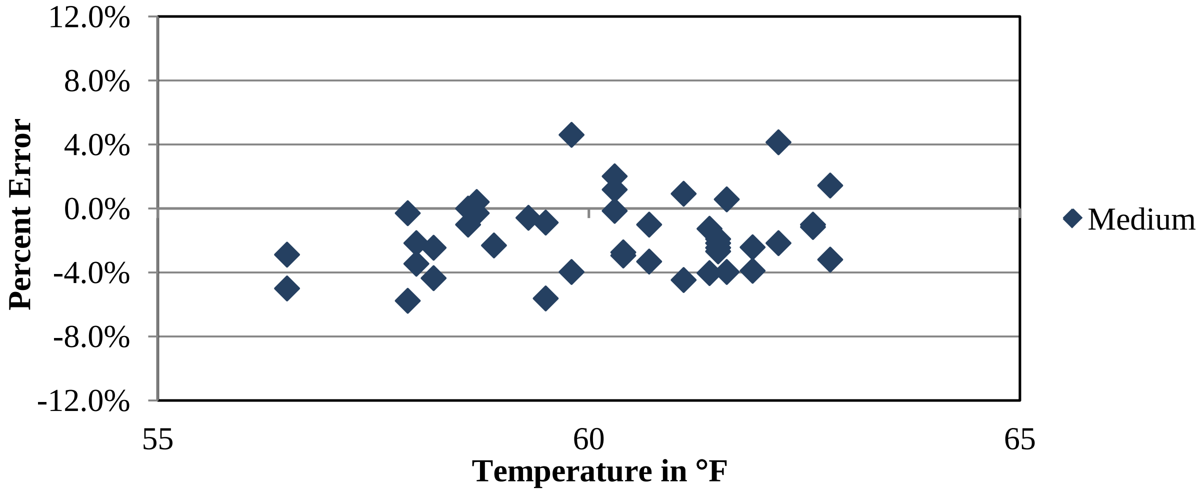


Figure 5-18 – Post-Validation GVW Errors by Temperature – 21-Mar-12

5.3.2.2 Steering Axle Weight Errors by Temperature

Figure 5-21 demonstrates that for steering axles, the WIM equipment appears to estimate weights with similar accuracy across the range of temperatures observed in the field. There does not appear to be a correlation between temperature and steering axle weight estimates at this site. The range in error is similar for the one temperature group.

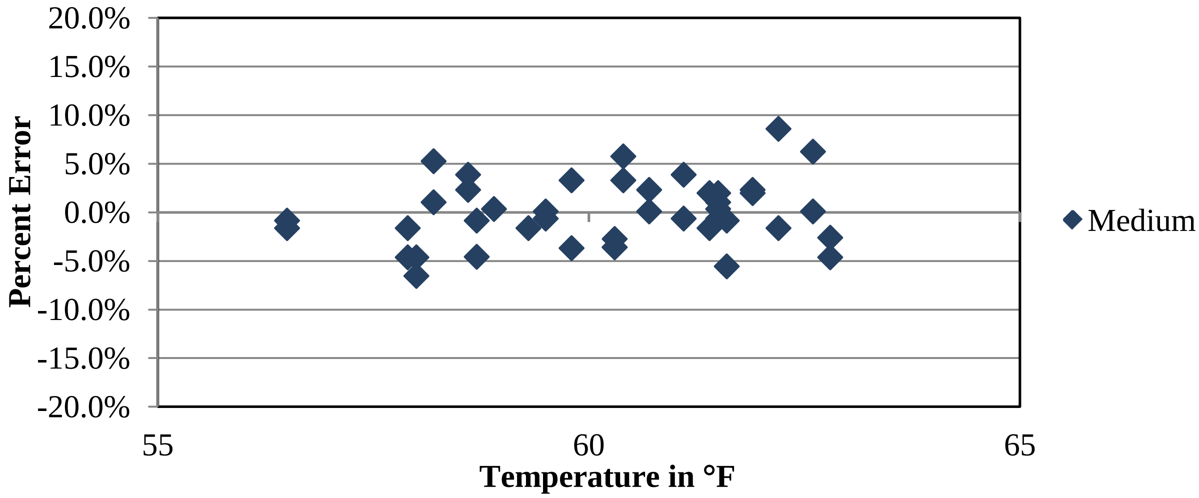


Figure 5-19 – Post-Validation Steering Axle Weight Errors by Temperature – 21-Mar-12

5.3.2.3 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-23, 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 the one temperature group.

