WIM System Field Calibration and Validation Summary Report

Virginia SPS-1
SHRP ID – 510100

Validation Date: June 25, 2013
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1 Executive Summary

A WIM validation was performed on June 25 and 26, 2013 at the Virginia SPS-1 site located on route US-29, milepost 12.8, 5.3 miles north of US 360.

This site was installed on November 4, 2006. The in-road sensors are installed in the southbound, righthand driving lane. The site is equipped with bending plate WIM sensors and an IRD iSINC WIM controller. The LTPP lane is identified as lane 1 in the WIM controller. From a comparison between the report of the most recent validation of this equipment on October 18, 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 equipment is operating within the manufacturer's tolerances. The loop sensors show deterioration of the loop sealant where parts of the sealant are mising. Neither of the WIM 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 pavement transition discussed in the previous validation report has been rehabilitated. The trucks appear to track down the center of the lane. Further pavement condition discussion is provided in Section 4.

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

Table 1-1 – Validation Results – 25-Jun-13

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	0.3 ± 7.1%	Pass
Tandem Axles	±15 percent	-0.1 ± 4.1%	Pass
GVW	±10 percent	0.5 ± 3.4%	Pass
Vehicle Length	±3.0 percent (1.7 ft)	-0.1 ± 0.2 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.2 ± 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 -0.6 ± 4.1 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 0.2 feet, and the speed and axle spacing measurements are based on the distance between the axle detector sensors, it can be concluded that the distance factor is set correctly and that the speeds being reported by the WIM equipment are within acceptable ranges.

This site is providing research quality vehicle classification data for heavy trucks (Class 6 – 13). The heavy truck misclassification rate of 0.0% is within the 2.0% acceptability criterion for LTPP SPS WIM sites. The overall misclassification rate of 3.0% from the 100 vehicle sample (Class 4 – 13) was due to one Class 3 vehicle and one Class 4 vehicle being misclassified as Class 5 vehicles and one Class 5 vehicle being misclassified as a Class 8 vehicle by the equipment.

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

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

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

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 8). Axle length (AL) was measured from the center hub of the first axle to the center hub of the last axle. Axle spacings were measured from the center hub of the each axle to the center hub of the subsequent axle. Overall length (OL) was measured from the edge of the front bumper to the edge of the rear bumper. The test trucks were re-weighed at the conclusion of the validation. The average validation test truck weights and measurements are provided in Table 1-2.

Table 1-2 – Validation Test Truck Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	74.7	10.3	17.4	17.4	14.8	14.8	14.5	4.3	29.0	4.4	52.2	58.2
2	66.2	11.3	14.9	14.9	12.5	12.5	14.2	4.2	22.8	4.3	45.5	52.0

The posted speed limit at the site is 65 mph. During the testing, the speed of the test trucks ranged from to 44 to 65 mph, a variance of 21 mph.

During test truck runs, pavement temperature was collected using a hand-held infrared temperature device. The validation pavement surface temperatures varied from 85.0 to 120.2 degrees Fahrenheit, a range of 35.2 degrees Fahrenheit. The sunny weather conditions provided the desired 30 degree range in temperatures.

A review of the LTPP Standard Release Database 27 shows that there are 6 years of level "E" WIM data for this site. This site requires no additional years of data to meet the minimum of five years of research quality data.

2 WIM System Data Availability and Pre-Visit Data Analysis

To assess the quality of the current traffic data, a pre-visit analysis was conducted by comparing a two-week data sample from January 9, 2013 (Data) to the most recent Comparison Data Set (CDS) from January 19, 2011. The assessments performed prior to the site visits are used to develop expected traffic flow characteristics for the validation. The results of further investigations performed as a result of the analyses are provided in Section 6 of this report.

2.1 LTPP WIM Data Availability

A review of the LTPP Standard Release Database 27 shows that there are 6 years of level "E" WIM data for this site. Table 2-1 provides a breakdown of the available data for years 2007 to 2012.

Table 2-1 – LTPP Data Availability

Year	Total Number of Days in Year	Number of Months
2007	339	12
2008	366	12
2009	365	12
2010	365	12
2011	355	12
2012	232	8

As shown in the table, this site requires no additional years of data to meet the minimum of five years of research quality data.

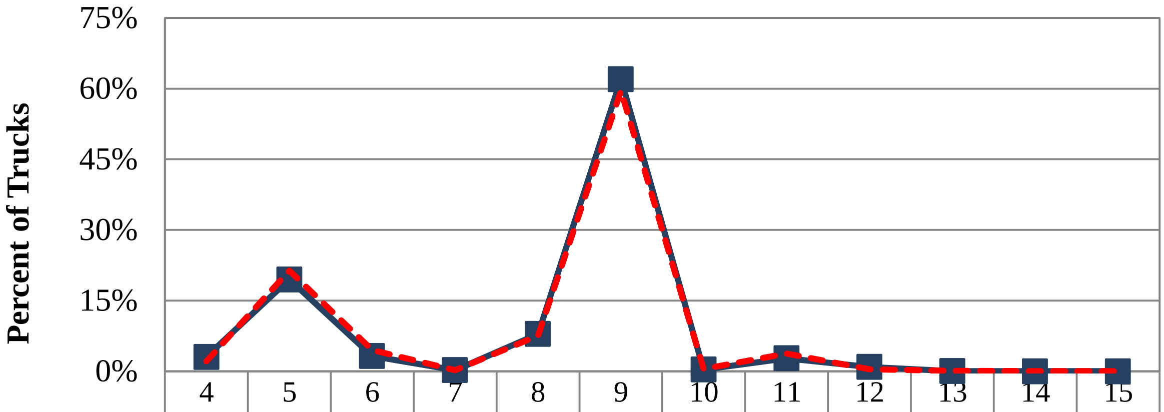
Table 2-2 provides a monthly breakdown of the available data for years 2007 through 2012.

Table 2-2 – LTPP Data Availability by Month

Year	Month												No. of Months
	1	2	3	4	5	6	7	8	9	10	11	12	
2007	28	28	31	17	21	30	31	31	30	31	30	31	12
2008	31	29	31	30	31	30	31	31	30	31	30	31	12
2009	31	28	31	30	31	30	31	31	30	31	30	31	12
2010	31	28	31	30	31	30	31	31	30	31	30	31	12
2011	31	28	31	30	31	30	22	30	30	31	30	31	12
2012	31	29	31	30	31	30	31	19					8

2.2 Classification Data Analysis

The traffic data was analyzed to determine the expected truck distributions. This analysis provides a basis for the classification distribution study that was conducted on site. Figure 2-1 provides a comparison of the truck type distributions between the sample dataset from January 9, 2013 (Data) and the most recent comparison Data Set (CDS) from January 19, 2011.



	4	5	6	7	8	9	10	11	12	13	14	15
Data	3.0%	19.5%	3.2%	0.2%	7.9%	62.0%	0.4%	2.8%	0.9%	0.0%	0.0%	0.0%
CDS	2.1%	21.4%	4.5%	0.2%	7.5%	59.6%	0.5%	3.7%	0.4%	0.1%	0.0%	0.0%

Truck Classifications

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 (62.0%) and Class 5 (19.5%) vehicles.

Table 2-3 also provides data for vehicle Classes 14 and 15. Class 14 vehicles are vehicles that are reported by the WIM equipment as having irregular measurements and cannot be classified properly, such as negative speeds from vehicles passing in the opposite direction of a two-lane road. Class 15 vehicles are unclassified vehicles. The table indicates that 0.0 percent of the vehicles at this site are unclassified.

