WIM System Field Calibration and Validation Summary Report

Louisiana SPS-1
SHRP ID – 220100

Validation Date: November 21, 2011
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1 Executive Summary

A WIM validation was performed on November 21 and 22, 2011 at the Louisiana SPS-1 site located on route US-171 at milepost 8.4, 7.4 miles north of Interstate 10.

This site was installed on December 13, 2007. The in-road sensors are installed in the northbound, righthand driving lane. The site is equipped with quartz 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 July 28, 2010 and this validation visit, it appears that no changes have occurred during this time to the basic operating condition of the equipment.

The equipment is in working order. Electronic and electrical checks of the WIM components determined that all equipment is functioning properly. A physical inspection noted that some of the sealant is missing from the trailing loop sensor. 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-Nov-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-0.3 ± 7.2%	Pass
Tandem Axles	±15 percent	-1.1 ± 4.8%	Pass
GVW	±10 percent	-0.9 ± 2.9%	Pass
Vehicle Length	±3.0 percent (1.9 ft)	-0.2 ± 1.4 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.1 ft	Pass

Truck speeds were manually collected for each test run by a radar gun and compared with the speed reported by the WIM equipment. For this site, the error in speed measurement was 0.5 ± 2.1 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 11.8% from the 80 truck sample (Class 4 – 13) was due to the 9 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 ore.

- The *Secondary* truck was a Class 9 vehicle with air suspension on the tractor tandem, steel spring suspension on the trailer tandem, standard tandem spacing on the tractor and standard tandem on the trailer. The Secondary truck was loaded with palletized bags of plastic beads.

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	76.5	10.4	17.6	17.6	15.4	15.4	19.9	4.3	29.7	4.1	58.0	61.6
2	69.5	10.1	17.2	17.2	12.5	12.5	18.0	4.5	30.5	4.1	57.1	67.6

The posted speed limit at the site is 65 mph. During the testing, the speed of the test trucks ranged from to 45 to 68 mph, a range of 23 mph.

During test truck runs, pavement temperature was collected using a hand-held infrared temperature device. The post-validation pavement surface temperatures varied from 69.6 to 78.5 degrees Fahrenheit, a range of 8.9 degrees Fahrenheit. The rainy weather conditions prevented attaining 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 October 17, 2011 (Data) to the most recent Comparison Data Set (CDS) from July 28, 2010. The assessments performed prior to the site visits are used to develop reasonable expectations for the validation. The results of further investigations performed as a result of the analyses are provided in Section 5 of this report.

2.1 LTPP WIM Data Availability

A review of the LTPP Standard Release Database 25 shows that there are 4 years of level "E" WIM data for this site. Table 2-1 provides a breakdown of the available data for years 2008 to 2011.

Table 2-1 – LTPP Data Availability

Year	Total Number of Days in Year	Number of Months
2008	320	12
2009	365	12
2010	358	12
2011	258	9

As shown in the table, this site requires one additional year of data to meet the minimum of five years of research quality data. The data meets the 210-day minimum requirement for a calendar year for years 2008 through 2011.

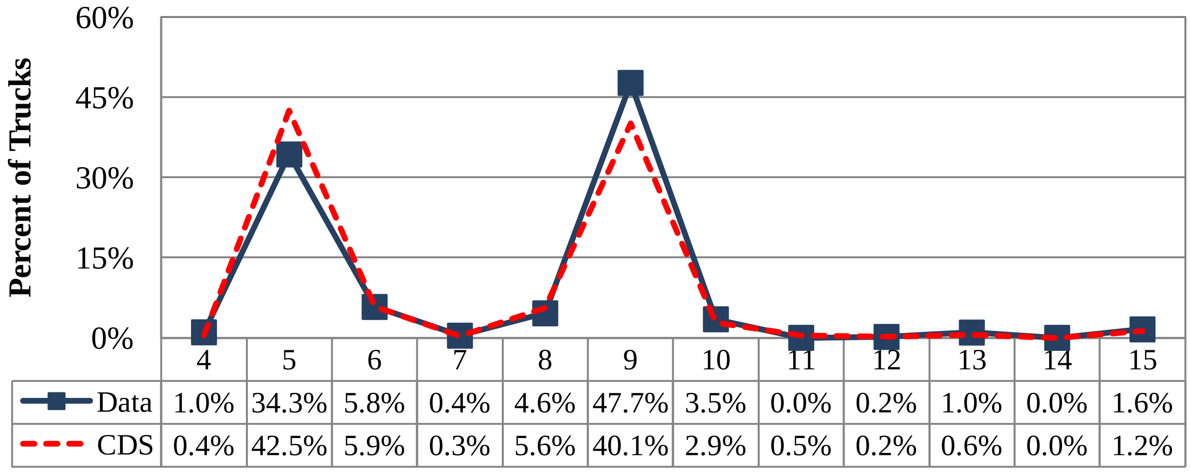
Table 2-2 provides a monthly breakdown of the available data for years 2008 through 2011.

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	
2008	8	29	31	30	31	30	23	16	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	24	31	30	31	30	31	12
2011	31	28	31	30	31	30	31	28	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 for the two datasets.



	4	5	6	7	8	9	10	11	12	13	14	15
Data	1.0%	34.3%	5.8%	0.4%	4.6%	47.7%	3.5%	0.0%	0.2%	1.0%	0.0%	1.6%
CDS	0.4%	42.5%	5.9%	0.3%	5.6%	40.1%	2.9%	0.5%	0.2%	0.6%	0.0%	1.2%

Figure 2-1 – Comparison of Truck Distribution

Table 2-3 provides statistics for the truck distributions at the site for the two periods represented by the two datasets. The table shows that according to the most recent data, the most frequent truck types crossing the WIM scale are Class 9 (47.7%) and Class 5 (34.3%). Table 2-3 also provides data for vehicle Classes 14 and 15. Class 14 vehicles are vehicles that are reported by the WIM equipment as having irregular measurements and cannot be classified properly, such as negative speeds from vehicles passing in the opposite direction of a two-lane road. Class 15 vehicles are unclassified vehicles. The table indicates that 1.6 percent of the vehicles at this site are unclassified.

Table 2-3 – Truck Distribution from W-Card

Vehicle Classification	CDS		Data		Change
	Date				
	7/28/20010		10/17/2011		
4	21	0.4%	62	1.0%	0.6%
5	2155	42.5%	2068	34.3%	-8.1%
6	297	5.9%	348	5.8%	-0.1%
7	16	0.3%	24	0.4%	0.1%
8	285	5.6%	276	4.6%	-1.0%
9	2036	40.1%	2875	47.7%	7.6%
10	146	2.9%	209	3.5%	0.6%

Vehicle Classification	CDS		Data		Change
	Date				
	7/28/20010		10/17/2011		
11	23	0.5%	0	0.0%	-0.5%
12	8	0.2%	10	0.2%	0.0%
13	28	0.6%	59	1.0%	0.4%
14	0	0.0%	0	0.0%	0.0%
15	61	1.2%	95	1.6%	0.4%

From the table it can be seen that the percentage of Class 9 vehicles has increased by 7.6 percent from July 2010 and October 2011. Changes in the percentage of heavier trucks may be attributed to seasonal and natural variations in truck distributions. During the same time period, the percentage of Class 5 trucks decreased by 8.1 percent. These differences may be attributed to changes in the use of the roadway for local deliveries, cross-classifications of type 3 and 5 vehicles, as well as natural variations in truck volumes.

2.3 Speed Data Analysis

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

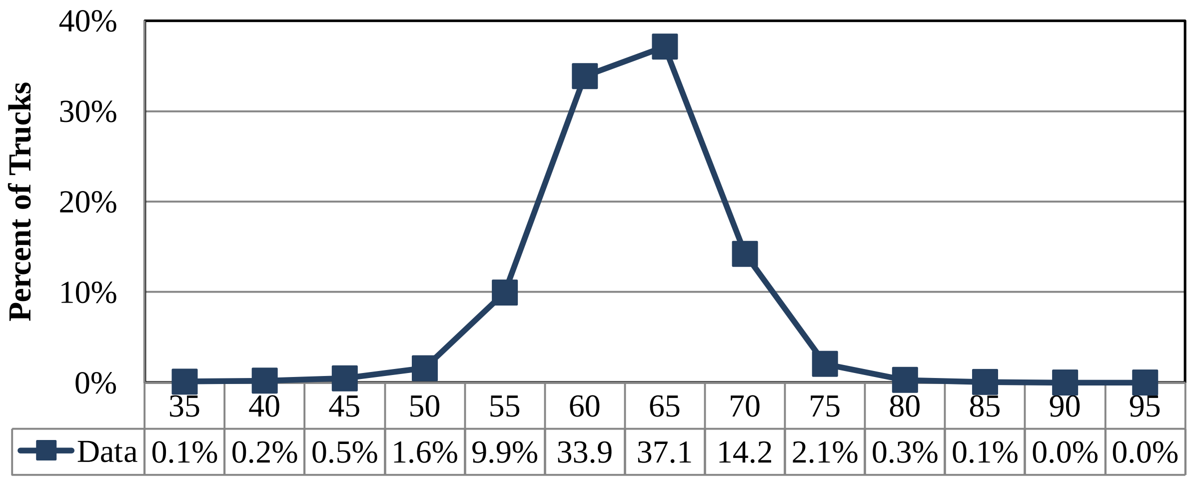


Figure 2-2 – Truck Speed Distribution – 17-Oct-11

As shown in Figure 2-2, the majority of the trucks at this site are traveling between 60 and 70 mph. The posted speed limit at this site is 65 and the 85th percentile speed for trucks at this site is 66 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 October 2011 and the Comparison Data Set from July 2010.

As shown in Figure 2-3, there is a downward shift for the loaded trucks and an upward shift for the unloaded trucks between the July 2010 Comparison Data Set (CDS) and the October 2011 two-week sample W-card dataset (Data).

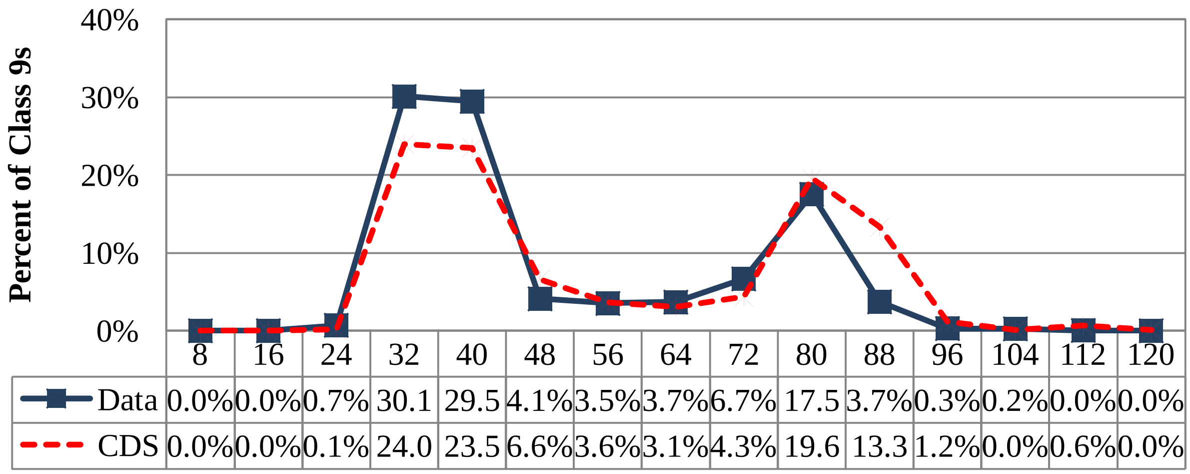


Figure 2-3 – Comparison of Class 9 GVW Distribution

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				
	7/28/20010		10/17/2011		
8	0	0.0%	0	0.0%	0.0%
16	0	0.0%	0	0.0%	0.0%
24	3	0.1%	20	0.7%	0.6%
32	487	24.0%	859	30.1%	6.1%
40	477	23.5%	841	29.5%	6.0%
48	134	6.6%	117	4.1%	-2.5%
56	73	3.6%	100	3.5%	-0.1%
64	62	3.1%	105	3.7%	0.6%

GVW weight bins (kips)	CDS		Data		Change
	Date				
	7/28/20010		10/17/2011		
72	88	4.3%	190	6.7%	2.3%
80	397	19.6%	500	17.5%	-2.0%
88	270	13.3%	106	3.7%	-9.6%
96	24	1.2%	8	0.3%	-0.9%
104	1	0.0%	7	0.2%	0.2%
112	13	0.6%	1	0.0%	-0.6%
120	1	0.0%	0	0.0%	0.0%
Average =	52.7 kips		46.4 kips		-6.3 kips

As shown in the table, the percentage of unloaded Class 9 trucks in the 32 to 40 kips range increased by 6.0 percent while the percentage of loaded class 9 trucks in the 72 to 80 kips range decreased by 2.0 percent. During this time period the percentage of overweight trucks decreased by 10.9 percent. Based on the average Class 9 GVW values from the per vehicle records, the GVW average for this site decreased by 12.0 percent, from 52.7 kips to 46.4 kips kips. This indicates a possible negative drift in the WIM system calibration.

2.5 Class 9 Front Axle Weight Data Analysis

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

Figure 2-4 shows a comparison between Class 9 front axle weight plots generated by using the two week W-card sample from October 2011 and the Comparison Data Set from July 2010. The percentages of light axles (9.5 to 10.0 kips) increased by approximately 5.5% and the percentages of heavy axles (11.0 to 11.5 kips) decreased by approximately 5.6%, indicating possible negative bias (underestimation of loads) in front axle measurement.