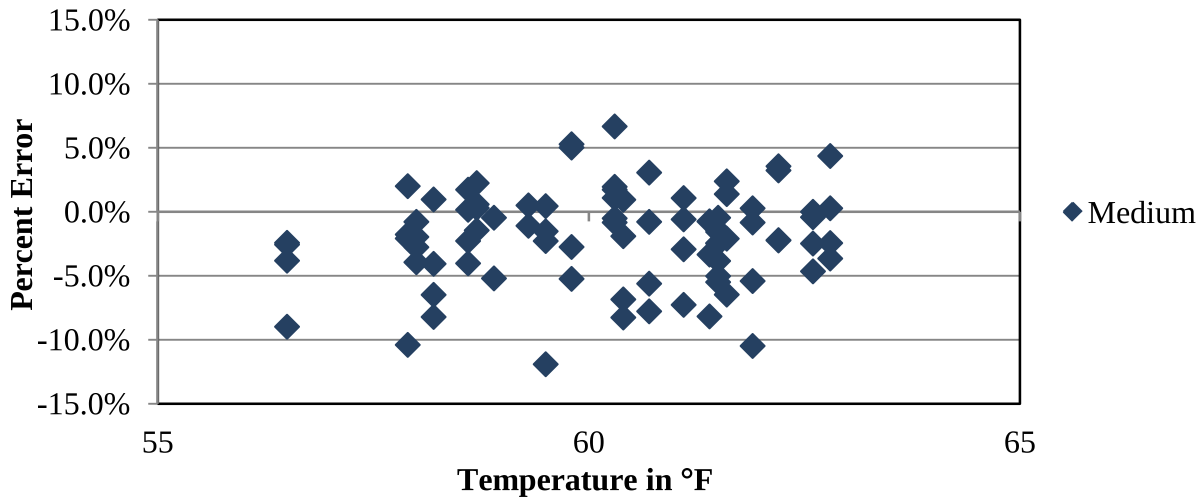


Figure 5-20 – Post-Validation Tandem Axle Weight Errors by Temperature – 21-Mar-12

5.3.2.4 GVW Errors by Temperature and Truck Type

As shown in Figure 5-25, when analyzed by truck type, GVW measurement errors for both trucks are similar at all temperatures. For both trucks, the range of errors and bias are reasonably consistent over the range of temperatures.

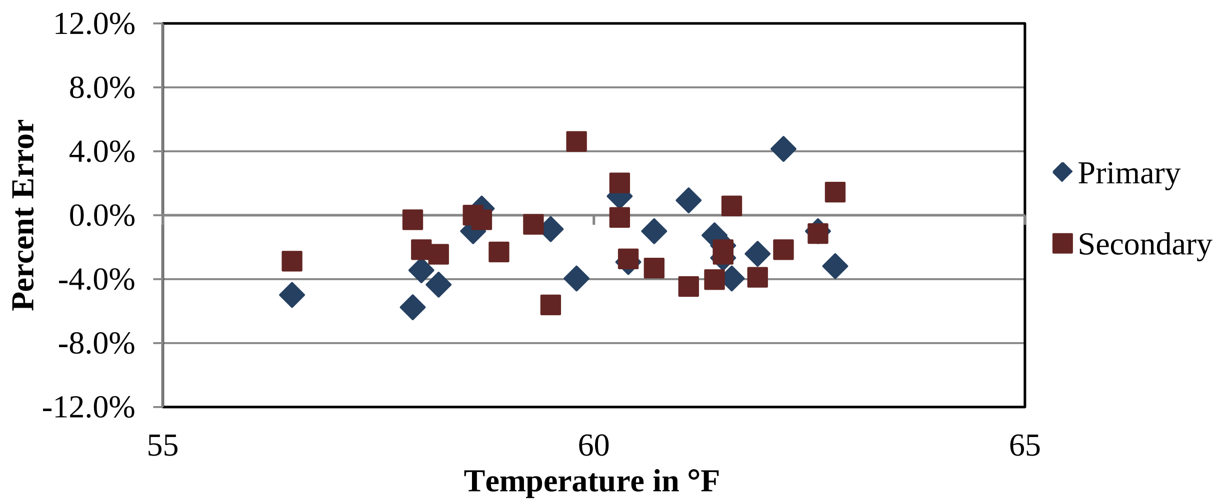


Figure 5-21 – Post-Validation GVW Error by Truck and Temperature – 21-Mar-12

5.3.3 Classification and Speed Evaluation

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

For the post-validation classification study at this site, a manual sample of 103 vehicles including 100 trucks (Class 4 through 13) was collected. Video was collected during the study to provide a means for further analysis of misclassifications and vehicles whose classifications could not be determined with a high degree of certainty in the field.

Misclassified vehicles are defined as those vehicles that are manually classified by observation as one type of vehicle but identified by the WIM equipment as another type of vehicle. The misclassifications by pair are provided in Table 5-15. The table illustrates the breakdown of vehicles observed and identified by the equipment for the manual classification study. As shown in Table 5-15, one Class 3 vehicle was misclassified as a Class 5 vehicle, one Class 5 vehicle was misclassified as a Class 4 vehicle, and two Class 5 vehicles were misclassified as Class 8 vehicles by the equipment.

Table 5-15 – Post-Validation Misclassifications by Pair – 21-Mar-12

		WIM											
		3	4	5	6	7	8	9	10	11	12	13	14
Observed	3	-		1									
	4		-										
	5		1	-			2						
	6				-								
	7					-							
	8						-						
	9							-					
	10								-				
	11									-			
	12										-		
	13											-	-

As shown in the table, a total of 4 vehicles, including 0 heavy trucks (6 – 13) were misclassified by the equipment. Based on the vehicles observed during the post-validation study, the misclassification percentage is 0.0% for heavy trucks (vehicle classes 6 – 13), which is within the 2.0% acceptability criteria for LTPP SPS WIM sites. The overall misclassification rate for all vehicles (3 – 15) is 3.9 percent, primarily due to misclassification of lightweight vehicles in Class 3 and Class 4. The causes for the misclassifications were not investigated in the field.