Table 2-3 – Truck Distribution from W-Card

Vehicle Classification	CDS		Data		Change
	Date				
	1/19/2011		1/9/2013		
4	216	2.1%	309	3.0%	0.9%
5	2197	21.4%	1977	19.5%	-1.9%
6	462	4.5%	327	3.2%	-1.3%
7	24	0.2%	23	0.2%	0.0%
8	775	7.5%	802	7.9%	0.4%
9	6119	59.6%	6290	62.0%	2.5%
10	49	0.5%	38	0.4%	-0.1%
11	383	3.7%	279	2.8%	-1.0%
12	43	0.4%	92	0.9%	0.5%
13	7	0.1%	4	0.0%	0.0%
14	0	0.0%	0	0.0%	0.0%
15	0	0.0%	0	0.0%	0.0%

From the table it can be seen that the percentage of Class 9 vehicles has increased by 2.5 percent from January 2011 and January 2013. Changes in the percentage of heavier trucks may be attributed to natural and seasonal variations in truck distributions and an increase in goods movement during current economic cycle. During the same time period, the percentage of Class 5 trucks decreased by 1.9 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.

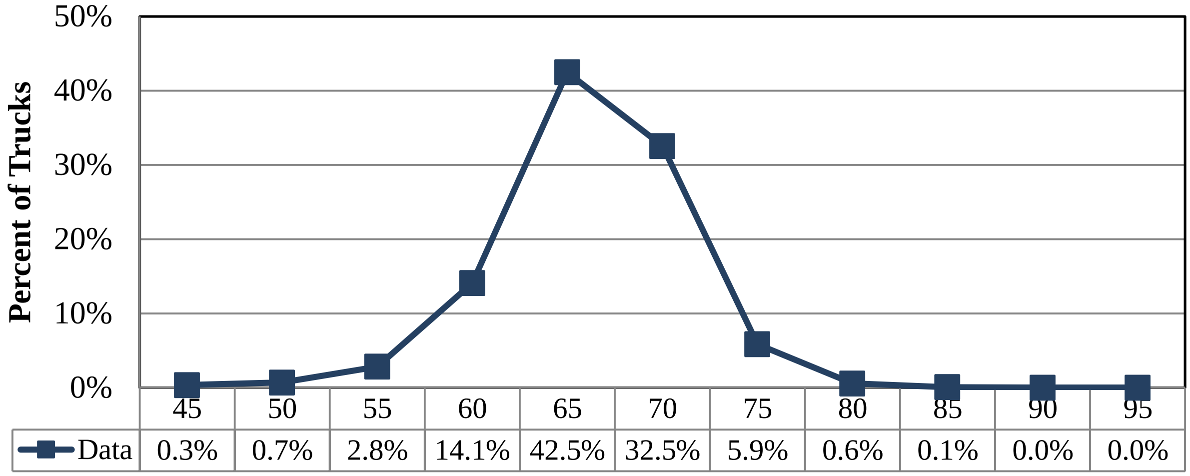


Figure 2-2 – Truck Speed Distribution – 9-Jan-13

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 68 mph. The range of truck speeds for the validation will be 45 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 January 2013 and the Comparison Data Set from January 2011.

As shown in Figure 2-3, there is a slight downward shift for the loaded peak and a slight upward shift for the unloaded peak between the January 2011 Comparison Data Set (CDS) and the January 2013 two-week sample W-card dataset (Data). The results indicate that there may have been a small change in the type of commodity being transported by trucks traveling over the WIM system, a change in pavement condition or sensor deterioration.

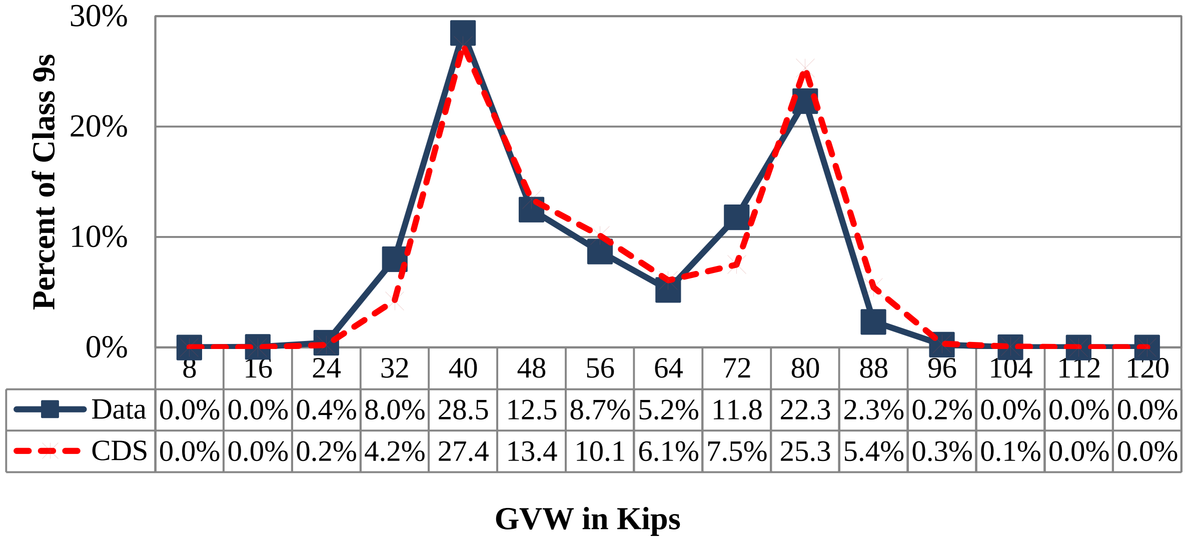


Figure 2-3 – Comparison of Class 9 GVW Distribution

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

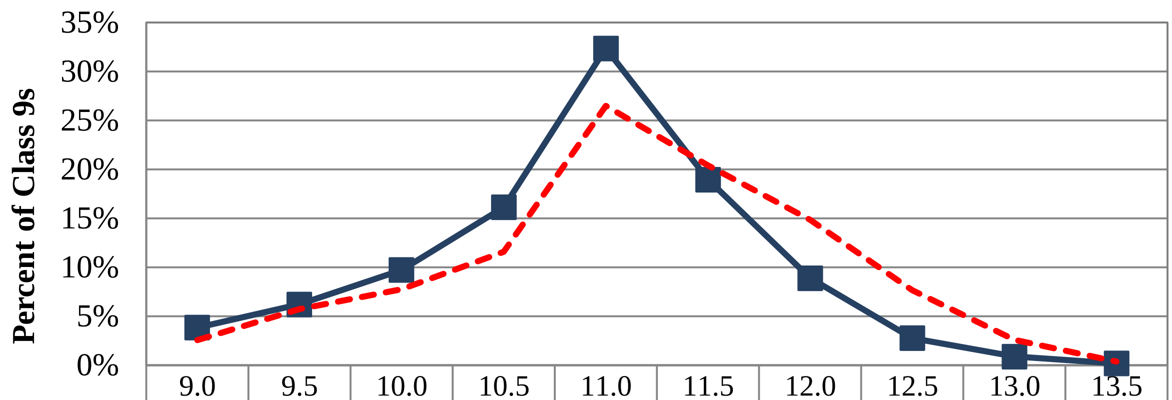
GVW weight bins (kips)	CDS		Data		Change
	Date				
	1/19/2011		1/9/2013		
8	0	0.0%	0	0.0%	0.0%
16	0	0.0%	2	0.0%	0.0%
24	13	0.2%	26	0.4%	0.2%
32	257	4.2%	500	8.0%	3.8%
40	1664	27.4%	1782	28.5%	1.1%
48	814	13.4%	780	12.5%	-0.9%
56	616	10.1%	543	8.7%	-1.4%
64	369	6.1%	326	5.2%	-0.9%
72	455	7.5%	737	11.8%	4.3%
80	1539	25.3%	1395	22.3%	-3.0%
88	330	5.4%	145	2.3%	-3.1%
96	19	0.3%	15	0.2%	-0.1%
104	4	0.1%	1	0.0%	0.0%
112	0	0.0%	0	0.0%	0.0%
120	0	0.0%	0	0.0%	0.0%
Average =	55.2 kips		52.6 kips		-2.6 kips