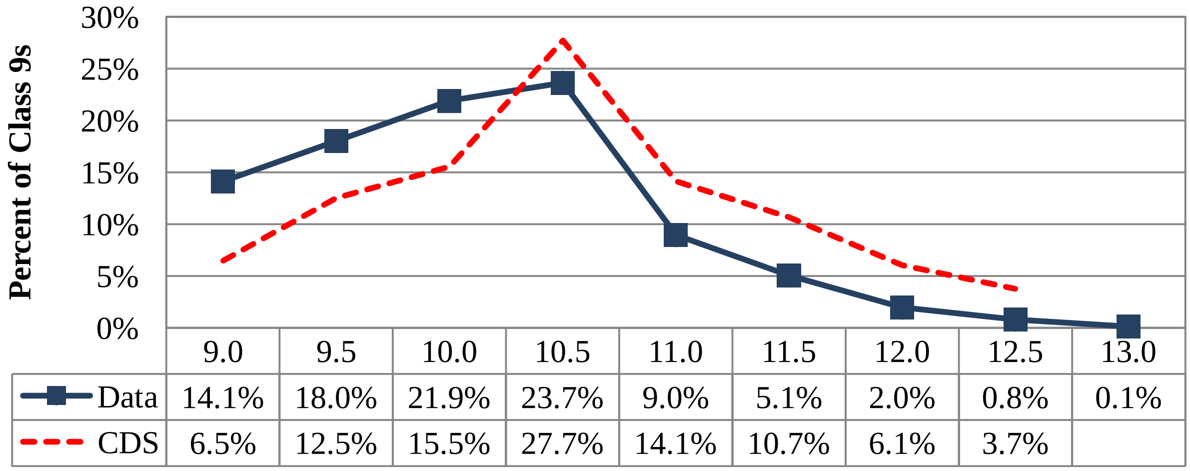


Figure 2-4 – Distribution of Class 9 Front Axle Weights

It can be seen in the figure that the greatest percentage of trucks have front axle weights measuring between 10.0 and 10.5 kips. The percentage of trucks in this range has decreased between the July 2010 Comparison Data Set (CDS) and the October 2011 dataset (Data).

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

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

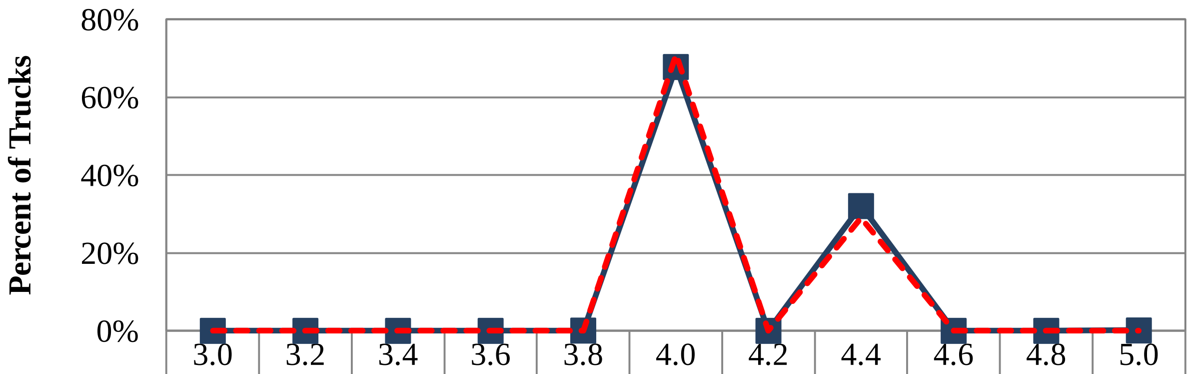
F/A weight bins (kips)	CDS		Data		Change
	Date				
	7/28/20010		10/17/2011		
9.0	48	2.4%	152	5.3%	3.0%
9.5	131	6.5%	402	14.1%	7.7%
10.0	254	12.5%	513	18.0%	5.5%
10.5	315	15.5%	623	21.9%	6.4%
11.0	562	27.7%	673	23.7%	-4.1%
11.5	286	14.1%	255	9.0%	-5.1%
12.0	216	10.7%	144	5.1%	-5.6%
12.5	123	6.1%	56	2.0%	-4.1%
13.0	76	3.7%	23	0.8%	-2.9%
13.5	16	0.8%	4	0.1%	-0.6%
Average =	10.8 kips		10.3 kips		-0.5 kips

The table shows that the average front axle weight for Class 9 trucks has decreased by 0.5 kips, or 4.6 percent. According to the values from the per vehicle records, the average front axle weight for Class 9 trucks is 10.3 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.



	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0
Data	0.0%	0.0%	0.0%	0.0%	0.1%	67.8%	0.0%	32.0%	0.0%	0.0%	0.1%
CDS	0.0%	0.0%	0.0%	0.0%	0.0%	71.0%	0.0%	29.0%	0.0%	0.0%	0.0%

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

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

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

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

Tandem 1 spacing bins (feet)	CDS		Data		Change
	Date				
	7/28/20010		10/17/2011		
3.0	0	0.0%	0	0.0%	0.0%
3.2	0	0.0%	0	0.0%	0.0%
3.4	0	0.0%	0	0.0%	0.0%
3.6	0	0.0%	0	0.0%	0.0%
3.8	0	0.0%	2	0.1%	0.1%
4.0	1441	71.0%	1935	67.8%	-3.2%

Tandem 1 spacing bins (feet)	CDS		Data		Change
	Date				
	7/28/20010		10/17/2011		
4.2	0	0.0%	0	0.0%	0.0%
4.4	589	29.0%	915	32.0%	3.0%
4.6	0	0.0%	0	0.0%	0.0%
4.8	0	0.0%	0	0.0%	0.0%
5.0	0	0.0%	3	0.1%	0.1%
Average =	4.1 feet		4.1 feet		0.0 feet

From the table it can be seen that the drive tandem spacing of Class 9 trucks at this site is between 3.8 and 4.6 feet. Based on the average Class 9 drive tandem spacing values from the per vehicle records, the average tractor tandem spacing is 4.1 feet, which is identical to the expected average of 4.1 feet from the CDS per vehicle records. Further axle spacing analyses are performed during the validation and post-validation analysis.

2.7 Data Analysis Summary

Historical data analysis involved the comparison of the most recent Comparison Data Set (July 2010) based on the last calibration with the most recent two-week WIM data sample from the site (October 2011). Comparison of vehicle class distribution data indicates a 7.6 percent increase in the number of Class 9 vehicles. Analysis of Class 9 weight data indicates that front axle weights have decreased by 4.6 percent and average Class 9 GVW has decreased by 12.0 percent for the October 2011 data, indicating a negative drift in the WIM system calibration. The data indicates an average truck tandem spacing of 4.1 feet, which is identical the expected average of 4.1 feet.

3 WIM Equipment Discussion

From a comparison between the report of the most recent validation of this equipment on July 28, 2010 and this validation visit, it appears that no changes have occurred during this time to the basic operating condition of the equipment.

3.1 Description

This site was installed on December 13, 2007 by International Road Dynamics. It is instrumented with quartz 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. During the inspection, it was noted that sections of the loop sealant from the trailing loop have come loose, as shown in the photos below.

Photo 3-1 – Trailing Loop Sensor Sealant - 1

Photo 3-2 – Trailing Loop Sensor Sealant - 2

Photo 3-3 – Trailing Loop Sensor Sealant - 3

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

No unscheduled equipment maintenance actions are recommended.

4 Pavement Discussion

4.1 Pavement Condition Survey

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

4.2 Profile and Vehicle Interaction

Profile data was collected on March 16, 2011 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 122 in/mi and is located approximately 467 feet prior to the WIM scale. The highest IRI value within the 400 foot approach section was 78 in/mi and is located approximately 106 feet prior to the WIM scale. Since these IRI values are within acceptable ranges for pavement smoothness, the IRI values for these areas do not raise concern on how they may affect truck dynamics or their effect on the accuracies of the WIM system

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

4.3 LTPP Pavement Profile Data Analysis

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

Table 4-1 – Recommended WIM Smoothness Index Thresholds

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

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

The profile analysis was based on four different indices: Long Range Index (LRI), which represents the pavement roughness starting 25.8 m prior to the scale and ending 3.2 m after the scale in the direction of travel; Short Range Index (SRI), which represents the pavement roughness beginning 2.74 m prior to the WIM scale and ending 0.46 m after the scale; Peak LRI – the highest value of LRI within 30 m prior to the scale; and Peak SRI – the highest value of SRI between 2.45 m prior to the scale and 1.5 m after the scale. The results from the analysis for each of the indices for the right wheel path (RWP) and left wheel path (LWP) values for the 3 left, 3 right and 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)	0.585	0.527	0.545			0.552
		SRI (m/km)	0.412	0.389	0.452			0.418
		Peak LRI (m/km)	0.661	0.538	0.548			0.582
		Peak SRI (m/km)	0.518	0.523	0.531			0.524
	RWP	LRI (m/km)	0.718	0.498	0.600			0.605
		SRI (m/km)	0.623	0.727	0.642			0.664
		Peak LRI (m/km)	0.720	0.545	0.603			0.623
		Peak SRI (m/km)	*0.701*	*0.740*	0.763			*0.735*
Center	LWP	LRI (m/km)	0.558	0.611	0.579	0.581	0.549	0.582
		SRI (m/km)	0.292	0.539	0.652	0.665	0.296	0.537
		Peak LRI (m/km)	0.689	0.619	0.594	0.590	0.587	0.623
		Peak SRI (m/km)	*0.360*	*0.607*	0.796	0.756	*0.444*	*0.630*
	RWP	LRI (m/km)	0.615	0.516	0.472	0.465	0.523	0.517
		SRI (m/km)	0.853	0.660	0.638	0.704	0.734	0.714
		Peak LRI (m/km)	0.644	0.586	0.566	0.555	0.554	0.588
		Peak SRI (m/km)	1.057	*0.664*	*0.639*	*0.745*	0.833	0.776
Right	LWP	LRI (m/km)	0.558	0.718	0.629			0.635
		SRI (m/km)	0.695	0.837	0.722			0.751
		Peak LRI (m/km)	0.598	0.730	0.639			0.656
		Peak SRI (m/km)	**0.996**	**1.136**	**1.008**			**1.047**
	RWP	LRI (m/km)	0.518	0.481	0.502			0.500
		SRI (m/km)	0.528	0.599	0.355			0.494
		Peak LRI (m/km)	0.551	0.495	0.578			0.541
		Peak SRI (m/km)	*0.550*	*0.676*	*0.365*			*0.530*

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 left wheel path of the right shift passes (shown in bold).

4.4 Recommended Pavement Remediation

No pavement remediation is recommended.

5 Statistical Reliability of the WIM Equipment

The following section provides summaries of data collected during the 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 November 21, 2011, beginning at approximately 10:49 AM and continuing until 1:19 PM.

The *two* test trucks consisted of:

- A Class 9 truck, loaded with ore, and equipped with air suspension on truck and trailer tandems and with standard tandem spacings on both the tractor and trailer.

- A Class *9*, *5*-axle truck, loaded with palletized bags of plastic beads, and equipped with air suspension on the tractor, steel spring 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	78.2	10.7	17.5	17.5	16.3	16.3	19.9	4.3	29.7	4.1	58.0	62.0
2	69.7	10.2	17.3	17.3	12.5	12.5	18.0	4.5	30.5	4.1	57.1	67.6

Test truck speeds varied by 17 mph, from 51 to 68 mph. The measured pre-validation pavement temperatures varied 10.4 degrees Fahrenheit, from 80.8 to 91.2. The overcast and foggy weather conditions prevented attaining 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 did not meet the LTPP requirements for Vehicle Length measurement as a result of the pre-validation test truck runs.

Table 5-2 – Pre-Validation Overall Results – 21-Nov-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-5.4 ± 4.6%	Pass
Tandem Axles	±15 percent	-6.9 ± 4.1%	Pass
GVW	±10 percent	-6.5 ± 2.3%	Pass
Vehicle Length	±3.0 percent (1.9 ft)	3.7 ± 1.3 ft	FAIL
Axle Length	± 0.5 ft [150mm]	0.1 ± 0.1 ft	Pass

Truck speed was manually collected for each test run using a radar gun and compared with the speed reported by the WIM equipment. For this site, the average error in speed measurement over all speeds was 1.2 ± 2.6 mph, which is greater than the ±1.0 mph tolerance established by the LTPP Field Guide. However, since the site is measuring axle spacing length with a mean error of 0.1 feet, and the speed and axle spacing measurements are based on the distance between the axle detector sensors, it can be concluded that the distance factor is set correctly and that the speeds being reported by the WIM equipment are within acceptable ranges.

5.1.1 Statistical Speed Analysis

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

Parameter	95% Confidence Limit of Error	Low	Medium	High
		51.0 to 56.7 mph	56.8 to 62.4 mph	62.5 to 68.0 mph
Steering Axles	±20 percent	-5.8 ± 6.8%	-5.7 ± 4.5%	-4.7 ± 3.5%
Tandem Axles	±15 percent	-6.5 ± 5.6%	-7.4 ± 4.0%	-6.7 ± 3.3%
GVW	±10 percent	-6.3 ± 3.1%	-6.8 ± 2.3%	-6.2 ± 2.1%
Vehicle Length	±3.0 percent (1.9 ft)	3.5 ± 1.4 ft	3.7 ± 1.4 ft	3.9 ± 1.5 ft
Vehicle Speed	± 1.0 mph	0.5 ± 2.3 mph	1.5 ± 2.7 mph	1.5 ± 2.9 mph
Axle Length	± 0.5 ft [150mm]	0.1 ± 0.1 ft	0.1 ± 0.1 ft	0.1 ± 0.1 ft

From the table, it can be seen that the WIM equipment underestimates all weights at all speeds. The range in error for all parameters appears to decrease as speed increases.