The combined results of the misclassifications resulted in an undercount of one Class 3 and two Class 5 vehicles and an overcount of one Class 4 vehicle and two Class 8 vehicles, as shown in

Table 5-16. The misclassified percentage represents the percentage of the misclassified vehicles in the manual sample.

Table 5-16 – Post-Validation Classification Study Results – 21-Mar-12

Class	3	4	5	6	7	8	9	10	11	12	13
Observed Count	3	0	10	1	0	3	78	1	4	3	0
WIM Count	2	1	8	1	0	5	78	1	4	3	0
Observed Percent	2.9	0.0	9.7	1.0	0.0	2.9	75.7	1.0	3.9	2.9	0.0
WIM Percent	1.9	1.0	7.8	1.0	0.0	4.9	75.7	1.0	3.9	2.9	0.0
Misclassified Count	1	0	3	0	0	0	0	0	0	0	0
Misclassified Percent	33.3	0.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unclassified Count	0	0	0	0	0	0	0	0	0	0	0
Unclassified Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Unclassified vehicles are defined as those vehicles that cannot be identified by the WIM equipment algorithm. These are typically trucks with unusual trailer tandem configurations and are identified as Class 15 by the WIM equipment. The unclassified vehicles by pair are provided in Table 5-17.

Table 5-17 – Post-Validation Unclassified Trucks by Pair – 21-Mar-12

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

Based on the manually collected sample of the 100 trucks, 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 -1.0 mph; the range of errors was 1.4 mph.

5.3.4 Final WIM System Compensation Factors

The final factors left in place at the conclusion of the validation are provided in Table 5-18.

Table 5-18 – Final Factors

Speed Point	**MPH**	**Right**	**Left**
		1	**2**
80	50	3082	3011
88	55	3172	3098
96	60	3102	3029
104	65	2987	2918
112	70	2981	2912
Axle Distance (cm)		373	
Dynamic Comp (%)		109	
Loop Width (cm)		211	

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 post-validation classification and speed study is conducted to possibly determine the cause of each truck misclassification.

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

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 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.

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 54 to 67 mph.
- Pavement temperature. Pavement temperature ranged from 56.5 to 62.8 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	-24.7480	16.4737	-1.5023	0.1417
Speed	0.1692	0.0894	1.8936	0.0663
Temp	0.2126	0.2462	0.8634	0.3937
Truck	0.2581	0.7352	0.3511	0.7276

The lowest probability value given in Table 5-15 was 0.0663 for speed. This means that there is about a 7 percent chance that the value of regression coefficient for speed (0.1692) is zero (rather than 0.1692). Overall, only speed had a significant effect on GVW measurement errors.

The relationship between speed and GVW 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.

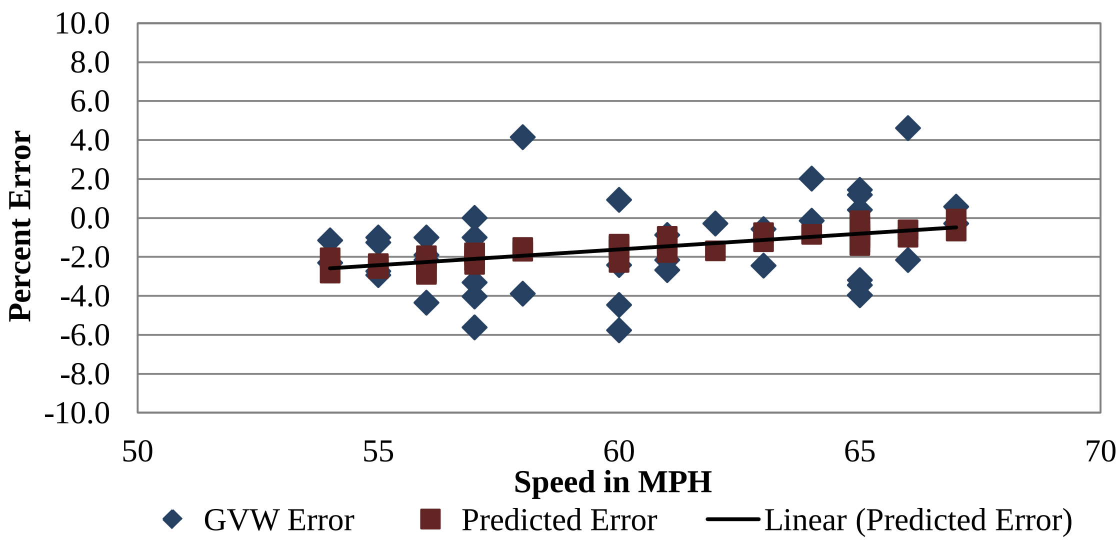


Figure 6-1 – Influence of Speed on the Measurement Error of GVW

The quantification of the relationship is provided by the value of the regression coefficient, in this case 0.1692 (in Table 6-1). This means, for example, that for a 10 mph increase in speed, the error is increased by about 1.7 percent (0.1692 x 10). The statistical assessment of the relationship is provided by the probability value of the regression coefficient (0.0663) and is marginally 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	0.1692	0.0663	-	-	-	-
Steering axle	-0.5205	$4.34\ 10^{-6}$	0.4296	0.1142	-	-
Tandem axle tractor	0.1194	0.1220	-	-	1.5875	0.0148
Tandem axle trailer	0.4753	0.0059	-	-	-	-