As shown in the table, the percentage of unloaded class 9 trucks in the 32 to 40 kips range increased by 1.1 percent while the percentage of loaded class 9 trucks in the 72 to 80 kips range decreased by 3.0 percent. During this time period the percentage of overweight trucks decreased by 3.2 percent. Based on the average Class 9 GVW values from the per vehicle records, the GVW average for this site decreased by 5.0 percent, from 55.2 to 52.6 kips.

2.5 Class 9 Front Axle Weight Data Analysis

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

Figure 2-4 shows a comparison between Class 9 front axle weight plots generated by using the two week W-card sample from January 2013 and the Comparison Data Set from January 2011. The percentage of light axles (9.5 to 10.5 kips increased by approximately 6.3% and the percentage of heavy axles (11.5 to 12.5 kips) decreased by approximately 10.9%, 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	3.8%	6.2%	9.7%	16.1%	32.4%	19.0%	8.9%	2.8%	0.9%	0.2%
CDS	2.6%	5.7%	7.8%	11.6%	26.5%	20.4%	14.8%	7.7%	2.6%	0.4%

Steering Axle Weight in Kips

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

It can be seen in the figure that the greatest percentage of trucks have front axle weights measuring between 10.5 and 11.5 kips. The percentage of trucks in this range has increased between the January 2011 Comparison Data Set (CDS) and the January 2013 dataset (Data).

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

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

F/A weight bins (kips)	CDS		Data		Change
	Date				
	1/19/2011		1/9/2013		
9.0	156	2.6%	240	3.8%	1.3%
9.5	347	5.7%	388	6.2%	0.5%
10.0	471	7.8%	608	9.7%	2.0%
10.5	703	11.6%	1008	16.1%	4.6%
11.0	1606	26.5%	2021	32.4%	5.9%
11.5	1237	20.4%	1184	19.0%	-1.4%
12.0	900	14.8%	555	8.9%	-6.0%
12.5	465	7.7%	173	2.8%	-4.9%
13.0	157	2.6%	55	0.9%	-1.7%
13.5	23	0.4%	12	0.2%	-0.2%
Average =	10.9 kips		10.7 kips		-0.2 kips

The table shows that the average front axle weight for Class 9 trucks has decreased by 0.2 kips, or 1.8 percent. According to the values from the per vehicle records, the average front axle weight for Class 9 trucks is 10.7 kips.

2.6 Class 9 Tractor Tandem Spacing Data Analysis

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

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

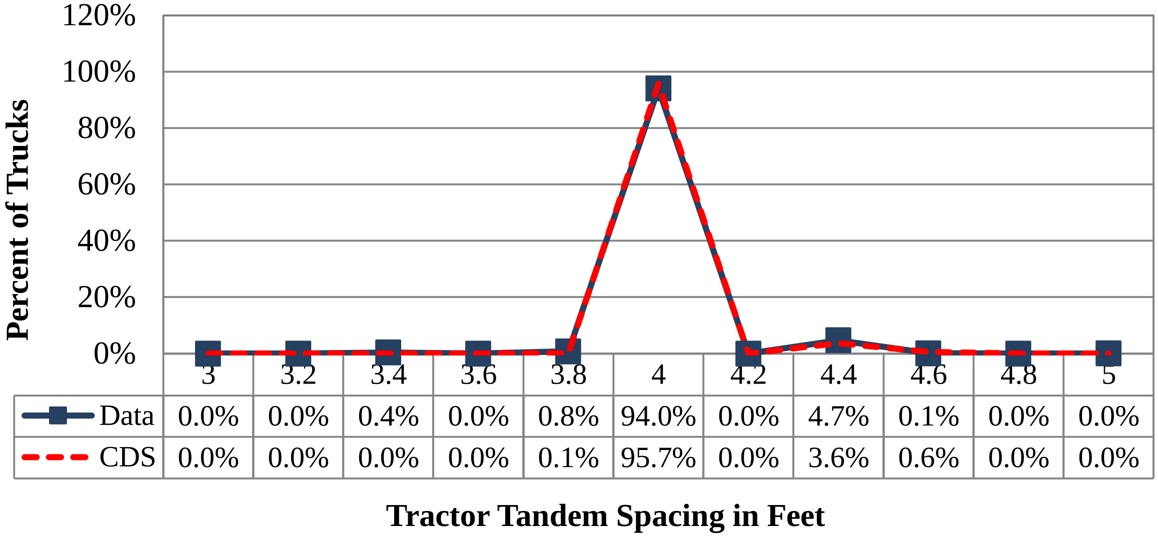


Figure 2-5 – Comparison of Class 9 Tractor Tandem Spacing

As seen in the figure, the Class 9 tractor tandem spacings for the January 2011 Comparison Data Set and the January 2013 Data are nearly identical.

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

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

Tandem 1 spacing bins (feet)	CDS		Data		Change
	Date				
	1/19/2011		1/9/2013		
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%	22	0.4%	0.4%
3.6	0	0.0%	0	0.0%	0.0%
3.8	4	0.1%	49	0.8%	0.7%
4.0	5821	95.7%	5878	94.0%	-1.7%
4.2	0	0.0%	0	0.0%	0.0%
4.4	220	3.6%	294	4.7%	1.1%
4.6	34	0.6%	6	0.1%	-0.5%
4.8	0	0.0%	0	0.0%	0.0%
5.0	1	0.0%	3	0.0%	0.0%
Average =	4.0 feet		4.0 feet		0.0 feet

From the table it can be seen that the drive tandem spacing of Class 9 trucks at this site is between 3.8 and 4.4 feet. Based on the average Class 9 drive tandem spacing values from the per vehicle records, the average tractor tandem spacing is 4.0, which is identical to the expected average of 4.0 from the CDS per vehicle records. Further axle spacing analyses are performed during the validation and validation analysis.

2.7 Data Analysis Summary

Historical data analysis involved the comparison of the most recent Comparison Data Set (January 2011) based on the last calibration with the most recent two-week WIM data sample from the site (January 2013). Comparison of vehicle class distribution data indicates a 2.5 percent increase in the percentage of Class 9 vehicles. Analysis of Class 9 weight data indicates that front axle weights have decreased by 1.8 percent and average Class 9 GVW has decreased by 5.0 percent for the January 2013 data. The data indicates an average truck tandem spacing of 4.0 feet, which is identical to the expected average of 4.0 feet.

3 Pavement Discussion

3.1 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. It was noted that a pavement transition is located 327 feet prior to the site. Slight bouncing by the test trucks was observed at this location, however the effects appeared to dissipate before the trucks crossed over the WIM scales. The distress did not appear to affect the accuracy of the WIM sensors.