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

5.1.1.1 GVW Errors by Speed

As shown in Figure 5-1, the equipment underestimated GVW at all speeds. The extent of underestimation appears to be similar for all speeds. The range in error is reasonably consistent over the entire range of speeds.

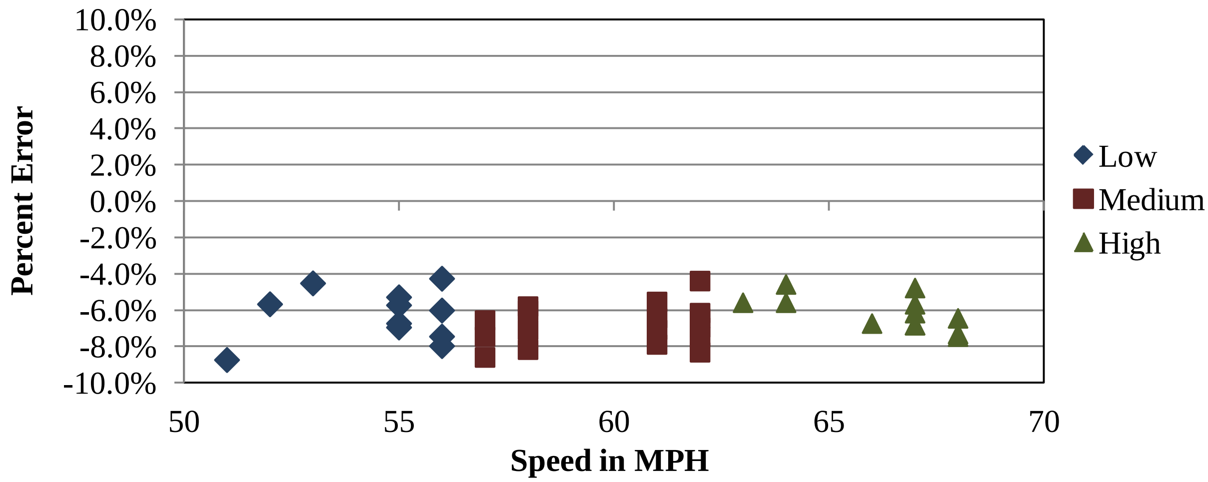


Figure 5-1 – Pre-Validation GVW Error by Speed – 21-Nov-11

5.1.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-2, the equipment underestimates steering axle weights with similar bias at all speeds. The range in error appears to decrease as speed increases.

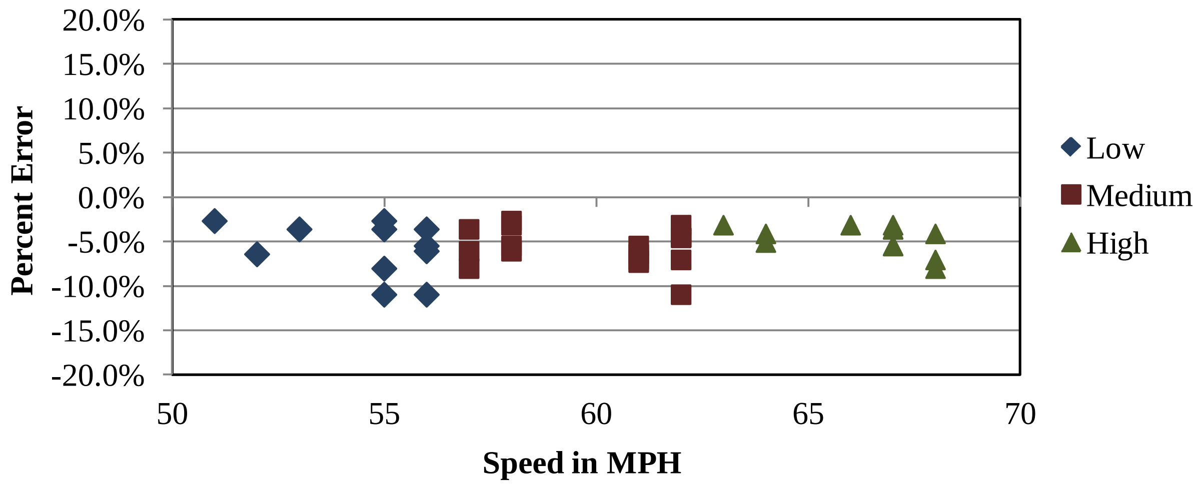


Figure 5-2 – Pre-Validation Steering Axle Weight Errors by Speed – 21-Nov-11

5.1.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 5-3, the equipment underestimates tandem axle weights at all speeds. The range in error appears to decrease as speed increases.

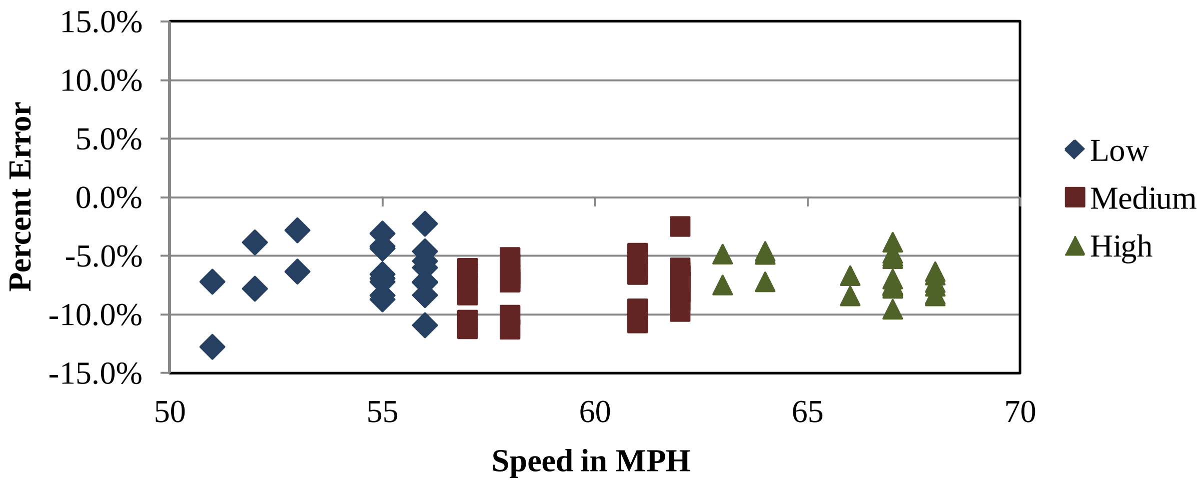


Figure 5-3 – Pre-Validation Tandem Axle Weight Errors by Speed – 21-Nov-11

5.1.1.4 GVW Errors by Speed and Truck Type

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

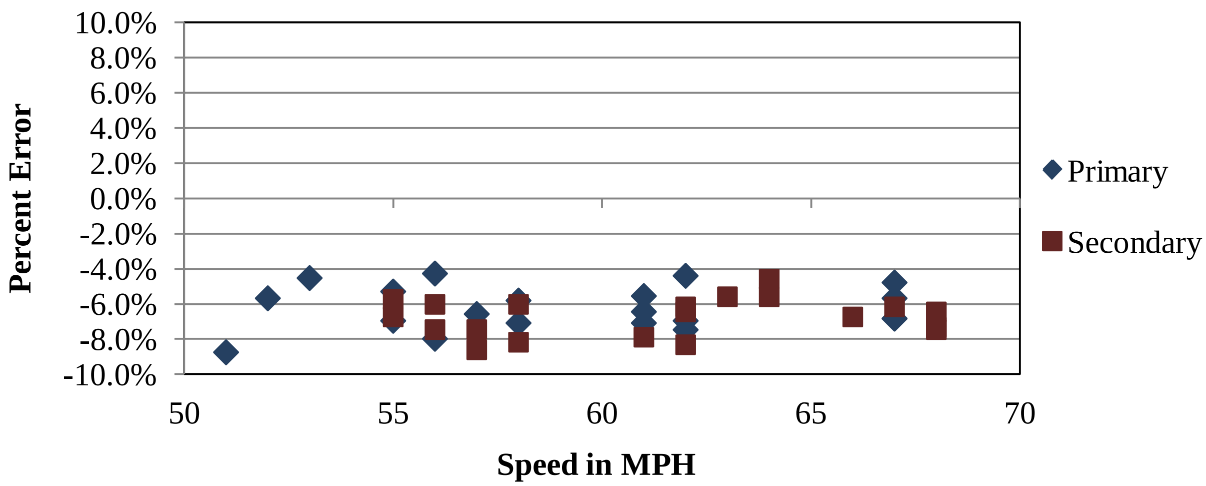


Figure 5-4 – Pre-Validation GVW Errors by Truck and Speed – 21-Nov-11

5.1.1.5 Axle Length Errors by Speed

For this site, the error in axle length measurement was consistent at all speeds. The range in axle length measurement error ranged from 0.0 feet to 0.2 feet. Distribution of errors is shown graphically in Figure 5-5.

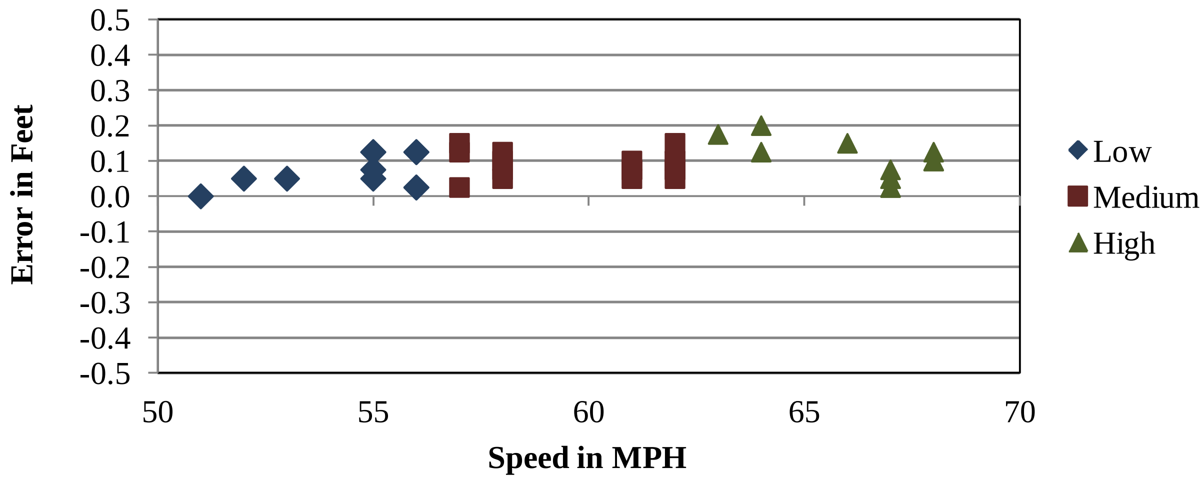


Figure 5-5 – Pre-Validation Axle Length Errors by Speed – 21-Nov-11

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 3.0 to 4.4 feet. Distribution of errors is shown graphically in Figure 5-6.

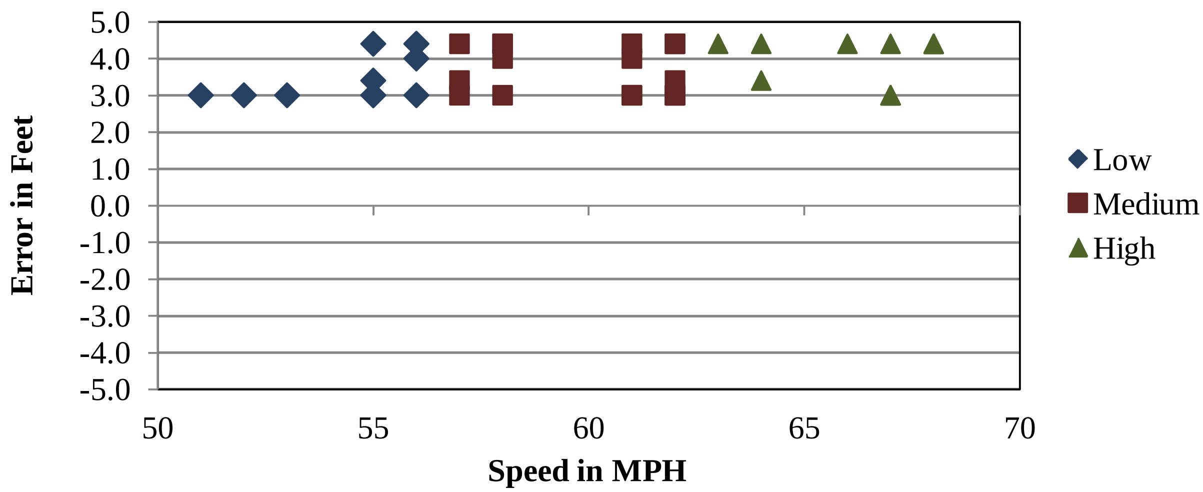


Figure 5-6 – Pre-Validation Overall Length Error by Speed – 21-Nov-11

5.1.2 Statistical Temperature Analysis

Statistical analysis was performed for the test truck run data to investigate whether a relationship exists between pavement temperature and WIM equipment weight and distance measurement accuracy. The range of pavement temperatures varied 10.4 degrees, from 80.8 to 91.2 degrees Fahrenheit. The pre-validation test runs are being reported under one temperature group, as shown in Table 5-4.