6.1.4 Conclusions

1. According to Table 6-2, speed had statistically significant effect on measurement errors of GVW, steering axles, and tandem axles on trailers. The effect of speed on the measurement errors depended on truck type. For example, Figure 6-2 shows that whereas there was no significant effect of speed on the measurement errors of tandem axles on trailer for the Primary truck, the effect was statistically significant for the Secondary truck. Figure 6-3 shows trends for the steering axles. In this case, both truck types have statistically significant influence on the measurement errors of the steering axles, and the trend is negative (as also indicated by the negative regression coefficient for steering axles).

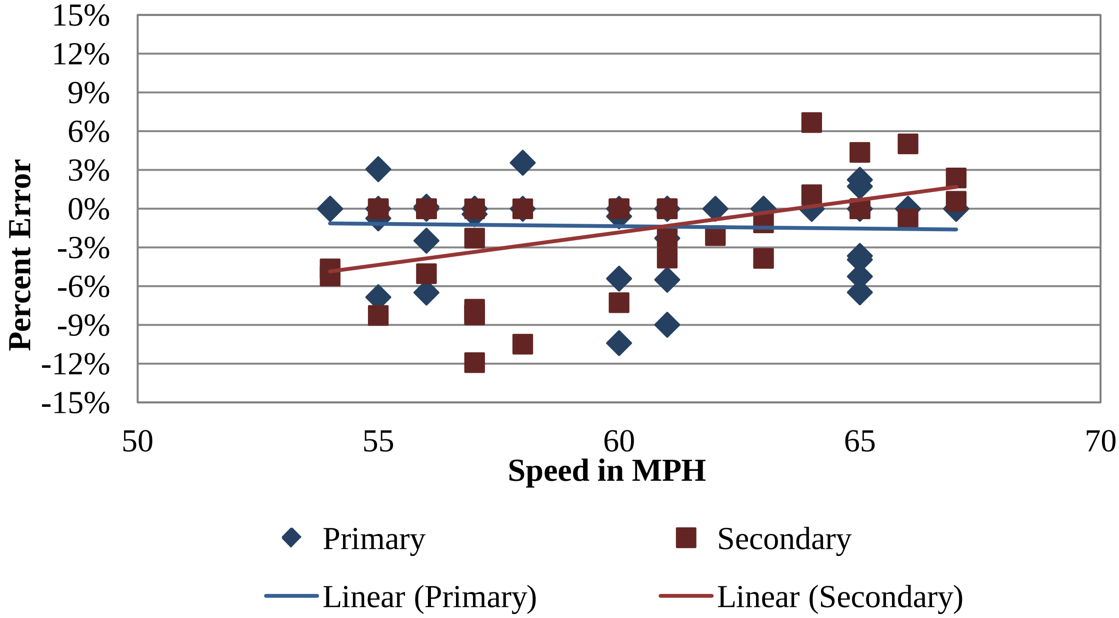


Figure 6-2 – Influence of Speed on Measurement Errors of Tandem Axles on Trailer

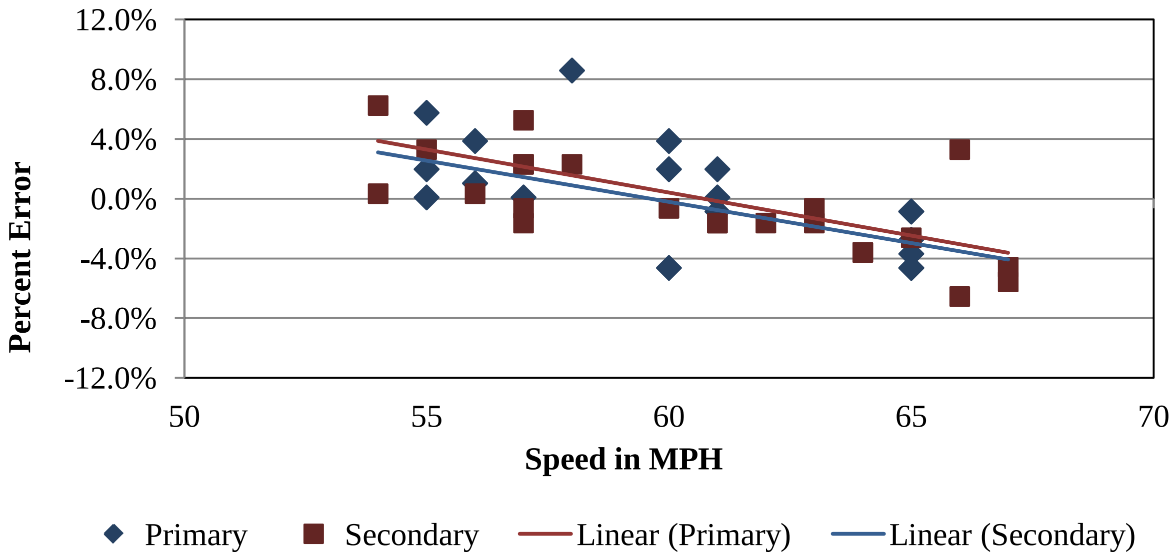


Figure 6-3 – Influence of Speed on Measurement Errors of Steering Axles

2. The effect of temperature on measurement errors of axle weights was not statistically significant. However, the range of pavement temperatures was only 6.3 °F.