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 3-1.

Table 3-1 – 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 3-1, 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 3-2.

Table 3-2 – WIM Index Values

Profiler Passes			**Pass 1**	**Pass 2**	**Pass 3**	**Pass 4**	**Pass 5**	**Avg**
Left	LWP	LRI (m/km)	0.893	0.849	0.878			0.873
		SRI (m/km)	*0.498*	*0.470*	0.666			0.545
		Peak LRI (m/km)	**0.984**	**0.924**	**0.903**			**0.937**
		Peak SRI (m/km)	0.802	*0.645*	0.844			0.764
	RWP	LRI (m/km)	0.694	0.715	0.724			0.711
		SRI (m/km)	*0.315*	*0.461*	*0.369*			*0.382*
		Peak LRI (m/km)	0.725	0.760	0.724			0.736
		Peak SRI (m/km)	0.991	0.798	0.862			0.884
Center	LWP	LRI (m/km)	0.527	0.609	0.602	0.574	0.541	0.571
		SRI (m/km)	0.725	0.796	0.669	0.604	0.617	0.682
		Peak LRI (m/km)	0.532	0.844	0.674	0.679	0.568	0.659
		Peak SRI (m/km)	0.883	0.971	0.799	0.811	0.785	0.850
	RWP	LRI (m/km)	0.870	0.899	0.843	0.669	0.653	0.787
		SRI (m/km)	0.523	0.606	0.548	*0.393*	*0.359*	*0.486*
		Peak LRI (m/km)	0.870	0.969	0.843	0.669	0.653	0.801
		Peak SRI (m/km)	0.921	0.896	0.854	*0.713*	*0.650*	0.807
Right	LWP	LRI (m/km)	0.688	0.685	0.741			0.705
		SRI (m/km)	0.687	0.627	0.676			0.663
		Peak LRI (m/km)	0.689	0.711	0.751			0.717
		Peak SRI (m/km)	0.979	0.826	0.920			0.908
	RWP	LRI (m/km)	0.757	0.737	0.679			0.724
		SRI (m/km)	*0.261*	0.604	0.559			*0.475*
		Peak LRI (m/km)	0.757	0.737	0.688			0.727
		Peak SRI (m/km)	*0.516*	*0.686*	*0.731*			*0.644*

From Table 3-2 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 LRI values in the left wheel path of the left shift passes (shown in bold).

3.2 Profile and Vehicle Interaction

Profile data was collected on March 27, 2012 by the North Atlantic 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 358 in/mi and is located approximately 327 feet prior to the WIM scale. The highest IRI value within the 400 foot approach section was 337 in/mi and is located approximately 328 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.

The pavement transition located 327 feet prior to the site had been rehabilitated since the previous validation visit, as shown in Photo 3-1 and Photo 3-2. The distress did not appear to affect the accuracy of the WIM sensors.

Photo 3-1 - Pavement Transition 12 Feet Prior to WIM Scales

Photo 3-2 – Pavement Transition 12 Feet Prior to WIM Scales (2)

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.

3.3 Recommended Pavement Remediation

No pavement remediation is recommended.

4 WIM Equipment Discussion

From a comparison between the report of the most recent validation of this equipment on October 18, 2011 and this validation visit, it appears that no changes have occurred during this time to the basic operating condition of the equipment.

4.1 Description

This site was installed on November 4, 2006 by International Road Dynamics. It is instrumented with bending plate weighing sensors and an IRD iSINC WIM Controller. As the installation contractor, IRD also performs routine equipment maintenance and data quality checks of the WIM data.

4.2 Physical Inspection

Prior to the pre-validation test truck runs, a physical inspection of all WIM equipment and support services equipment was conducted. As shown in Photos 4-1 and 4-2, the loop sealant has deteriorated and is missing in some parts. No other deficiencies were noted. Photographs of all system components were taken and are presented in Section 8.

Photo 4-1 – Missing Loop Sealant – Leading Loop Sensor

Photo 4-2 – Missing Loop Sealant – Trailing Loop Sensor

4.3 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.

4.4 Equipment Troubleshooting and Diagnostics

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

4.5 Recommended Equipment Maintenance

It is recommended that the missing loop sealant be repaired to prevent water intrusion and further deterioration. No other unscheduled equipment maintenance actions are recommended.

5 Statistical Reliability of the WIM Equipment

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

5.3 Validation

The 40 validation test truck runs were conducted on June 25, 2013, beginning at approximately 9:03 AM and continuing until 3:20 PM.

The two test trucks consisted of:

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

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

Table 5-1 - Validation Test Truck Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	74.7	10.3	17.4	17.4	14.8	14.8	14.5	4.3	29.0	4.4	52.2	58.2
2	66.2	11.3	14.9	14.9	12.5	12.5	14.2	4.2	22.8	4.3	45.5	52.0

Test truck speeds varied by 21 mph, from 44 to 65 mph. The measured validation pavement temperatures varied 35.2 degrees Fahrenheit, from 85.0 to 120.2. The sunny weather conditions provided the desired minimum 30 degree temperature range. Table 5-2 is a summary of post validation results.

Table 5-2 – Validation Overall Results – 25-Jun-13

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	0.3 ± 7.1%	Pass
Tandem Axles	±15 percent	-0.1 ± 4.1%	Pass
GVW	±10 percent	0.5 ± 3.4%	Pass
Vehicle Length	±3.0 percent (1.7 ft)	-0.1 ± 0.2 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.2 ± 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 -0.6 ± 4.1 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 0.2 feet, and the speed and axle spacing length measurements are based on the distance between the axle detector sensors, it can be concluded that the distance factor is set correctly and that the speeds being reported by the WIM equipment are within similar acceptable ranges.

5.3.1 Statistical Speed Analysis

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

Table 5-3 – Validation Results by Speed – 25-Jun-13

Parameter	95% Confidence Limit of Error	Low	Medium	High
		44.0 to 51.0 mph	51.1 to 58.1 mph	58.2 to 65.0 mph
Steering Axles	±20 percent	-1.3 ± 8.2%	1.3 ± 5.5%	0.9 ± 8.4%
Tandem Axles	±15 percent	-0.7 ± 2.8%	1.2 ± 3.1%	1.0 ± 5.8%
GVW	±10 percent	-0.7 ± 2.7%	1.2 ± 1.1%	0.9 ± 5.3%
Vehicle Length	±3.0 percent (1.7 ft)	-0.1 ± 0.2 ft	-0.1 ± 0.2 ft	-0.1 ± 0.2 ft
Vehicle Speed	± 1.0 mph	-0.5 ± 3.3 mph	-0.3 ± 5.6 mph	-1.1 ± 3.9 mph
Axle Length	± 0.5 ft [150mm]	0.2 ± 0.1 ft	0.2 ± 0.1 ft	0.2 ± 0.1 ft

From the table, it can be seen that the WIM equipment estimates all weights with similar accuracy at all speeds. There does not appear to be a relationship between weight estimates and speed at this site.

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

5.3.1.1 GVW Errors by Speed

As shown in Figure 5-1, the equipment estimated GVW with similar accuracy at all speeds. The range in error is greater at the low and high speeds when compared with the medium speeds.