Table 5-4 – Pre-Validation Results by Temperature – 21-Nov-11

Parameter	95% Confidence Limit of Error	Medium
		80.8 to 91.2 degF
Steering Axles	±20 percent	-5.4 ± 4.6%
Tandem Axles	±15 percent	-6.9 ± 4.1%
GVW	±10 percent	-6.5 ± 2.3%
Vehicle Length	±3.0 percent (1.9 ft)	3.7 ± 1.3 ft
Vehicle Speed	± 1.0 mph	1.2 ± 2.6 mph
Axle Length	± 0.5 ft [150mm]	0.1 ± 0.1 ft

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

5.1.2.1 GVW Errors by Temperature

From Figure 5-7, it can be seen that the equipment underestimates GVW across the range of temperatures observed in the field.

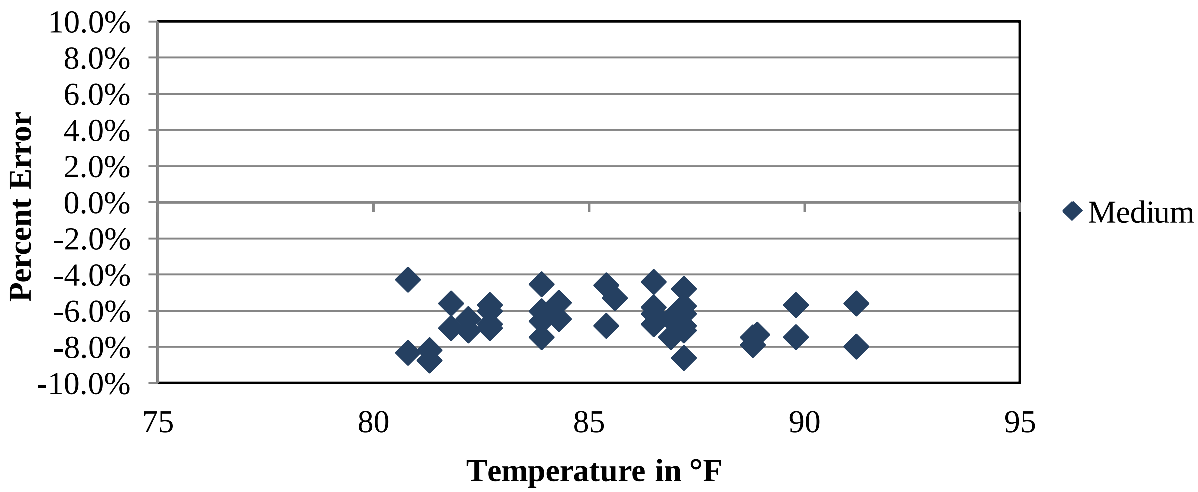


Figure 5-7 – Pre-Validation GVW Errors by Temperature – 21-Nov-11

5.1.2.2 Steering Axle Weight Errors by Temperature

Figure 5-8 illustrates that for steering axles, the WIM equipment underestimated weights at all temperatures.

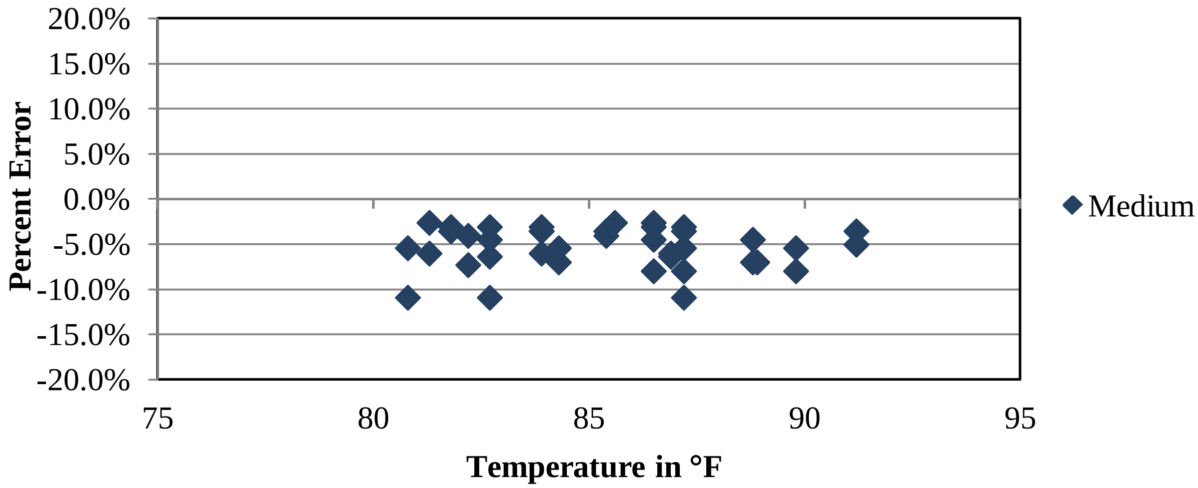


Figure 5-8 – Pre-Validation Steering Axle Weight Errors by Temperature – 21-Nov-11

5.1.2.3 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-9, the WIM equipment underestimated tandem axle weights across the range of temperatures observed in the field.

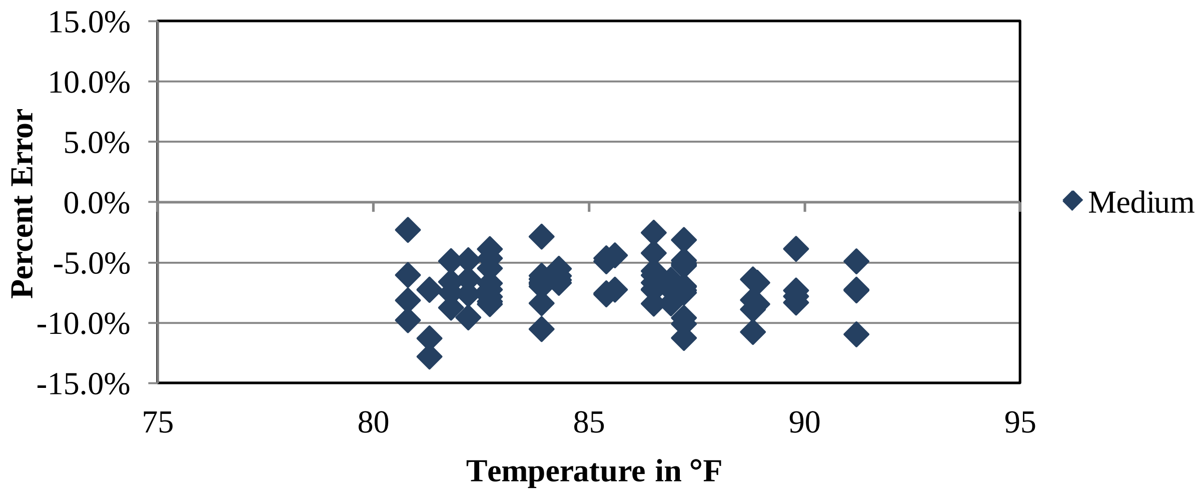


Figure 5-9 – Pre-Validation Tandem Axle Weight Errors by Temperature – 21-Nov-11

5.1.2.4 GVW Errors by Temperature and Truck Type

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

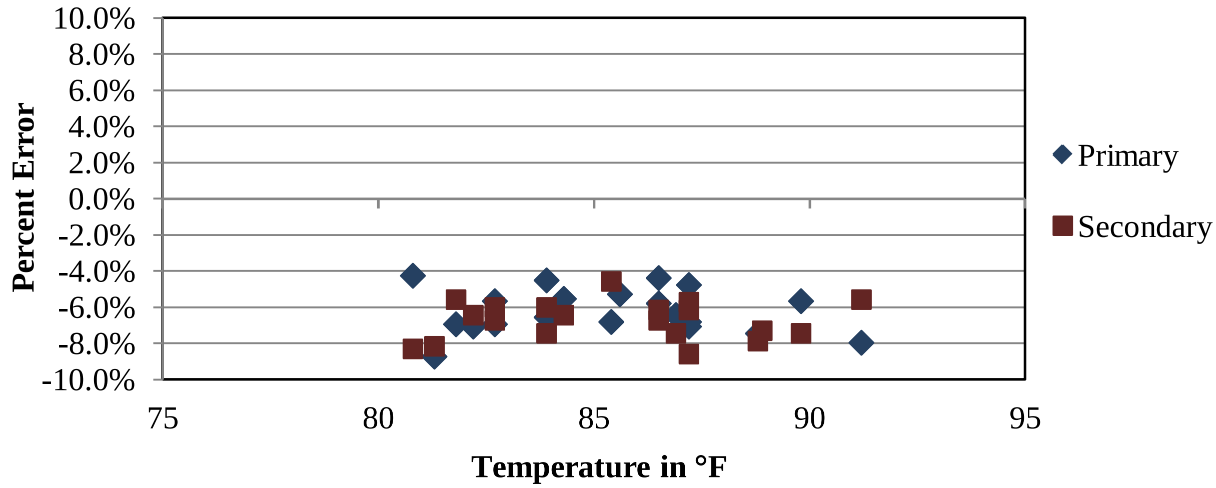


Figure 5-10 – Pre-Validation GVW Error by Truck and Temperature – 21-Nov-11

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 three-hour sample of trucks was collected rather than the preferred 100 truck sample due to low truck volume. A manual sample of 81 vehicles including 59 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 misclassified percentage represents the percentage of the misclassified vehicles in the manual sample. The misclassifications by pair are provided in Table 5-5. As shown in the table, a total of 17 vehicles, including 0 heavy trucks (6 – 13) were misclassified by the equipment. Based on the vehicles observed during the pre-validation study, the misclassification percentage is 0.0% for heavy trucks (6 – 13), which is within the 2.0% acceptability criteria for LTPP SPS WIM sites.

As shown in the table, three class 3 vehicles were misclassified as a Class 5 vehicles, thirteen Class 5 vehicles were identified as Class 3 vehicles, and one Class 5 vehicle was misclassified as a Class 8 vehicle by the equipment. The cause of the misclassifications was not investigated in the field.

As shown in the table, a total of 17 vehicles, including 0 heavy trucks (6 – 13) were misclassified by the equipment. Based on the vehicles observed during the pre-validation study, the misclassification percentage is 0.0% for heavy trucks (6 – 13), which is within the 2.0% acceptability criteria for LTPP SPS WIM sites. The overall misclassification rate for all vehicles (3 – 15) is 21.0%.

Table 5-5 – Pre-Validation Misclassifications by Pair – 21-Nov-11

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

The combined results produced an overcount of ten Class 3 vehicles and one Class 8 vehicles and an undercount of eleven Class 5 vehicles, as shown in Table 5-6. The table illustrates the breakdown of vehicles observed and identified by the WIM equipment for the manual classification study.

Table 5-6 – Pre-Validation Classification Study Results – 21-Nov-11

Class	3	4	5	6	7	8	9	10	11	12	13
Observed Count	22	0	25	4	0	0	27	3	0	0	0
WIM Count	32	0	14	4	0	1	27	3	0	0	0
Observed Percent	27.2	0.0	30.9	4.9	0.0	0.0	33.3	3.7	0.0	0.0	0.0
WIM Percent	39.5	0.0	17.3	4.9	0.0	1.2	33.3	3.7	0.0	0.0	0.0
Misclassified Count	3	0	14	0	0	0	0	0	0	0	0
Misclassified Percent	13.6	0.0	56.0	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 5-7.

Table 5-7 – Pre-Validation Unclassified Trucks by Pair – 21-Nov-11

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

Based on the manually collected sample of 59 trucks, 0.0% of the vehicles at this site were reported as unclassified during the study. This is within the established criteria of 2.0% for LTTP SPS WIM sites.

For speed, the mean error for WIM equipment speed measurement was 0.9 mph; the range of errors was 1.2 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-Nov-11

Speed Point	MPH	Left		Right	
		1	3	2	4
80	50	3322	3322	3644	3644
88	55	3392	3392	3720	3720
96	60	3366	3366	3693	3693
104	65	3397	3397	3727	3727
112	70	3397	3397	3727	3727
Axle Distance (cm)		308			
Dynamic Comp (%)		100			
Loop Width (cm)		250			

5.2.1 Calibration Iteration 1

5.2.1.1 Equipment Adjustments

For GVW, the pre-validation test truck runs produced an overall error of -6.5% and errors of -6.3%, -6.8%, and -6.2% at the 55, 60 and 65 mph speed points respectively. To compensate for these errors, the changes shown in Table 5-9 were made to the compensation factors. The errors for the 55 mph and 65 mph speed points were extrapolated to derive new compensation factors for the 50 mph and 70 mph speed points.

Table 5-9 – Calibration Factor Adjustments - 22-Nov-11

Speed Points	Old Factors				New Factors			
	Left		Right		Left		Right	
	1	3	2	4	1	3	2	4
80	3322	3322	3644	3644	3602	3602	3951	3951
88	3392	3392	3720	3720	3649	3649	4001	4001
96	3366	3366	3693	3693	3630	3630	3982	3982
104	3397	3397	3727	3727	3631	3631	3983	3983
112	3397	3397	3727	3727	3678	3678	4035	4035
Axle Distance (cm)	308				307			
Dynamic Comp (%)	100				99			
Loop Width (cm)	250				362			

5.2.1.2 Calibration 1 Results

The results of the 17 first 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 first calibration iteration.