3. Truck type had statistically significant effect on only measurement errors of tandem axle on tractor only at 0.0148 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. The mean measurement error for tandem axles on tractors for the Secondary truck was about 1.6 % larger than the corresponding error for the Primary truck.

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

6.2 Misclassification Analysis

A post-visit analysis was conducted on the truck misclassifications identified during the post-validation conducted in the field. For this site, a total of 4 vehicles, including 0 heavy trucks (6 – 13) were misclassified by the equipment. There were two Class 5 vehicles misclassified as Class 8 vehicles. According to the Sheet 20, these vehicles were vehicle numbers 32231 and 33555. The captures of the real-time records for these vehicles are provided in Figure 6-6 and Figure 6-7.

(32231) LANE #1	CLASS 8	GVW 21.5 kips		LENGTH 62 ft	
SPEED 65 mph		MAX GVW 75.5 kips		Wed Mar 21 2012 9:39:08 (565)	
AXLE	SEPARATION (ft)	LEFT WT (kips)	RIGHT WT (kips)	TOTAL WT (kips)	ALLOWABLE (kips)
1 S		3.0	2.8	5.8	20.0
2 S	14.4	3.7	3.3	7.0	20.0
3 D	32.4	1.6	2.8	4.3	17.0
4 D	4.0	1.7	2.6	4.3	17.0

Figure 6-4 – Vehicle Record 32231

(33555) LANE #1	CLASS 8	GVW 20.7 kips		LENGTH 46 ft	
SPEED 65 mph		MAX GVW 75.5 kips		Wed Mar 21 2012 11:32:58 (2281)	
AXLE	SEPARATION (ft)	LEFT WT (kips)	RIGHT WT (kips)	TOTAL WT (kips)	ALLOWABLE (kips)
1 S		2.2	2.3	4.5	20.0
2 S	11.4	2.9	3.4	6.3	20.0
3 D	22.1	2.2	2.1	4.3	17.0
4 D	2.9	2.9	2.8	5.7	17.0

Figure 6-5 – Vehicle Record 33555

The video capture of vehicle 32231 is provided in Photo 6-1. As the photo illustrates, the misclassification involved a Class 5 pick-up towing a trailer. The WIM system identified the vehicle as a Class 8 vehicle. Setting minimum weight limit on trailer axles could prevent this misclassification in the future.

Photo 6-1 – Video Capture of Vehicle 32231

The video capture of vehicle 33555 is provided in Photo 6-2. As the photo illustrates, the misclassification involved a Class 5 pick-up towing a horse trailer. The WIM system identified this vehicle as a Class 8 vehicle. Setting minimum weight limit on trailer axles could prevent this misclassification in the future.

Photo 6-2 – Video Capture of Vehicle 33555

6.3 Traffic Data Analysis

6.3.1 Average GVW and Steering Axle Weights

As a result of the Post-Visit Traffic Data Analysis, it appears that the calibration adjustments brought the average GVW and Steering Axle weights for the site in line with the Comparison Data Set from March 10, 2011, as shown in Table 6-3.

Table 6-3 – Average GVW and Steering Axle Weights

Data Set	Date	Average GVW (kips)	Average Steering Axle (kips)
Comparison	March 10, 2011	62.5	11.6
Pre-Visit Sample	December 19, 2011	61.0	11.5
Post-Visit Sample	March 31, 2012	62.4	11.6

6.3.2 Imbalance in Steering Axle Weights

A post-visit data analysis was carried out using the data obtained after the final calibration factors were set. The results of the post-visit imbalance analysis of steering axle weights are presented in Table 6-3.

Table 6-4 – Front Axle Weight Imbalance

Data Set	Date	Left	Right	Imbalance	PCT
Pre-Visit Sample	January 30, 2012	5.55	5.67	Right	2.1%
Post-Visit Sample	March 31, 2012	5.96	5.66	Left	5.0%

As shown in the table, for the post-visit sample, the left weights are 5.0 percent greater than the right side weights. Theoretically, there should be no imbalance for evenly loaded trucks on a level road. However, because of the cross-sectional slope of the pavement, evenly loaded trucks on straight highway segments have right-sided imbalance equal to the cross-sectional slope of the pavement. On straight highway segments, with asphalt or concrete pavements, the typical cross-sectional slope is 1.5 to 2 percent. The left-sided post-visit imbalance of 5.0 percent suggests that the left and right weighpad have different sensitivities to weights or different calibration factors.

6.3.3 WIM System Factor Adjustments

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

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 post-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	
15-May-07	-	100	50	0	-	63	0	-	0	0	-	0
16-May-07	-	100	50	-	-	50	0	0	0	0	-	0
28-Oct-08	-	0	0	0	-	0	0	0	0	0	-	0
29-Oct-08	-	-	-	0	0	0	0	-	0	0	-	0
8-Mar-11	-	0	0	0	0	0	0	100	0	0	0	0
9-Mar-11	-	0	20	0	0	0	0	0	0	0	0	0
20-Mar-12	50	0	40	0	0	0	0	67	0	0	0	0
21-Mar-12	33	0	30	0	0	0	0	0	0	0	0	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 post-validations.