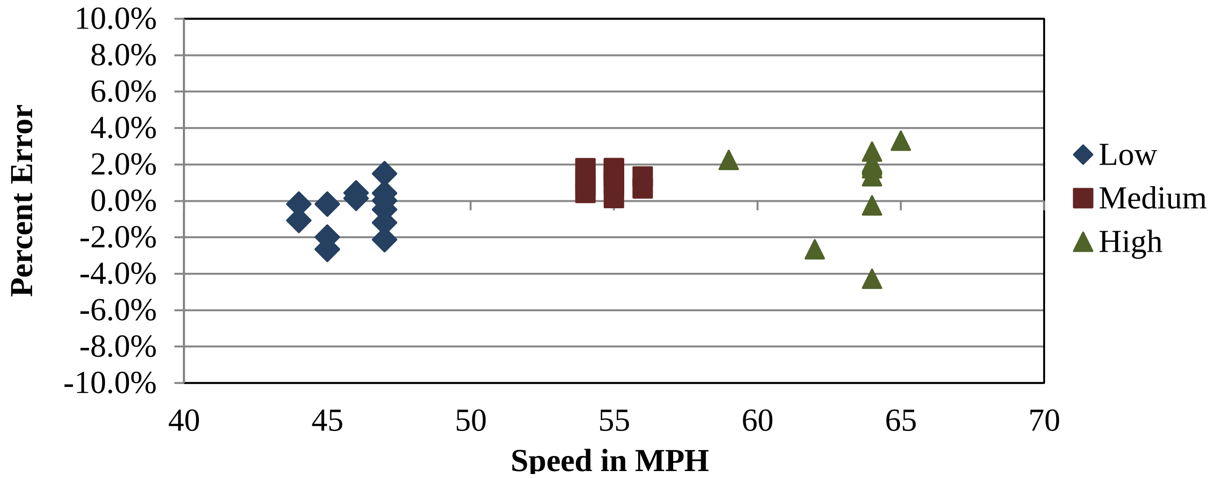


Figure 5-1 – Validation GVW Errors by Speed – 25-Jun-13

5.3.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-2, the equipment estimated steering axle weights with similar accuracy at all speeds. The range in error is greater at the low and high speeds when compared with medium speeds. There does not appear to be a correlation between speed and weight estimates at this site.

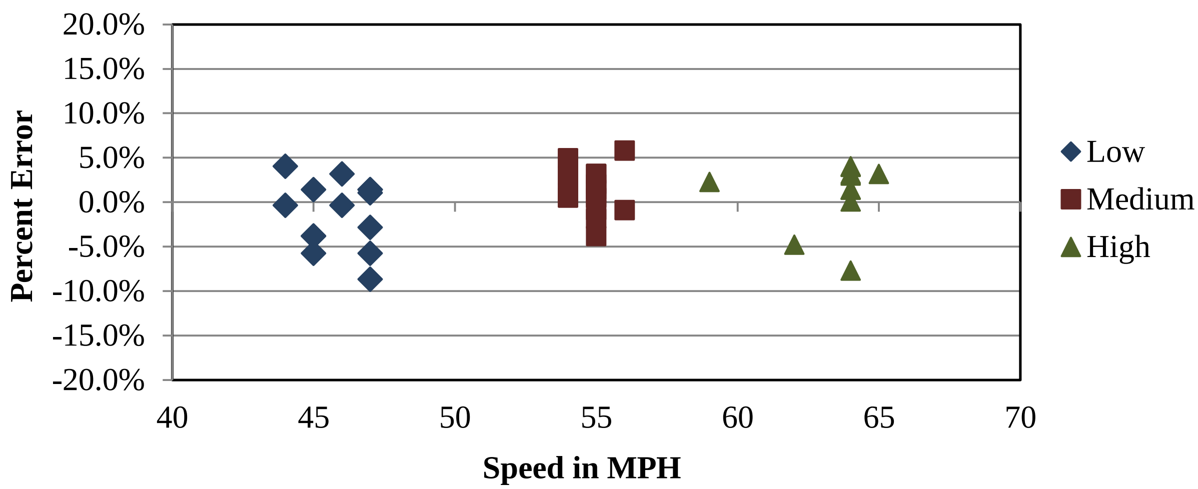


Figure 5-2 – Validation Steering Axle Weight Errors by Speed – 25-Jun-13

5.3.1.3 Tandem Axle Weight Errors by Speed

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

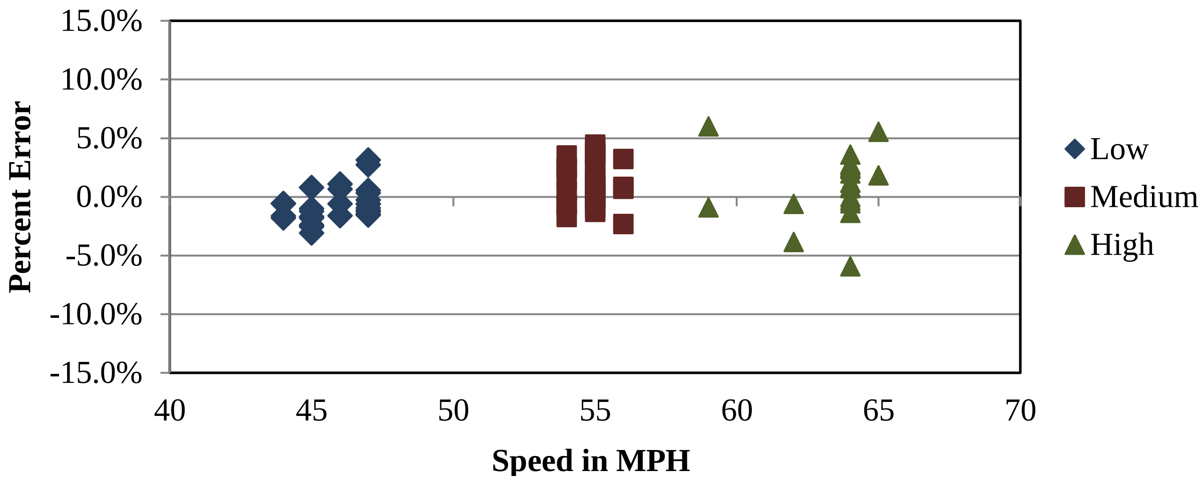


Figure 5-3 – Validation Tandem Axle Weight Errors by Speed – 25-Jun-13

5.3.1.4 GVW Errors by Speed and Truck Type

It can be seen in Figure 5-4 that when the GVW errors are analyzed by truck type, the WIM equipment precision and bias is similar for both the heavily loaded (Primary) truck and the partially loaded (Secondary) truck at the low and medium speeds. At the higher speeds, the range in GVW error increases due to the increased underestimation of GVW for the Primary truck.

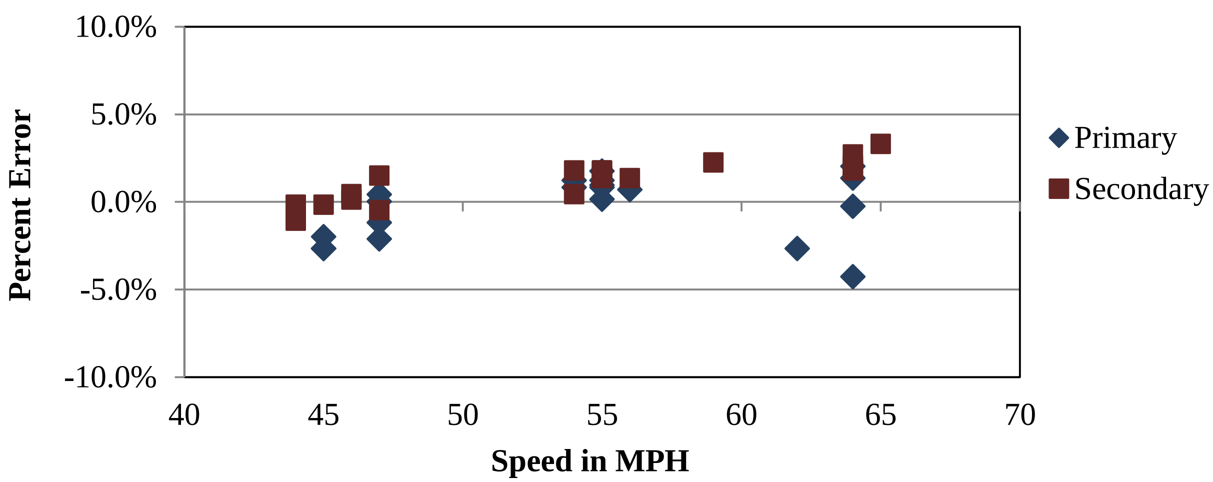


Figure 5-4 – Validation GVW Error by Truck and Speed – 25-Jun-13

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 5-5.