Table 5-10 – Calibration 1 Results – 22-Nov-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-1.4 ± 6.8%	Pass
Tandem Axles	±15 percent	-1.0 ± 4.5%	Pass
GVW	±10 percent	-0.9 ± 2.2%	Pass
Vehicle Length	±3.0 percent (1.9 ft)	-0.2 ± 1.5 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.1 ft	Pass

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

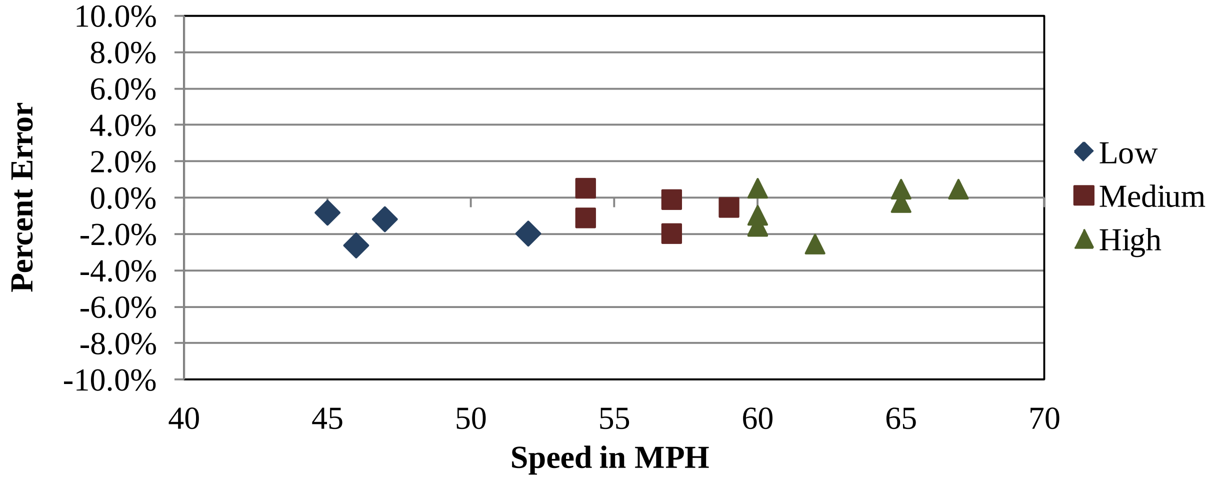


Figure 5-11 – Calibration 1 GVW Error by Speed – 22-Nov-11

Based on the results of the first calibration, where weight estimate bias decreased to -0.9 percent, a second calibration was not considered to be necessary. The 17 calibration runs were combined with 23 additional post-validation runs to complete the WIM system validation.

5.3 Post-Validation

The 42 post-validation test truck runs were conducted on November 22, 2011, beginning at approximately 7:58 AM and continuing until 12:59 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with ore, and equipped with air suspension on truck and trailer tandems and with standard tandem spacings on both the tractor and trailer.
- A Class 9, 5-axle truck, loaded with palletized bags of plastic beads, and equipped with air suspension on the tractor, steel spring 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	76.5	10.4	17.6	17.6	15.4	15.4	19.9	4.3	29.7	4.1	58.0	61.6
2	69.5	10.1	17.2	17.2	12.5	12.5	18.0	4.5	30.5	4.1	57.1	67.6

Test truck speeds varied by 23 mph, from 45 to 68 mph. The measured post-validation pavement temperatures varied 8.9 degrees Fahrenheit, from 69.6 to 78.5. The rainy weather conditions prevented attaining the desired minimum 30 degree temperature range. Table 5-12 is a summary of post validation results.

Table 5-12 – Post-Validation Overall Results – 22-Nov-11

Parameter	**95% Confidence Limit of Error**	**Site Values**	**Pass/Fail**
Steering Axles	±20 percent	-0.3 ± 7.2%	Pass
Tandem Axles	±15 percent	-1.1 ± 4.8%	Pass
GVW	±10 percent	-0.9 ± 2.9%	Pass
Vehicle Length	±3.0 percent (1.9 ft)	-0.2 ± 1.4 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.1 ft	Pass

Truck speed was manually collected for each test run using a radar gun and compared with the speed reported by the WIM equipment. For this site, the average error in speed measurement for all speeds was 0.5 ± 2.1 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, 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 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 – 22-Nov-11

Parameter	95% Confidence Limit of Error	Low	Medium	High
		45.0 to 57.0 mph	57.1 to 62.0 mph	62.1 to 68.0 mph
Steering Axles	±20 percent	0.5 ± 6.3%	-1.0 ± 7.5%	-0.5 ± 9.0%
Tandem Axles	±15 percent	-1.6 ± 4.0%	-1.4 ± 4.2%	-0.4 ± 6.0%
GVW	±10 percent	-1.2 ± 2.0%	-1.2 ± 2.2%	-0.4 ± 4.0%
Vehicle Length	±3.0 percent (1.9 ft)	-0.2 ± 1.4 ft	-0.2 ± 1.7 ft	-0.3 ± 1.5 ft
Vehicle Speed	± 1.0 mph	0.6 ± 2.6 mph	0.3 ± 1.7 mph	0.5 ± 2.3 mph
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.2 ft	0.0 ± 0.1 ft	0.0 ± 0.1 ft

From the table, it can be seen that the WIM equipment estimates all weights with similar accuracy at all speeds. The range of errors increase as speed increases, indicating a possible effect of speed on error variance at this site.

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

5.3.1.1 GVW Errors by Speed

As shown in Figure 5-12, the equipment estimated GVW with similar accuracy at all speeds. The range in error appears to increase as speed increases.

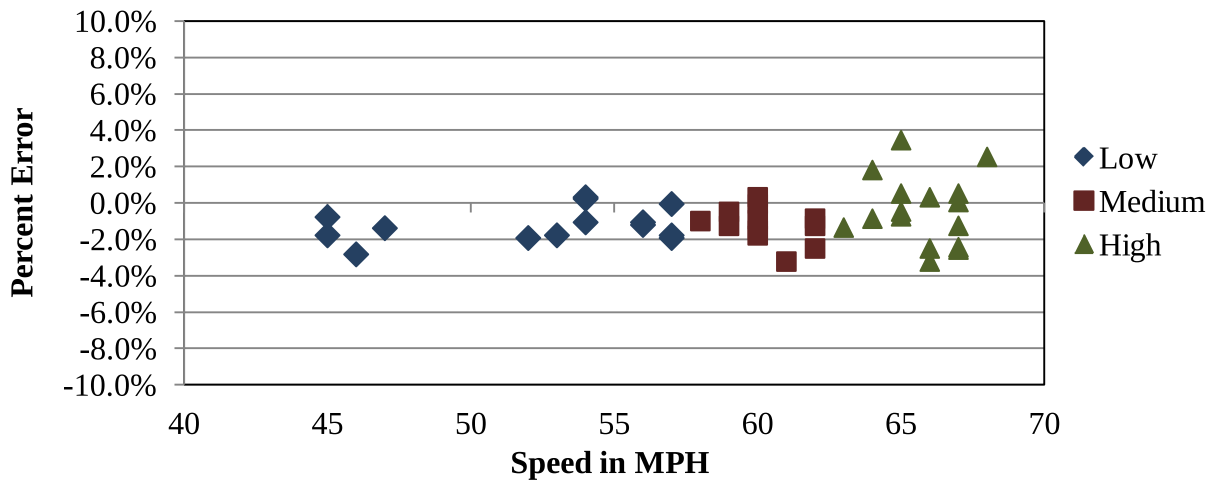


Figure 5-12 – Post-Validation GVW Errors by Speed – 22-Nov-11

5.3.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-13, the equipment estimated steering axle weights with similar accuracy at all speeds. The range in error appears to increase as speed increases, indicating a possible correlation between speed and error variance at this site.

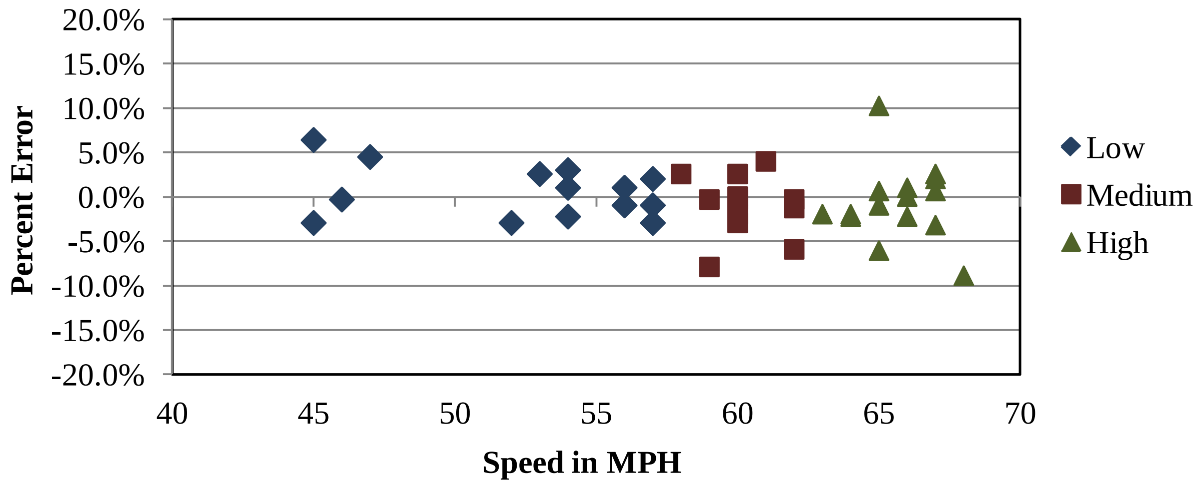


Figure 5-13 – Post-Validation Steering Axle Weight Errors by Speed – 22-Nov-11

5.3.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 5-14, the equipment estimated tandem axle weights with similar accuracy at all speeds. The range in error appears to increase as speed increases.

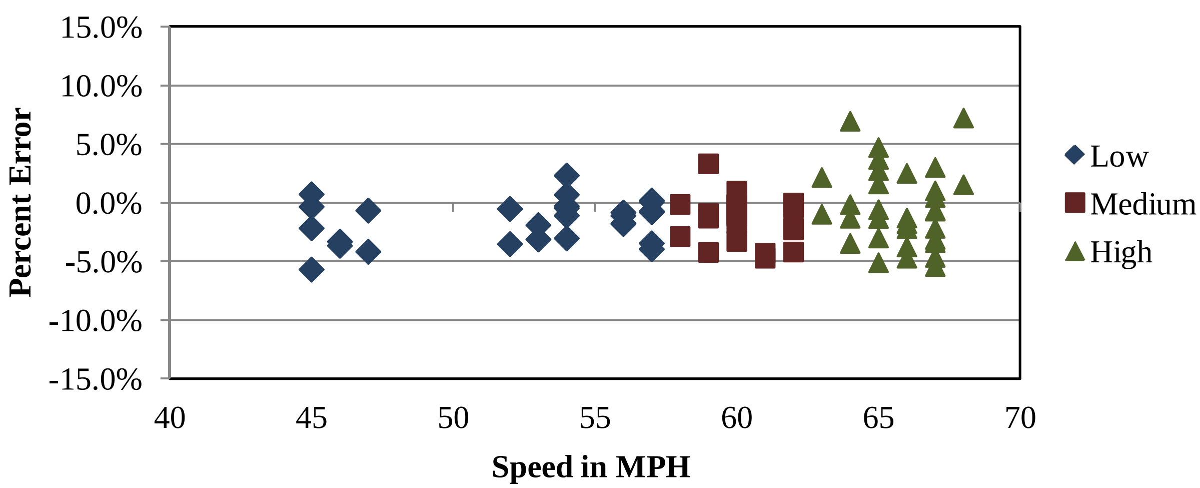


Figure 5-14 – Post-Validation Tandem Axle Weight Errors by Speed – 22-Nov-11

5.3.1.4 GVW Errors by Speed and Truck Type

It can be seen in Figure 5-15 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.

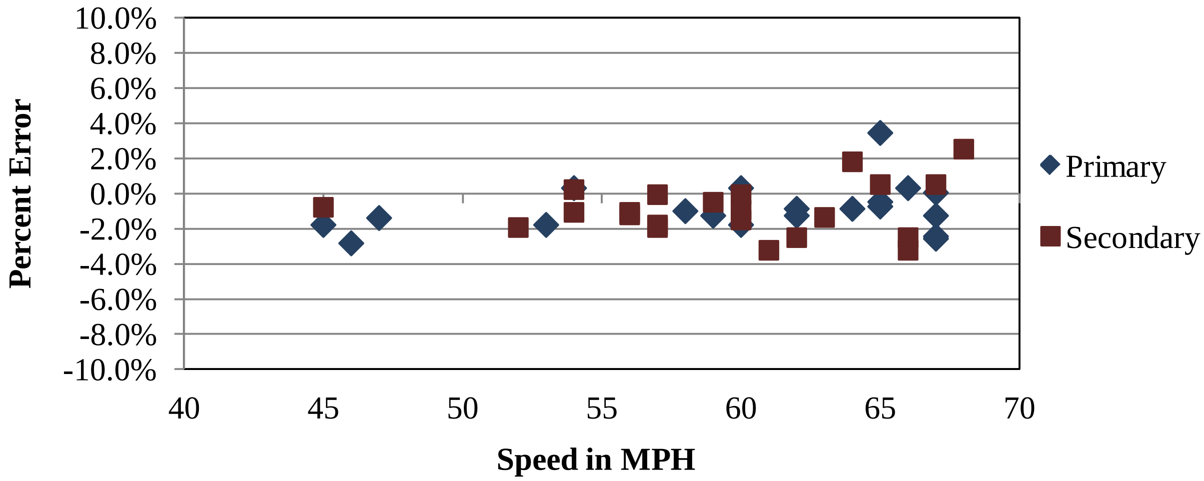


Figure 5-15 – Post-Validation GVW Error by Truck and Speed – 22-Nov-11

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 0.2 feet. Distribution of errors is shown graphically in Figure 5-16.