Table 7-2 – Weight Validation History

Date	Mean Error and 2SD		
	GVW	Steering Axles	Tandem Axle Groups
15-May-07	2.0 ± 6.4	-0.6 ± 6.7	2.5 ± 8.3
16-May-07	1.1 ± 3.6	-2.0 ± 7.0	1.6 ± 5.7
28-Oct-08	0.9 ± 4.9	-1.0 ± 5.6	1.2 ± 7.7
29-Oct-08	1.3 ± 3.7	-0.7 ± 5.1	1.6 ± 6.7
8-Mar-11	3.6 ± 4.7	1.3 ± 9.0	4.6 ± 6.4
9-Mar-11	1.6 ± 3.9	0.8 ± 10.3	0.9 ± 6.9
20-Mar-12	2.2 ± 4.8	4.9 ± 7.4	1.6 ± 7.0
21-Mar-12	-1.7 ± 4.7	-0.1 ± 6.9	-0.4 ± 6.7

The precision and bias of the WIM System GVW and tandem axle weight estimations appear to have remained reasonably consistent since the site was first validated. For steering axles, the 95% confidence interval (2SD) has fluctuated, ranging from ± 5.1 for the October 29, 2008 validation, to ± 10.3 for the March 9, 2011 validation. This may be due to the demonstrated effect of speed on the steering axle estimated as described in section 6.1.4 – GVW and Steering Axle Trends. From this information, it appears that the system demonstrates a tendency for the equipment to move toward an overestimation of weights over time. 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
- Pre-validation Sheet 16 – Site Calibration Summary
- Post-validation Sheet 16 – Site Calibration Summary
- Pre-validation Sheet 20 – Classification and Speed Study
- Post-validation Sheet 20 – Classification and Speed Study

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

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

WIM System Field Calibration and Validation - Photos

Arkansas, SPS-2
SHRP ID: 050200

Validation Date: March 20, 2012

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 Sensor

Photo 8 – Power Service Box

Photo 9 – Telephone Service Box

Photo 10 – Downstream

Photo 11 – Upstream

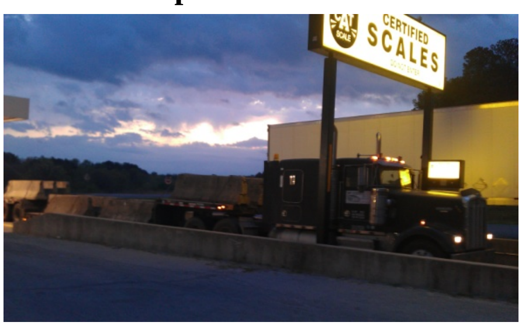


Photo 12 – Truck 1

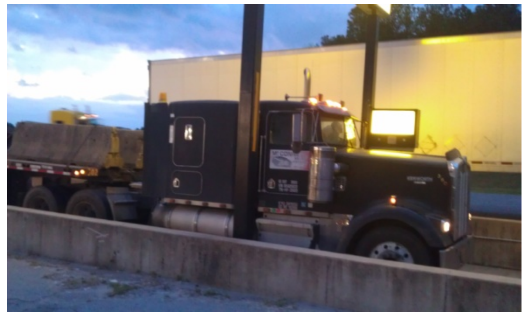


Photo 13 – Truck 1 Tractor

Photo 14 – Truck 1 Trailer and Load

Photo 15 – Truck 1 Suspension 1

Photo 16 – Truck 1 Suspension 2

Photo 17 – Truck 1 Suspension 3

Photo 18 – Truck 1 Suspension 4

Photo 19 – Truck 1 Suspension 5

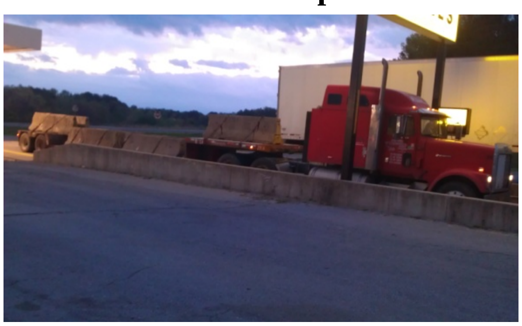


Photo 20 – Truck 2

Photo 21 – Truck 2 Tractor

Photo 22 – Truck 2 Trailer and Load

Photo 23 – Truck 2 Suspension 1

Photo 24 – Truck 2 Suspension 2

Photo 25 – Truck 2 Suspension 3

Photo 27 – Truck 2 Suspension 5

Photo 26 – Truck 2 Suspension 4

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 05 SPS WIM ID: 050200 DATE (mm/dd/yyyy) 3/20/2012