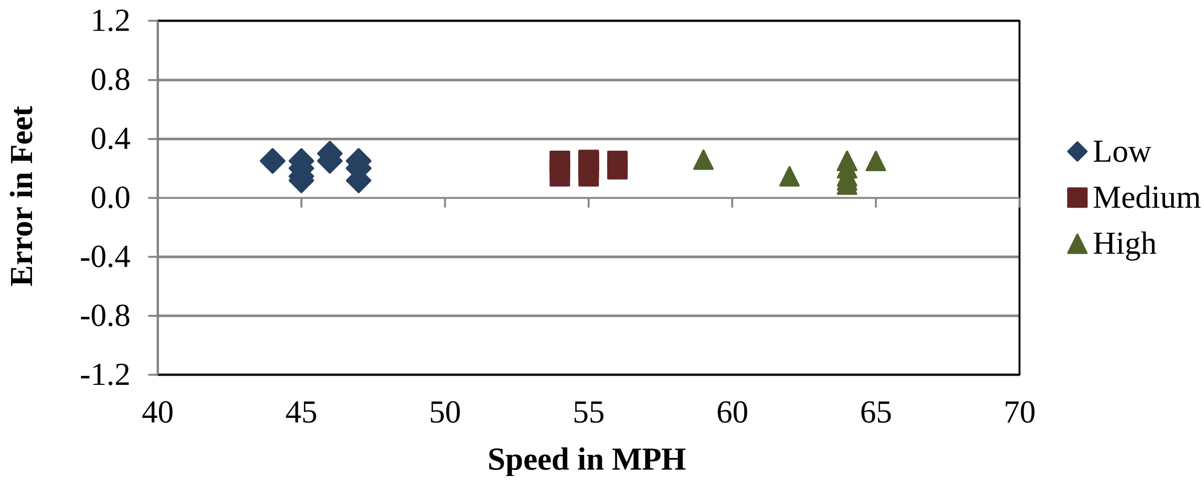


Figure 5-5 – Validation Axle Length Error by Speed – 25-Jun-13

5.3.1.6 Overall Length Errors by Speed

For this system, the WIM equipment measures overall length consistently over the entire range of speeds, with errors ranging from -0.2 to 0.0 feet. Distribution of errors is shown graphically in Figure 5-6.

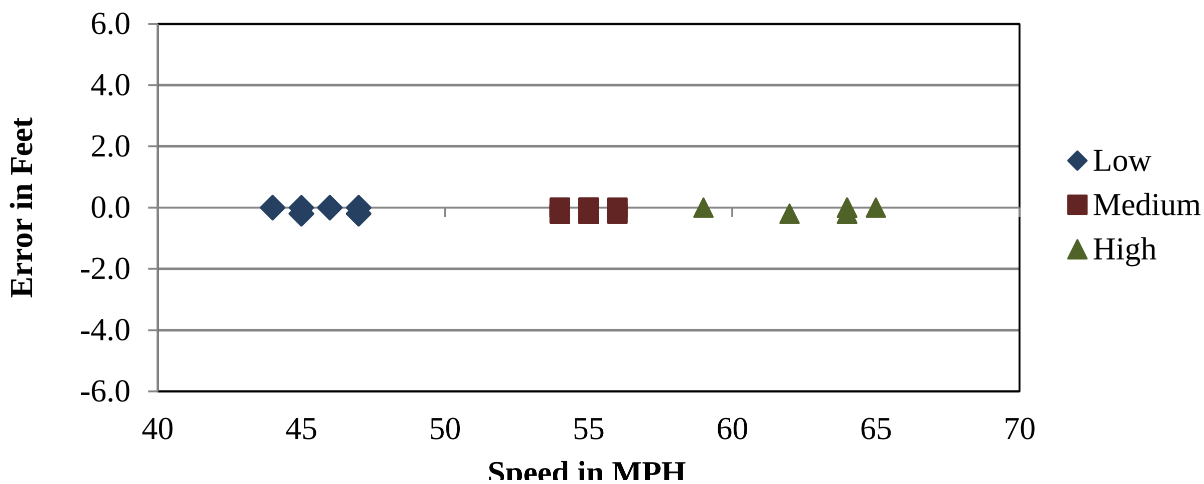


Figure 5-6 – Validation Overall Length Error by Speed – 25-Jun-13

5.3.2 Statistical Temperature Analysis

Statistical analysis was performed for the test truck run data to investigate whether a relationship exists between pavement temperature and WIM equipment weight and distance measurement accuracy. The range of pavement temperatures was 35.2 degrees, from 85.0 to 120.2 degrees

Fahrenheit. The validation test runs are reported under three temperature groups – low, medium and high, as shown in Table 5-4 below.

Table 5-4 – Validation Results by Temperature – 25-Jun-13

Parameter	95% Confidence Limit of Error	Low	Medium	High
		85.0 to 96.7 degF	96.8 to 108.6 degF	108.7 to 120.2 degF
Steering Axles	±20 percent	-0.5 ± 4.4%	1.2 ± 8.3%	0.0 ± 8.0%
Tandem Axles	±15 percent	-0.1 ± 4.3%	1.1 ± 4.2%	0.4 ± 4.4%
GVW	±10 percent	-0.2 ± 3.5%	1.2 ± 2.9%	0.3 ± 3.9%
Vehicle Length	±3.0 percent (1.7 ft)	-0.1 ± 0.3 ft	-0.1 ± 0.2 ft	-0.1 ± 0.2 ft
Vehicle Speed	± 1.0 mph	-0.5 ± 1.8 mph	-1.5 ± 6.7 mph	-0.1 ± 3.1 mph
Axle Length	± 0.5 ft [150mm]	0.2 ± 0.1 ft	0.2 ± 0.1 ft	0.2 ± 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 5-7, it can be seen that the equipment appears to estimate GVW with similar accuracy across the range of temperatures observed in the field. The range in error are greater at the higher temperatures. There does not appear to be a correlation between temperature and weight estimates at this site.