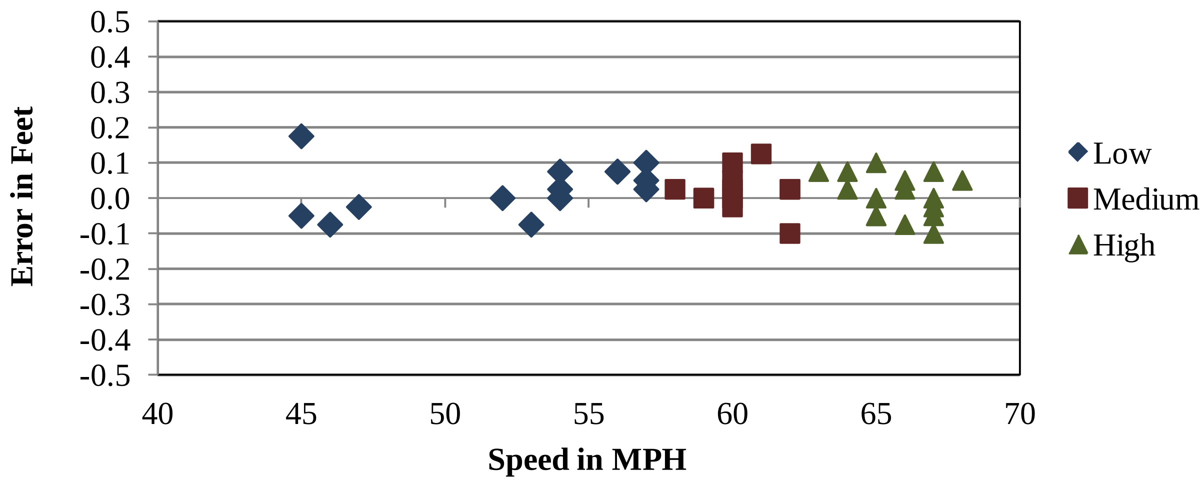


Figure 5-16 – Post-Validation Axle Length Error by Speed – 22-Nov-11

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 -1.6 to 0.4 feet. Distribution of errors is shown graphically in Figure 5-17.

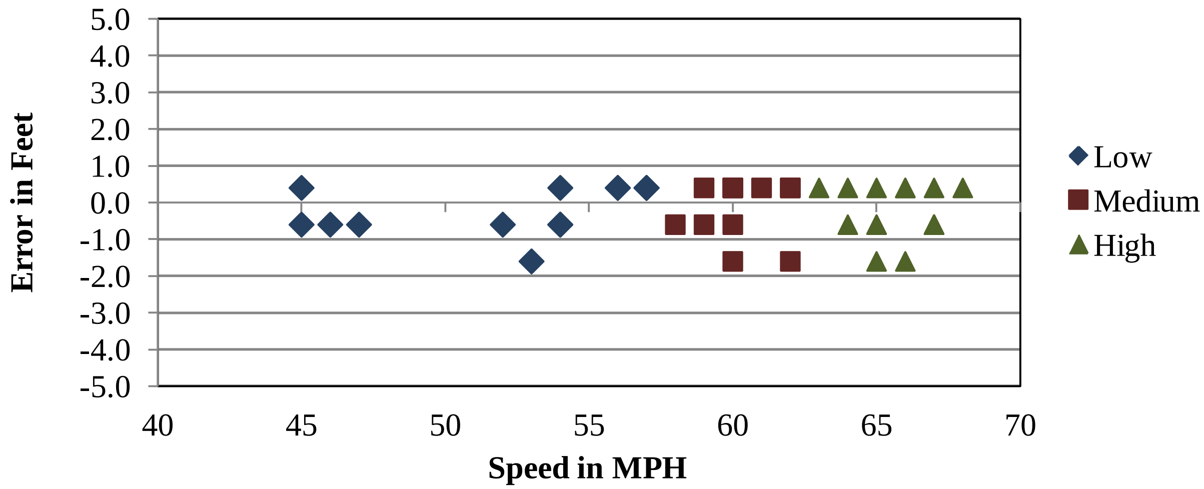


Figure 5-17 – Post-Validation Overall Length Error by Speed – 22-Nov-11

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 8.9 degrees, from 69.6 to 78.5 degrees Fahrenheit. The post-validation test runs are reported under one temperature group, as shown in Table 5-14 below.

Table 5-14 – Post-Validation Results by Temperature – 22-Nov-11

Parameter	95% Confidence Limit of Error	Medium
		69.6 to 78.5 degF
Steering Axles	±20 percent	-0.3 ± 7.2%
Tandem Axles	±15 percent	-1.1 ± 4.8%
GVW	±10 percent	-0.9 ± 2.9%
Vehicle Length	±3.0 percent (1.9 ft)	-0.2 ± 1.4 ft
Vehicle Speed	± 1.0 mph	0.5 ± 2.1 mph
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.1 ft

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

5.3.2.1 GVW Errors by Temperature

From Figure 5-18, 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 weight estimates at this site.

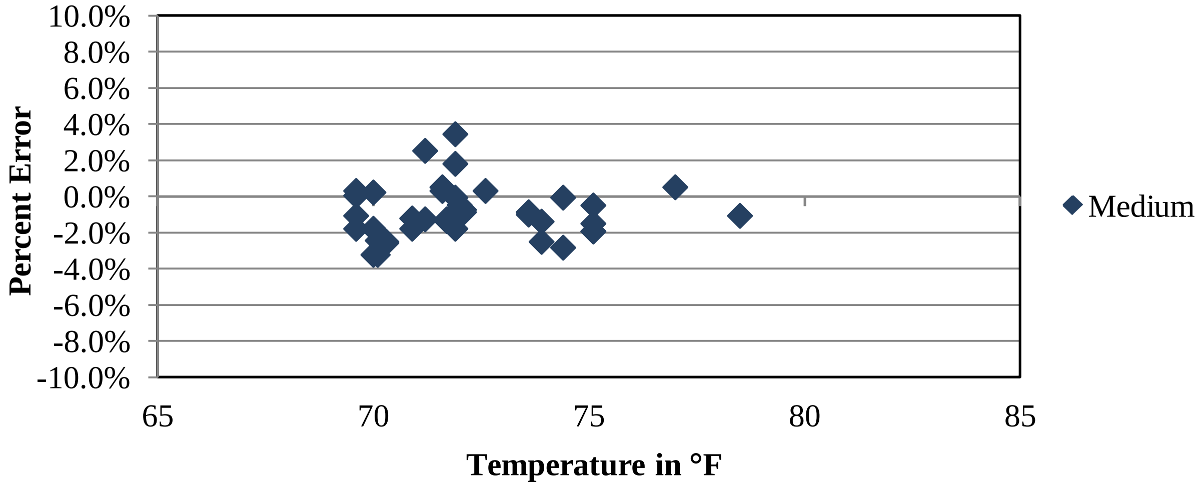


Figure 5-18 – Post-Validation GVW Errors by Temperature – 22-Nov-11

5.3.2.2 Steering Axle Weight Errors by Temperature

Figure 5-19 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.

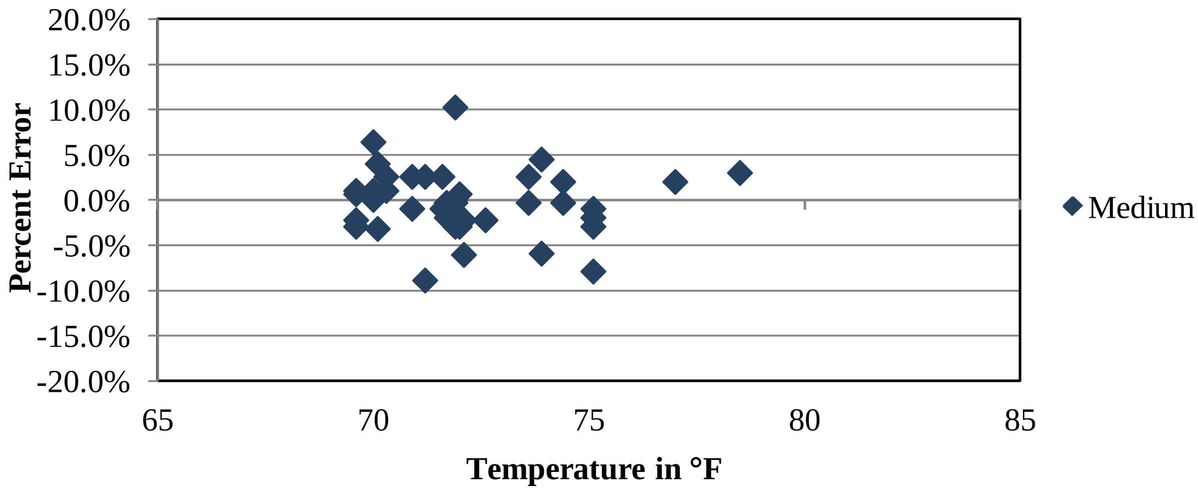


Figure 5-19 – Post-Validation Steering Axle Weight Errors by Temperature – 22-Nov-11

5.3.2.3 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-20, the WIM equipment appears to estimate tandem axle weights with similar accuracy across the range of temperatures observed in the field. There does not appear to be a correlation between temperature and tandem axle weight estimates at this site.

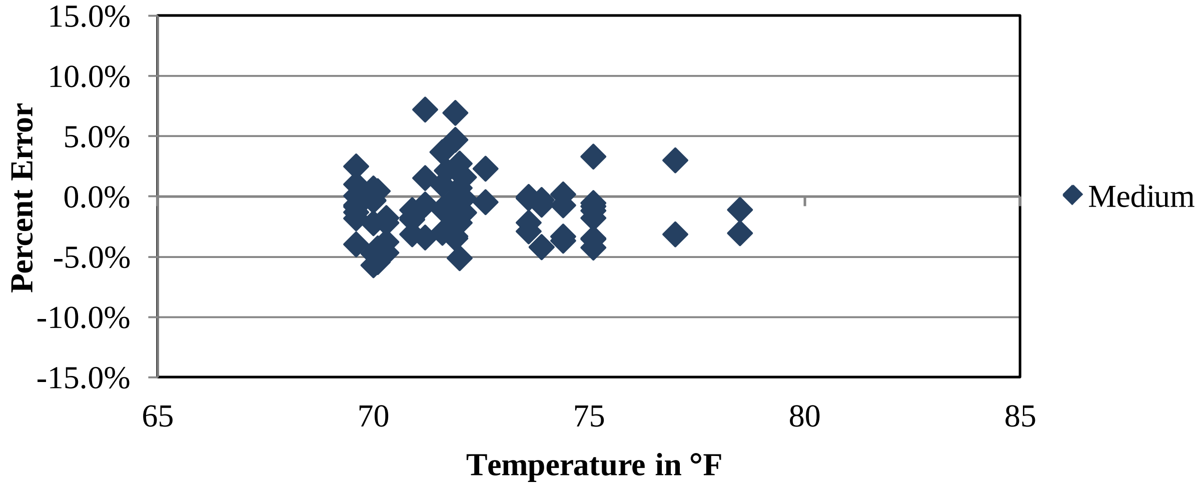


Figure 5-20 – Post-Validation Tandem Axle Weight Errors by Temperature – 22-Nov-11

5.3.2.4 GVW Errors by Temperature and Truck Type

As shown in Figure 5-21, 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 consistent over the range of temperatures.

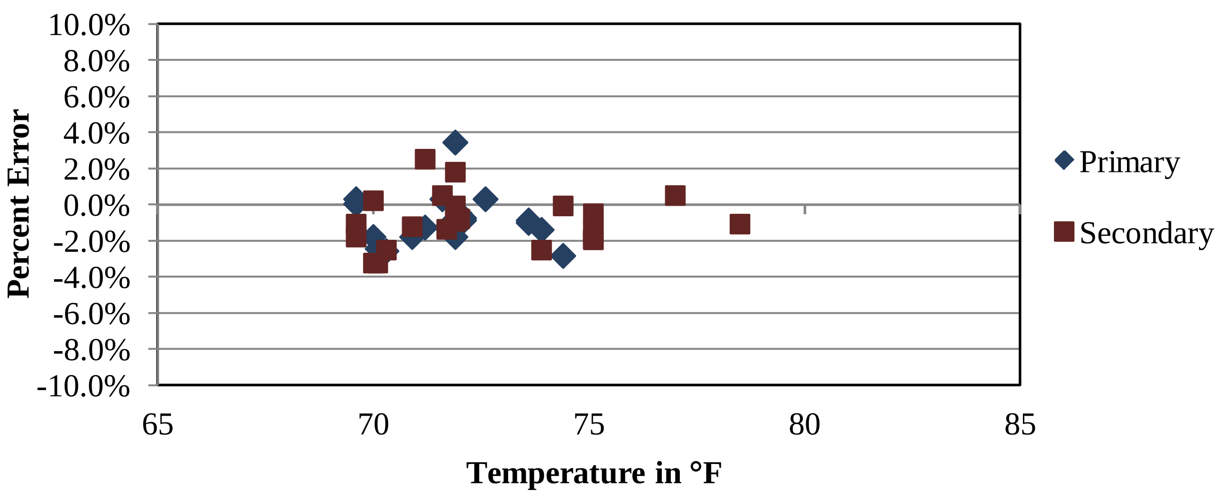


Figure 5-21 – Post-Validation GVW Error by Truck and Temperature – 22-Nov-11

5.3.3 GVW and Steering Axle Trends

Figure 5-22 is provided to illustrate the predicted GVW error with respect to the post-validation errors by speed.