SITE CALIBRATION INFORMATION

1. DATE OF CALIBRATION {mm/dd/yy} 3/20/12

2. TYPE OF EQUIPMENT CALIBRATED: Both

3. REASON FOR CALIBRATION: LTPP Validation

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

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

5. EQUIPMENT MANUFACTURER: IRD iSINC

WIM SYSTEM CALIBRATION SPECIFICS

6. CALIBRATION TECHNIQUE USED: Test Trucks

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

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

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

Mean Difference Between -

Dynamic and Static GVW:	2.2%	Standard Deviation:	2.4%
Dynamic and Static Single Axle:	4.9%	Standard Deviation:	3.7%
Dynamic and Static Double Axles:	1.6%	Standard Deviation:	3.4%

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

9. DEFINE SPEED RANGES IN MPH:

			Low		High	Runs
a.	Low	-	53.0	to	57.3	15
b.	Medium	-	57.4	to	61.8	13
c.	High	-	61.9	to	66.0	12
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: SPS WIM ID: DATE (mm/dd/yyyy)	05 050200 3/20/2012

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 2967 | 3038

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

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

CLASSIFIER TEST SPECIFICS

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

Manual

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

14. MEAN DIFFERENCE IN VOLUMES BY VEHICLES CLASSIFICATION:

FHWA Class 9:	0.0	FHWA Class		-	
FHWA Class 8:	Unk	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 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 05 SPS WIM ID: 050200 DATE (mm/dd/yyyy) 3/21/2012

SITE CALIBRATION INFORMATION

1. **DATE OF CALIBRATION** {mm/dd/yy} 3/21/12

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

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

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

5. **EQUIPMENT MANUFACTURER:** IRD iSINC

WIM SYSTEM CALIBRATION SPECIFICS

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

Number of Trucks Compared:
Number of Test Trucks Used: 2
Passes Per Truck: 22

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

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

Mean Difference Between -

Dynamic and Static GVW:	-1.7%	Standard Deviation:	2.3%
Dynamic and Static Single Axle:	-0.1%	Standard Deviation:	3.4%
Dynamic and Static Double Axles:	-0.4%	Standard Deviation:	3.3%

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

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

			Low		High	Runs
a.	Low	-	54.0	to	58.3	18
b.	Medium	-	58.4	to	62.8	10
c.	High	-	62.9	to	67.0	15
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 05 SPS WIM ID: 050200 DATE (mm/dd/yyyy) 3/21/2012

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 2912 | 2981

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

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

CLASSIFIER TEST SPECIFICS

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

Manual

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

14. MEAN DIFFERENCE IN VOLUMES BY VEHICLES CLASSIFICATION:

FHWA Class 9:	0.0	FHWA Class	5	-	-20.0
FHWA Class 8:	67.0	FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 0.0%

Validation Test Truck Run Set - Post

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: 05 SPS WIM ID: 050200 DATE (mm/dd/yyyy) 3/20/2012

Count - 102 Time = 1:09:26 Trucks (4-15) - 100 Class 3s - 2

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
61	9	24110	62	9	67	9	24212	68	9
65	9	24119	64	9	72	9	24214	72	9
65	9	24120	65	9	66	9	24217	66	9
63	9	24121	63	9	64	6	24218	65	6
64	9	24133	64	9	64	9	24220	64	9
63	12	24134	62	12	62	9	24224	64	9
59	9	24138	59	9	62	9	24225	66	9
57	5	24139	58	5	59	9	24227	60	9
0	**14**	**24140**	**56**	**5**	62	9	24228	63	9
66	9	24147	65	9	65	9	24229	67	9
64	9	24149	63	9	62	9	24233	65	9
62	3	24150	61	3	62	9	24236	63	9
65	5	24153	65	5	64	9	24239	64	9
67	11	24156	66	11	64	9	24240	65	9
65	9	24160	66	9	68	9	24242	63	9
64	9	24162	65	9	65	9	24246	66	9
63	9	24166	62	9	63	9	24252	68	9
64	9	24168	64	9	64	9	24253	66	9
62	9	24169	64	9	64	5	24255	65	5
65	9	24172	65	9	64	9	24262	64	9
67	9	24175	66	9	64	9	24263	64	9
63	9	24179	62	9	**60**	**8**	**24268**	**61**	**5**
59	**13**	**24183**	**61**	**10**	65	9	24271	65	9
62	9	24204	64	9	64	9	24275	64	9
64	9	24207	63	9	67	9	24285	69	9

Sheet 1 - 0 to 50 Start: 12:14:44 Stop: 12:32:36

Recorded By: ar

Verified By: djw Validation Test Truck Run Set - Pre

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 05 SPS WIM ID: 050200 DATE (mm/dd/yyyy) 3/20/2012

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
64	9	24289	65	9	67	9	24620	68	9
65	9	24294	66	9	59	9	24622	60	9
65	12	24295	65	12	62	6	24626	63	6
64	9	24297	64	9	62	9	24627	62	9
61	9	24298	62	9	65	9	24628	67	9
64	9	24301	66	9	65	10	24630	66	10
64	9	24304	65	9	63	9	24635	63	9
66	9	24308	66	9	67	9	24637	65	9
63	9	24312	64	9	64	9	24638	63	9
65	11	24314	66	11	62	9	24639	63	9
59	9	24317	59	9	68	9	24641	68	9
67	9	24322	67	9	65	9	24649	67	9
70	9	24323	72	9	70	9	24652	71	9
65	9	24324	66	9	**57**	**5**	**24663**	**58**	**3**
62	11	24326	64	11	60	9	24669	62	9
64	9	24328	65	9	58	9	24673	58	9
65	9	24332	65	9	67	9	24677	68	9
65	9	24335	65	9	62	9	24699	65	9
65	9	24340	65	9	65	9	24707	65	9
65	9	24343	66	9	62	9	24712	64	9
64	9	24344	64	9	71	9	24713	71	9
64	9	24352	64	9	68	9	24716	70	9
64	6	24356	64	6	68	9	24721	70	9
62	9	24357	65	9	60	9	24727	61	9
65	9	24358	66	9	**60**	**13**	**24742**	**60**	**10**