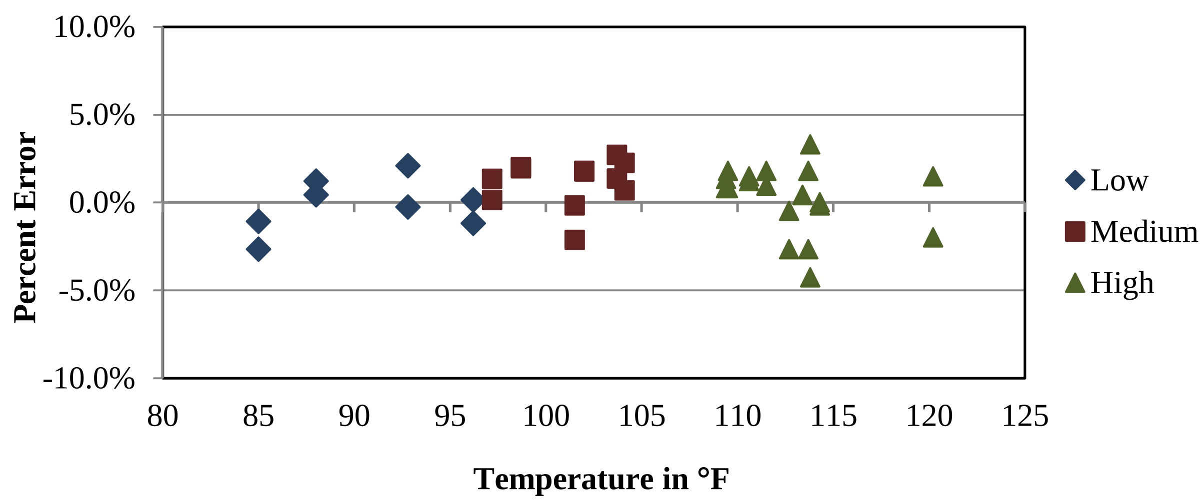


Figure 5-7 – Validation GVW Errors by Temperature – 25-Jun-13

5.3.2.2 Steering Axle Weight Errors by Temperature

Figure 5-8 demonstrates that for steering axles, the WIM equipment appears to estimate weights with similar 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 greater at the low and medium temperatures.

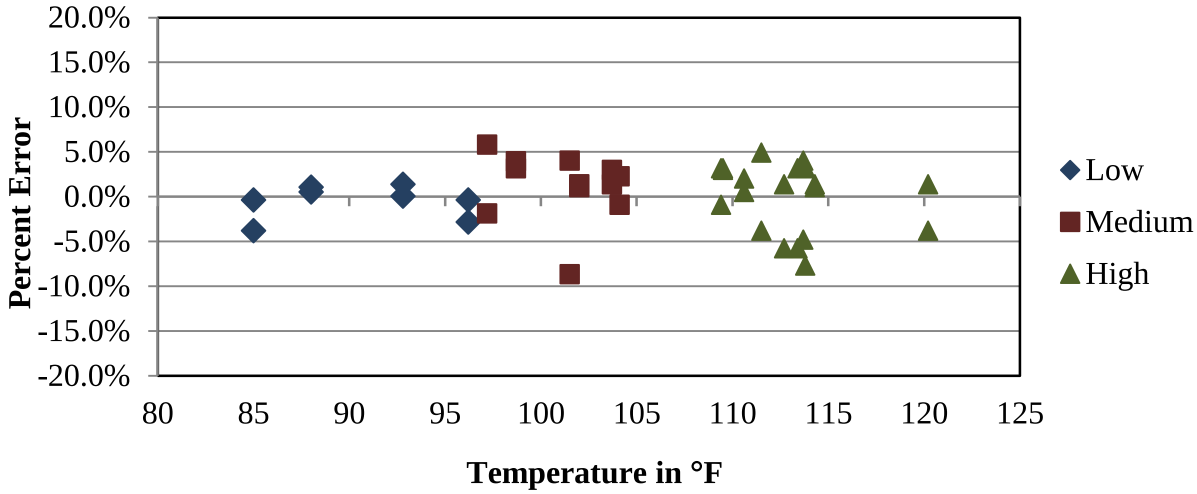


Figure 5-8 – Validation Steering Axle Weight Errors by Temperature – 25-Jun-13

5.3.2.3 Tandem Axle Weight Errors by Temperature

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

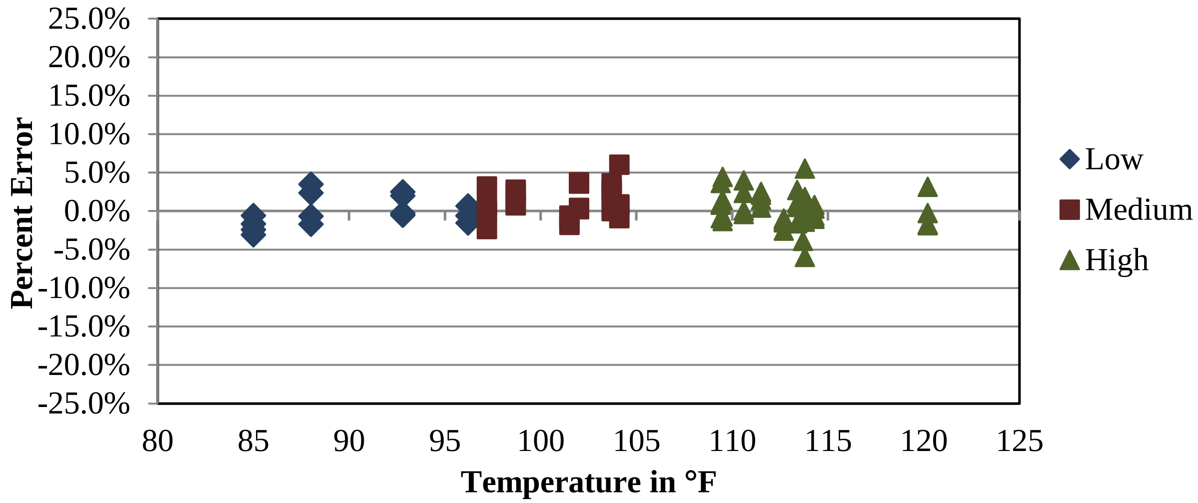


Figure 5-9 – Validation Tandem Axle Weight Errors by Temperature – 25-Jun-13

5.3.2.4 GVW Errors by Temperature and Truck Type

As shown in Figure 5-10, when analyzed by truck type, GVW measurement errors for both trucks are similar at the low and medium temperatures. At the medium and high temperatures, the range in error is greater due to underestimations of GVW for the Primary Truck.

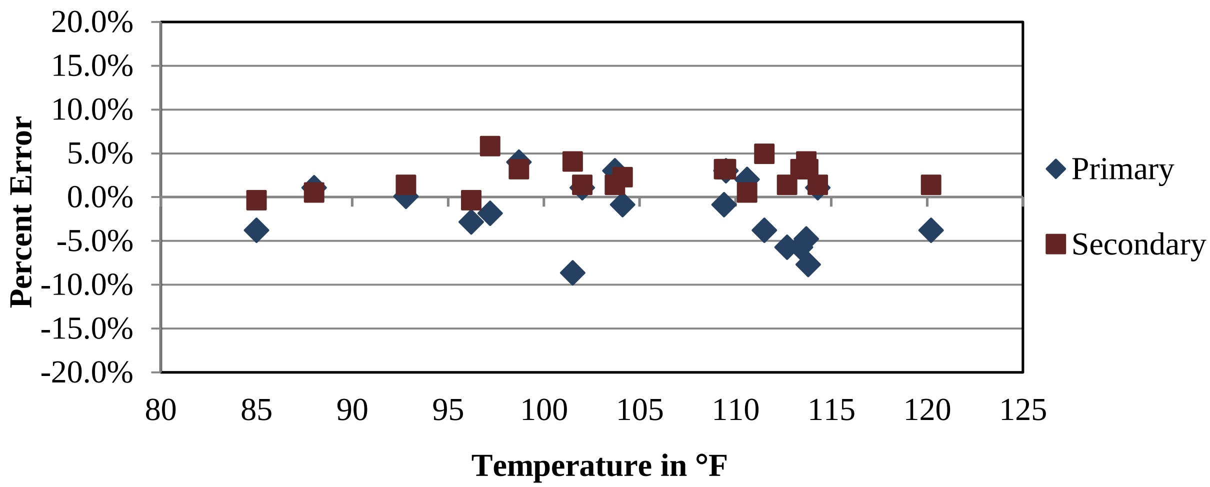


Figure 5-10 – Validation GVW Error by Truck and Temperature – 25-Jun-13

5.3.3 Classification and Speed Evaluation

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

For the validation classification study at this site, a manual sample of 100 vehicles including 99 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 5-5. 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 and one Class 4 vehicle were misclassified as Class 5 vehicles and one Class 5 vehicle was misclassified as a Class 8 vehicle by the equipment.