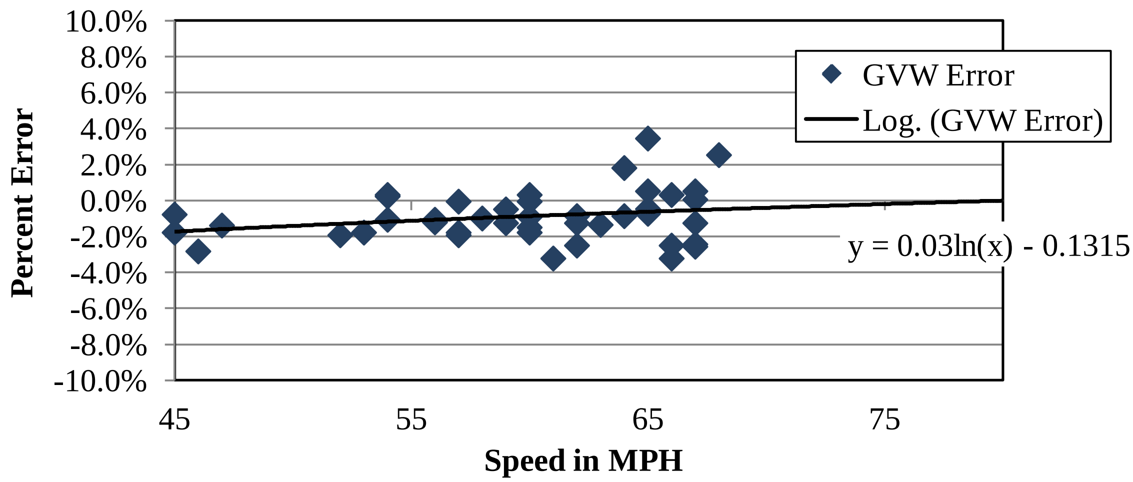


Figure 5-22 – GVW Error Trend by Speed

Figure 5-23 is provided to illustrate the predicted Steering Axle error with respect to the post-validation errors by speed.

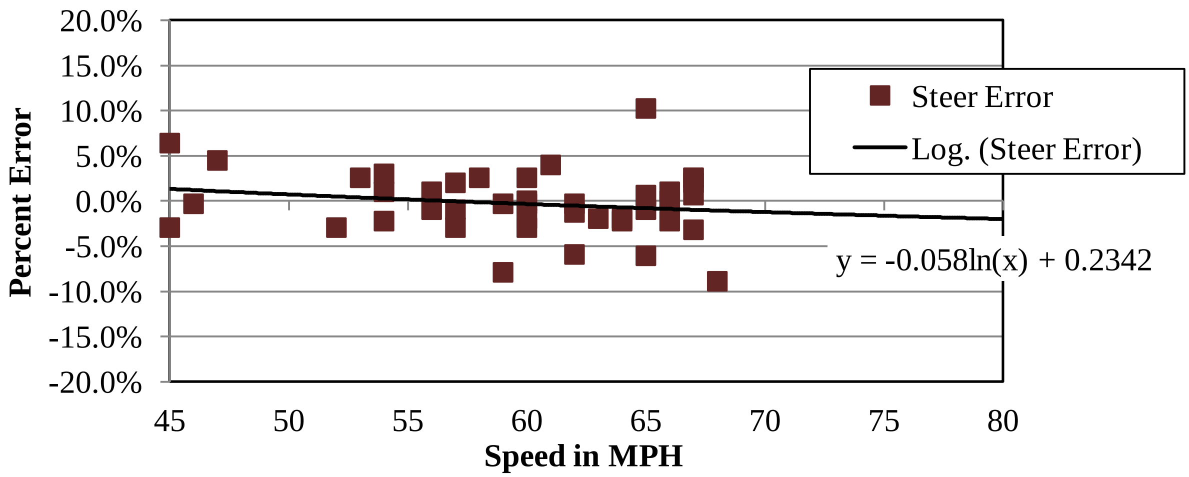


Figure 5-23 – Steering Axle Trend by Speed

5.3.4 Multivariable Analysis

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

Multivariable analysis provides additional insight on how factors like speed, temperature, and truck type may affect weight measurement errors for a specific WIM site. It is expected that multivariable analysis done systematically for many sites may reveal overall trends.

5.3.4.1 Data

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

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

- Truck type. Primary truck and secondary truck.
- Truck test speed. Truck test speed ranged from 45 to 68 mph.
- Pavement temperature. Pavement temperature ranged from 69.6 to 78.5 degrees Fahrenheit.
- Interaction between the factors such as the interaction between speed and pavement temperature.

5.3.4.2 Results

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

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

Parameter	Regression coefficients	Standard error	Value of t-distribution	Probability value
Intercept	-9.8815	9.1034	-1.0855	0.2849
Speed	0.0594	0.0368	1.6160	0.1148
Temp	0.0760	0.1162	0.6536	0.5175
Truck	-0.0750	0.4770	-0.1573	0.8759

Probability values given in Table 5.15 are all higher than 0.1. This means that there is more than 10 percent chance that the values of regression coefficients in Table 5.15 can occur by chance alone. For speed, the chance was lowest at about 11 percent.

The relationship between speed and measurement errors is shown in Figure 5-24. The figure includes trend line for the predicted percent error. Besides the visual assessment of the relationship, Figure 5-24 provides quantification and statistical assessment of the relationship.

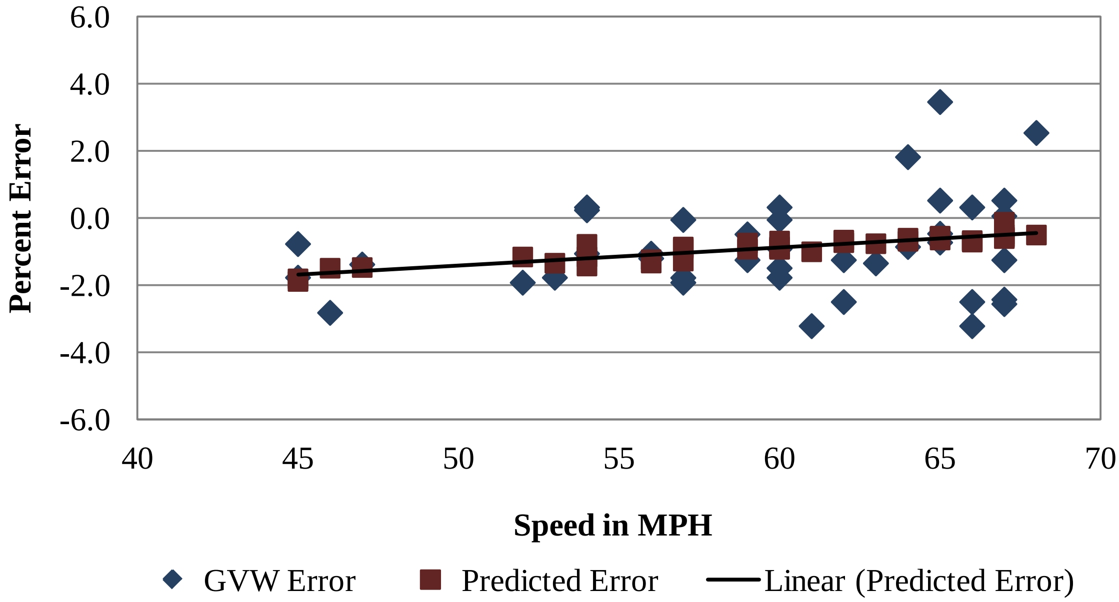


Figure 5-24 – Influence of Speed on the Measurement Error of GVW

The quantification is provided by the value of the regression coefficient, in this case 0.0594 (in Table 5-15). This means, for example, that for a 20 mph increase in speed, the % error is increased by about 1.2 % (0.0594 x 20). The statistical assessment of the relationship is provided by the probability value of the regression coefficient.

5.3.4.3 Summary Results

Table 5-16 lists regression coefficients and their probability values for all combinations of factors and % errors evaluated. Entries in the table are provided only if the probability value was smaller than 0.20. The dash in Table 5-16 indicates that the relationship was not statistically significant (the probability that the relationship can occur by chance alone was greater than 20 percent).

Table 5-16 – Summary of Regression Analysis

	Factor					
	Speed		Temperature		Truck type	
Weight, % error	Regression coefficient	Probability value	Regression coefficient	Probability value	Regression coefficient	Probability value
GVW	0.0594	0.1148	-	-	-	-
Steering axle	-	-	-	-	-2.0862	0.0801
Tandem axle tractor	0.2145	0.0029	-	-	-	-
Tandem axle trailer	-	-	-	-	-	-

5.3.4.4 Conclusions

1. Speed had statistically significant effect on the measurement errors of tandem axles on tractors, and may have an effect on the measurement errors of GVW.

2. Temperature had no statistically significant effect on measurement errors.

3. Truck type had statistically significant effect on the measurement errors of steering axle weights only. The regression coefficient for truck type in Table 5-16, represent the difference between the mean errors for the Primary and Secondary trucks. (Truck type is an indicator variable with values of 0 or 1.) Thus, the mean error for steering axle weights for the Secondary truck was about 2.09 % smaller than the corresponding error for the Primary truck.

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

5.3.5 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 pre-validation classification study at this site, a three-hour sample of trucks was collected rather than the preferred 100 truck sample due to low truck volume. A manual sample of 85 vehicles including 80 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 misclassified percentage represents the percentage of the misclassified vehicles in the manual sample. The misclassifications by pair are provided in Table 5-17. As shown in the table, a total of 10 vehicles, including 0 heavy trucks (6 – 13) were misclassified by the equipment. Based on the vehicles observed during the pre-validation study, the misclassification percentage is 0.0% for heavy trucks (6 – 13), which is within the 2.0% acceptability criteria for LTPP SPS WIM sites.

As shown in the table, one class 3 vehicle was misclassified as a Class 5 vehicles, and nine Class 5 vehicles were identified as Class 3 vehicles. The cause of the misclassifications was not investigated in the field. Further analysis of misclassifications may be performed using the collected video, if required.

Table 5-17 – Post-Validation Misclassifications by Pair – 22-Nov-11

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

The combined results produced an overcount of eight Class 3 vehicles and undercount of eight Class 5 vehicles, as shown in Table 5-18. The table illustrates the breakdown of vehicles observed and identified by the WIM equipment for the manual classification study.

Table 5-18 – Post-Validation Classification Study Results – 22-Nov-11

Class	3	4	5	6	7	8	9	10	11	12	13
Observed Count	5	0	34	4	0	3	39	0	0	0	0
WIM Count	13	0	26	4	0	3	39	0	0	0	0
Observed Percent	5.9	0.0	40.0	4.7	0.0	3.5	45.9	0.0	0.0	0.0	0.0
WIM Percent	15.3	0.0	30.6	4.7	0.0	3.5	45.9	0.0	0.0	0.0	0.0
Misclassified Count	1	0	9	0	0	0	0	0	0	0	0
Misclassified Percent	20.0	0.0	26.5	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 5-19.

Table 5-19 – Post-Validation Unclassified Trucks by Pair – 22-Nov-11

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

Based on the manually collected sample of the 80 trucks, 0.0% of the vehicles at this site were reported as unclassified during the study. This is within the established criteria of 2.0% for LTTP SPS WIM sites.

For speed, the mean error for WIM equipment speed measurement was 0.9 mph; the range of errors was 1.2 mph.

6 Previous WIM Site Validation Information

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

6.1 Sheet 16s

This site has validation information from five previous visits as well as the current one as summarized in the tables below and provided on the Traffic Sheet 16. Table 6-1 data was extracted from the most recent previous validation and was updated to include the results of this validation.

Table 6-1 – Classification Validation History

Date	Misclassification Percentage by Class										Pct Unclass
	4	5	6	7	8	9	10	11	12	13	
4-Mar-08	100	29	0	N/A	40	0	N/A	N/A	N/A	N/A	0
5-Mar-08	100	12	0	N/A	0	0	N/A	N/A	N/A	0	0
27-Jul-10	N/A	37	0	N/A	0	3	50	N/A	N/A	100	0
28-Jul-10	N/A	33	0	0	0	1	50	N/A	N/A	N/A	0
21-Nov-11	0	56	0	0	0	0	0	0	0	0	0
22-Nov-11	0	27	0	0	0	0	0	0	0	0	0

Table 6-2 data was extracted from the previous validation and was updated to include the results of this validation. The table provides the mean error and standard deviation for GVW, single axles and tandems for prior pre- and post-validations as reported on the LTPP Traffic Sheet 16s.

Table 6-2 – Weight Validation History

Date	Mean Error and SD		
	GVW	Single Axles	Tandem
4-Mar-08	0.4 ± 1.2	0.9 ± 2.0	0.2 ± 2.7
5-Mar-08	0.6 ± 2.0	-0.2 ± 2.1	-0.8 ± 3.6
27-Jul-10	-5.7 ± 1.3	-5.5 ± 2.3	-6.1 ± 2.0
28-Jul-10	0.0 ± 1.8	0.4 ± 2.8	-0.4 ± 2.2
21-Nov-11	-6.5 ± 1.2	-5.4 ± 2.3	-6.9 ± 2.0
22-Nov-11	-0.9 ± 1.4	-0.3 ± 3.6	-1.1 ± 2.4

The variability of the weight errors appears to have remained reasonably consistent since the site was first validated. From this information, it appears that the system demonstrates a tendency for the equipment to move toward an underestimation of GVW, and single and tandem axle weights, over time. The table also demonstrates the effectiveness of the validations in keeping the weight estimations within LTPP SPS WIM equipment tolerances.

6.2 Comparison of Past Validation Results

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

Table 6-3 – Comparison of Post-Validation Results

Parameter	95 %Confidence Limit of Error	Site Values (Mean Error and 95% Confidence Interval)		
		5-Mar-08	28-Jul-10	22-Nov-11
Steering Axles	±20 percent	-0.2 ± 4.2	0.4 ± 5.6	-0.3 ± 7.2
Tandem Axles	±15 percent	-0.8 ± 7.4	-0.4 ± 4.4	-1.1 ± 4.8
GVW	±10 percent	0.6 ± 4.0	0.0 ± 3.6	-0.9 ± 2.9

From Table 6-3, it appears that the mean error for all weights has remained reasonably consistent since the site was installed. The 95% confidence interval for GVW and tandem axles has decreased since the equipment was installed and the 95% confidence interval for steering axle weights has increased.