Sheet 2 - 51 to 100 Start: 12:33:05 Stop: 13:18:27

Recorded By: ar

Verified By: djw Validation Test Truck Run Set - Pre

Traffic Sheet 20	STATE CODE:	05
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	050200
SPEED AND CLASSIFICATION STUDIES	DATE (mm/dd/yyyy)	3/20/2012

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
64	9	24797	60	9					
65	11	24801	65	11					

Sheet 3 - 101 - 150 Start: 13:23:44 Stop: 13:24:10

Recorded By: ar

Verified By: djw Validation Test Truck Run Set - Pre

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 05 SPS WIM ID: 050200 DATE (mm/dd/yyyy) 3/21/2012

Count - 103 Time = 3:24:02 Trucks (4-15) - 100 Class 3s - 3

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
60	12	32055	60	12	66	9	32116	66	9
62	9	32056	63	9	**55**	**5**	**32119**	**59**	**3**
65	9	32059	65	9	62	5	32122	62	5
66	9	32060	66	9	63	9	32123	67	9
64	9	32064	63	9	60	9	32124	61	9
64	9	32065	64	9	65	9	32128	67	9
65	9	32073	66	9	67	5	32129	67	5
61	5	32075	64	5	60	9	32130	60	9
62	9	32076	66	9	60	9	32141	61	9
63	11	32077	64	11	64	9	32142	65	9
61	9	32078	61	9	67	9	32146	67	9
63	9	32080	63	9	62	9	32148	63	9
62	9	32082	63	9	62	9	32154	64	9
65	9	32088	68	9	63	9	32157	65	9
65	5	32091	66	5	62	9	32160	63	9
68	9	32092	69	9	65	9	32161	66	9
66	9	32093	66	9	61	9	32165	62	9
64	9	32096	65	9	64	9	32166	64	9
64	**4**	**32100**	**64**	**5**	64	9	32168	64	9
55	9	32101	55	9	65	9	32171	69	9
52	3	32102	52	3	65	5	32172	65	5
55	9	32107	62	9	68	9	32173	68	9
64	9	32110	64	9	66	9	32178	66	9
63	11	32113	63	11	61	9	32185	64	9
61	9	32114	62	9	55	9	32198	55	9

Sheet 1 - 0 to 50 Start: 9:15:33 Stop: 9:35:49

Recorded By: ar

Verified By: dw Validation Test Truck Run Set - Post

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: SPS WIM ID: DATE (mm/dd/yyyy)	05 050200 3/21/2012

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
45	3	32200	48	3	60	9	33497	61	9
63	9	32205	64	9	65	9	33499	68	9
56	12	32208	57	12	65	5	33500	66	5
59	8	32209	63	8	57	9	33503	56	9
65	9	32211	66	9	65	9	33505	65	9
62	9	32213	62	9	59	9	33509	59	9
63	9	32221	63	9	61	9	33511	64	9
57	9	32222	57	9	67	9	33514	67	9
57	9	32230	58	9	65	8	33516	65	8
62	**8**	**32231**	**62**	**5**	65	12	33520	66	12
61	9	32251	64	9	65	9	33522	68	9
62	9	33235	62	9	62	11	33526	65	11
65	9	33238	66	9	67	9	33552	68	9
60	10	33239	62	10	64	9	33554	65	9
65	9	33241	67	9	**65**	**8**	**33555**	**66**	**5**
67	9	33242	68	9	64	9	33559	62	9
65	9	33247	67	9	59	9	33561	58	9
65	9	33249	65	9	65	9	33563	67	9
67	9	33252	68	9	65	9	33567	65	9
60	5	33256	61	5	59	9	33569	64	9
64	11	33257	64	11	66	9	33576	66	9
65	9	33489	65	9	64	9	33577	65	9
62	9	33491	63	9	60	9	33581	63	9
60	8	33493	60	8	60	9	33588	62	9
67	9	33496	68	9	63	9	33593	64	9

Sheet 2 - 51 to 100 Start: 9:36:02 Stop: 12:38:16

Recorded By: ar

Verified By: dw Validation Test Truck Run Set - Post

Traffic Sheet 20	STATE CODE:	05
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	050200
SPEED AND CLASSIFICATION STUDIES	DATE (mm/dd/yyyy)	3/21/2012

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
60	6	33597	60	6					
57	9	33600	59	9					
56	9	33601	56	9					

Sheet 3 - 101 - 150 Start: 12:39:08 Stop: 12:39:35

Recorded By: ar

Verified By: dw

Validation Test Truck Run Set - Post