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

Table 6-4 – Final Factors

Speed Points	New Factors			
	Left		Right	
	1	3	2	4
80	3602	3602	3951	3951
88	3649	3649	4001	4001
96	3630	3630	3982	3982
104	3631	3631	3983	3983
112	3678	3678	4035	4035
Axle Distance (cm)	307			
Dynamic Comp (%)	99			
Loop Width (cm)	362			

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

7 Additional Information

The following information is provided in the attached appendix:

- Site Photographs
    - Equipment
    - Test Trucks
    - Pavement Condition
- 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

Louisiana, SPS-1
SHRP ID: 220100

Validation Date: November 22, 2011

Photo 1 – Cabinet Exterior

Photo 2 – Cabinet Interior (Front)

Photo 3 – Cabinet Interior (Back)

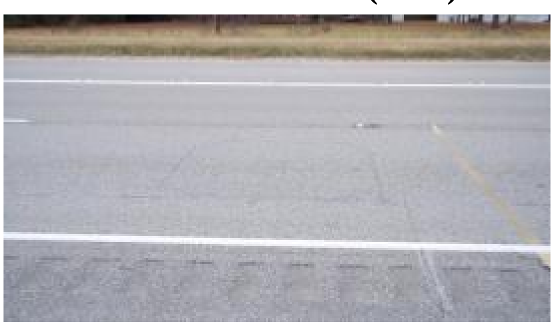


Photo 4 – Leading Loop

Photo 5 – Leading WIM Sensor

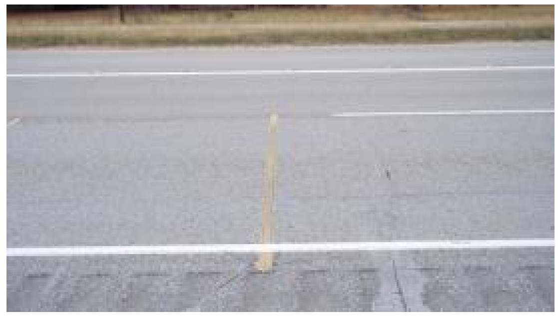


Photo 6 – Trailing WIM Sensor

Photo 7 – Trailing Loop Sensor

Photo 8 – Power Service Box

Photo 9 – Telephone Service Box

Photo 10 – Downstream

Photo 11 – Upstream

Photo 12 – Truck 1

Photo 13 – Truck 1 Tractor

Photo 14 – Truck 1 Trailer and Load

Photo 15 – Truck 1 Suspension 1

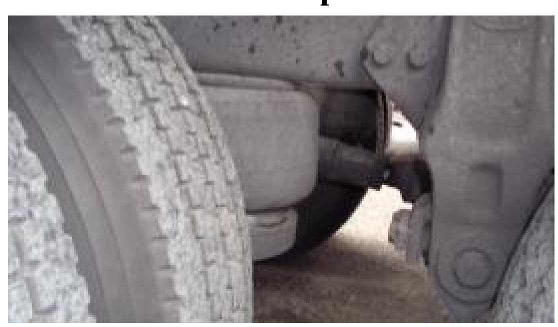


Photo 16 – Truck 1 Suspension 2

Photo 17 – Truck 1 Suspension 3

Photo 18 – Truck 1 Suspension 4

Photo 19 – Truck 1 Suspension 5

Photo 20 – Truck 2

Photo 21 – Truck 2 Tractor

Photo 22 – Truck 2 Trailer and Load

Photo 23 – Truck 2 Suspension 1

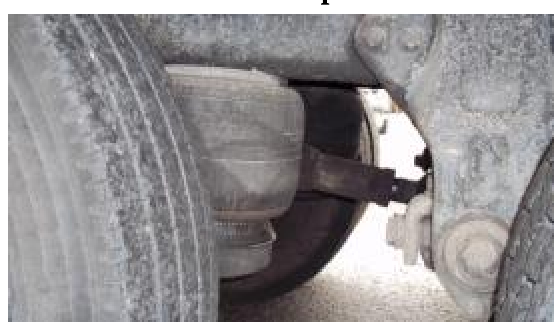


Photo 24 – Truck 2 Suspension 2

Photo 25 – Truck 2 Suspension 3

Photo 26 – Truck 2 Suspension 5

Photo 27 – Truck 2 Suspension 4

Traffic Sheet 16	STATE CODE:	22
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	220100
SITE CALIBRATION SUMMARY	DATE (mm/dd/yyyy)	11/21/2011

SITE CALIBRATION INFORMATION

1. DATE OF CALIBRATION {mm/dd/yy} 11/21/11

2. TYPE OF EQUIPMENT CALIBRATED: Both

3. REASON FOR CALIBRATION: LTPP Validation

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

a. Inductance Loops
c.
b. Quartz Piezo
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:	-6.5%	Standard Deviation:	1.2%
Dynamic and Static Single Axle:	-5.4%	Standard Deviation:	2.3%
Dynamic and Static Double Axles:	-6.9%	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	-	51.0	to	56.7	11
b.	Medium	-	56.8	to	62.4	17
c.	High	-	62.5	to	68.0	12
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 22 SPS WIM ID: 220100 DATE (mm/dd/yyyy) 11/21/2011

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3366 | 3693

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	-	-44.0
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: **Dean J. Wolf**

Contact Information: Phone: 717-975-3550

E-mail: dwolf@ara.com

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 22 SPS WIM ID: 220100 DATE (mm/dd/yyyy) 11/22/2011

SITE CALIBRATION INFORMATION

1. DATE OF CALIBRATION {mm/dd/yy} 11/22/11

2. TYPE OF EQUIPMENT CALIBRATED: Both

3. REASON FOR CALIBRATION: LTPP Validation

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

a. Inductance Loops c. ______

b. Quartz Piezo d. ______

5. EQUIPMENT MANUFACTURER: IRD iSINC

WIM SYSTEM CALIBRATION SPECIFICS

6. CALIBRATION TECHNIQUE USED: Test Trucks

Number of Trucks Compared: ______

Number of Test Trucks Used: 2

Passes Per Truck: 21

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

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

Mean Difference Between -

	Mean		Standard Deviation
Dynamic and Static GVW:	-0.9%	Standard Deviation:	1.4%
Dynamic and Static Single Axle:	-0.3%	Standard Deviation:	3.6%
Dynamic and Static Double Axles:	-1.1%	Standard Deviation:	2.4%

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

9. DEFINE SPEED RANGES IN MPH:

			Low		High	Runs
a.	Low	-		to		14
b.	Medium	-		to		12
c.	High	-		to		16
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 22 SPS WIM ID: 220100 DATE (mm/dd/yyyy) 11/22/2011

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3630 | 3982

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	-	-24.0
FHWA Class 8:	0.0	FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 0.0%

Validation Test Truck Run Set - Post

Person Leading Calibration Effort: **Dean J. Wolf**

Contact Information: Phone: 717-975-3550

E-mail: dwolf@ara.com

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 22 SPS WIM ID: 220100 DATE (mm/dd/yyyy) 11/21/2011

Count - 81 Time = 2:38:28 Trucks (4-15) - 59 Class 3s - 22

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
58	6	27300	58	6	59	9	27459	59	9
60	3	27304	60	3	52	5	27462	52	5
70	3	27310	70	3	**55**	**3**	**27483**	**55**	**5**
60	10	27311	60	10	59	9	27494	59	9
57	9	27319	55	9	63	9	27496	61	9
68	5	27323	66	5	59	9	27497	59	9
59	3	27325	57	3	**62**	**8**	**27510**	**61**	**5**
60	9	27332	58	9	58	3	27514	58	3
59	3	27339	59	3	61	5	27526	60	5
64	3	27352	62	3	**64**	**5**	**27528**	**64**	**3**
54	9	27355	52	9	**59**	**3**	**27549**	**59**	**5**
55	3	27367	54	3	57	3	27558	56	3
70	3	27371	67	3	**55**	**3**	**27569**	**55**	**5**
60	3	27372	58	3	55	3	27575	55	3
59	9	27377	58	9	**60**	**3**	**27586**	**61**	**5**
49	3	27379	50	3	62	9	27587	61	9
59	6	27389	58	6	64	9	27589	64	9
57	3	27398	55	3	57	9	27594	54	9
66	9	27400	65	9	64	9	27609	61	9
63	3	27409	61	3	57	9	27617	54	9
52	3	27420	52	3	49	5	27627	50	5
50	3	27422	48	3	54	9	27646	52	9
66	9	27426	64	9	57	9	27657	58	9
54	9	27434	52	9	55	5	27676	52	5
62	9	27445	62	9	62	10	27732	62	10

Sheet 1 - 0 to 50 Start: 14:52:57 Stop: 15:57:35

Recorded By: djw Verified By: kt

Validation Test Truck Run Set - Pre

Traffic Sheet 20 **LTPP MONITORED TRAFFIC DATA** **SPEED AND CLASSIFICATION STUDIES**	STATE CODE: 22 SPS WIM ID: 220100 DATE (mm/dd/yyyy) 11/21/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
68	**3**	**27742**	**70**	**5**	59	5	28046	57	5
58	5	27759	54	5	**60**	**3**	**28074**	**59**	**5**
60	**5**	**27766**	**58**	**3**	58	6	28076	58	6
58	**3**	**27771**	**58**	**5**	55	5	28119	55	5
59	**3**	**27779**	**58**	**5**	61	9	28237	60	9
59	9	27783	61	9	**50**	**3**	**28241**	**49**	**5**
64	10	27804	63	10					
64	9	27805	63	9					
56	5	27809	56	5					
57	3	27841	56	3					
59	**3**	**27852**	**57**	**5**					
52	**5**	**27866**	**51**	**3**					
64	5	27879	63	5					
60	9	27885	58	9					
57	3	27889	56	3					
59	5	27890	57	5					
57	9	27916	56	9					
67	9	27956	65	9					
52	**3**	**27966**	**51**	**5**					
60	**3**	**27976**	**59**	**5**					
67	9	27977	68	9					
65	9	28017	65	9					
62	6	28029	61	6					
60	3	28032	59	3					
62	**3**	**28038**	**61**	**5**					

Sheet 2 - 51 to 100 Start: 15:58:00 Stop: 17:31:25

Recorded By: djw Verified By: kt

Validation Test Truck Run Set - Pre

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 22 SPS WIM ID: 220100 DATE (mm/dd/yyyy) 11/22/2011

Count - 85 Time = 3:01:58 Trucks (4-15) - 80 Class 3s - 5

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
58	6	31290	58	6	55	5	31538	55	5
59	9	31296	59	9	56	9	31541	55	9
62	9	31299	61	9	65	9	31546	65	9
47	6	31301	45	6	56	9	31549	55	9
65	9	31325	64	9	**59**	**3**	**31560**	**59**	**5**
57	5	31335	57	5	65	5	31565	65	5
55	5	31345	54	5	62	9	31566	60	9
64	5	31347	64	5	59	9	31567	60	9
58	5	31354	57	5	65	9	31573	65	9
54	5	31367	52	5	57	9	31574	55	9
59	3	31376	58	3	**67**	**3**	**31578**	**68**	**5**
57	5	31414	56	5	68	9	31589	66	9
57	3	31438	55	3	57	8	31595	56	8
53	**3**	**31446**	**53**	**5**	48	8	31604	48	8
62	5	31459	60	5	57	9	31611	56	9
67	9	31470	67	9	**66**	**3**	**31629**	**65**	**5**
61	9	31491	60	9	64	3	31653	62	3
57	5	31494	56	5	57	9	31662	55	9
60	5	31495	59	5	55	9	31672	55	9
70	9	31499	69	9	59	9	31677	59	9
64	**5**	**31504**	**63**	**3**	58	9	31679	56	9
60	9	31506	59	9	47	5	31703	47	5
52	8	31508	52	8	60	5	31729	58	5
56	5	31527	55	5	61	5	31769	60	5
67	9	31535	66	9	62	9	31774	62	9

Sheet 1 - 0 to 50 Start: 13:30:00 Stop: 15:04:47

Recorded By: djw Verified By: kt

Validation Test Truck Run Set - Post

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 22 SPS WIM ID: 220100 DATE (mm/dd/yyyy) 11/22/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
69	9	31787	69	9	65	6	32062	65	6
54	9	31792	54	9	62	9	32087	60	9
67	9	31797	67	9	59	5	32103	59	5
56	9	31807	56	9	67	9	32115	66	9
55	5	31808	55	5	53	5	32165	51	5
54	5	31809	55	5	65	3	32171	65	3
63	9	31847	63	9	63	5	32225	62	5
63	9	31852	63	9	55	5	32226	55	5
56	5	31853	57	5	59	9	32292	59	9
56	9	31857	55	9	62	9	32319	62	9
65	9	31866	65	9					
59	5	31867	60	5					
60	9	31878	60	9					
57	9	31881	55	9					
42	5	31889	45	5					
60	9	31906	60	9					
62	**3**	**31919**	**61**	**5**					
61	**3**	**31922**	**61**	**5**					
60	**3**	**31951**	**60**	**5**					
60	9	31952	60	9					
59	9	31953	60	9					
64	5	31974	64	5					
67	**3**	**31993**	**68**	**5**					
62	**3**	**31998**	**62**	**5**					
60	6	32003	60	6					

Sheet 2 - 51 to 100 Start: 15:06:04 Stop: 16:31:58

Recorded By: djw Verified By: kt

Validation Test Truck Run Set - Post