Table 5-5 – Validation Misclassifications by Pair – 25-Jun-13

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

As shown in the table, a total of 3 vehicles, including 0 heavy trucks (6 – 13) were misclassified by the equipment. Based on the vehicles observed during the 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 3.0 percent due to misclassification of lightweight vehicles in Class 3, Class 4 and Class 5.

The causes for the misclassifications were not investigated in the field. A post-visit investigation of misclassified vehicles was performed using the collected video. The analysis determined that the Class 3 that was a full-size pick-up with a utility body. The Class 5 that was identified by the equipment as a Class 8 was a box truck towing a trailer. The Class 4 identified by the system as a Class 5 was a bus with a short wheelbase.

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

Table 5-6 – Validation Classification Study Results – 25-Jun-13

Class	3	4	5	6	7	8	9	10	11	12	13
Observed Count	1	1	20	8	0	5	63	1	1	0	0
WIM Count	0	0	21	8	0	6	63	1	1	0	0
Observed Percent	1.0	1.0	20.0	8.0	0.0	5.0	63.0	1.0	1.0	0.0	0.0
WIM Percent	0.0	0.0	21.0	8.0	0.0	6.0	63.0	1.0	1.0	0.0	0.0
Misclassified Count	1	1	1	0	0	0	0	0	0	0	0
Misclassified Percent	100.0	100.0	5.0	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. Based on the manually collected sample of the 99 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 -0.1 mph; the range of errors was 1.0 mph.

Since the equipment is measuring all weight and distance parameters within the LTPP requirements for SPS WIM sites and with a very low bias (the average measurement error for GVW is 0.5 percent), a calibration of the system was not required and therefore was not carried out.

5.3.4 Final WIM System Compensation Factors

The final factors left in place at the conclusion of the validation are provided in Table 5-7.

Table 5-7 – Final Factors

Speed Point	MPH	Left	Right
		1	2
72	45	3331	3331
88	55	3309	3309
104	65	3314	3314
120	75	3314	3314
136	85	3314	3314
Axle Distance (cm)		368	
Dynamic Comp (%)		104	
Loop Width (cm)		185	

6 Post-Visit Data Analysis

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

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

6.1 Regression Analysis

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

Multivariable analysis provides additional insight on how factors 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 44 to 65 mph.
- Pavement temperature. Pavement temperature ranged from 85.0 to 120.2 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	-6.1975	3.0111	-2.0582	0.0469
Speed	0.1018	0.0307	3.3160	0.0021
Temp	0.0037	0.0230	0.1627	0.8716
Truck	1.5162	0.4306	3.5210	0.0012

The lowest probability value given in Table 6-1 was 0.0012 for truck type. This means that there is about a 0.12 percent chance that the value of regression coefficient for truck (1.5162) can occur by chance alone. This relationship is further investigated in Section 6.1.5. Changes in speed or temperature did not showed statistically significant effect on changes in GVW measurement error.

The relationship between speed and measurement errors is shown in Figure 6-1. The figure includes a trend line for the predicted percent error. Besides the visual assessment of the relationship. The quantification of the relationship is provided by the value of the regression coefficient, in this case 0.1018 (in Table 6-1). This means, for example, that for a 10 mph increase in speed, the error is increased by about one percent (0.1018 x 10). The statistical assessment of the relationship is provided by the probability value of the regression coefficient (0.0021) and is statistically significant (values equal or less than 0.05 indicate statistical significance in this case).

Changes in temperature did not show statistically significant effect on changes in GVW measurement error.

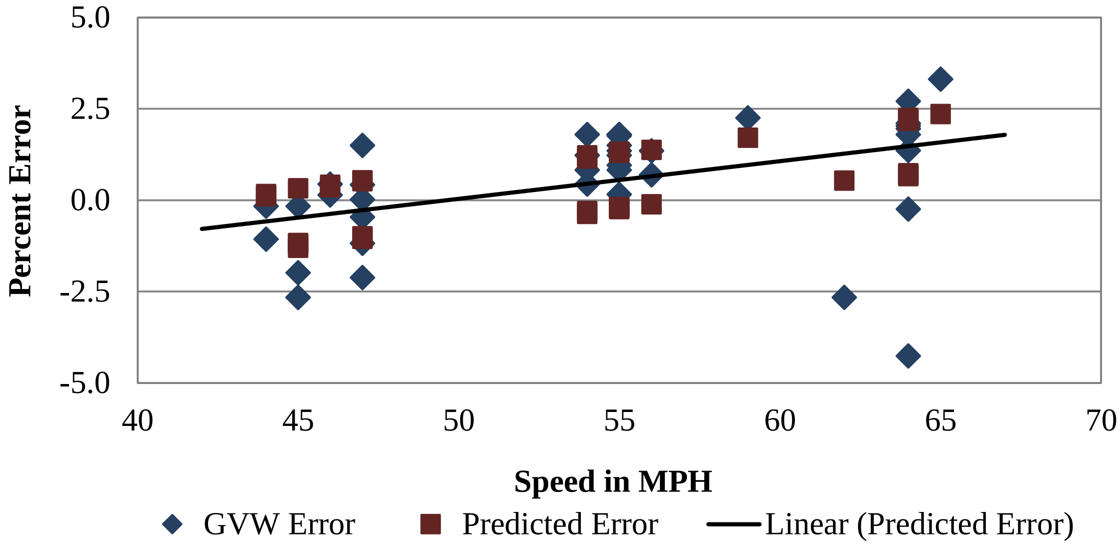


Figure 6-1 – Influence of Speed on the GVW Measurement Error

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	0.1018	0.0021	-	-	1.5162	0.0012
Steering axle	0.1267	0.0515	-	-	4.0230	0.0001
Tandem axle tractor	0.0783	0.0550	-	-	-	-
Tandem axle trailer	0.1316	0.0028	-	-	-	-

6.1.4 Conclusions

1. According to Table 6-2, speed had a statistically significant effect on all measurement errors. However, while the effect of speed was statistically significant, the size of the effect was small as shown in Figure 6-1.

2. Temperature did not have a statistically significant effect on any of the measurement errors.

3. Truck type had statistically significant effect on GVW measurement errors only at 0.0012 probability value, and steering axle measurements at only a .00001 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.) Thus, for example, the difference in the average measurement error for GVW between the Primary and Secondary trucks was about 1.5 percent (1.5162 in Table 6-1).

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.

6.1.5 Contribution of Two Trucks to Calibration

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

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

Figure 6-2 and associated statistical analysis show that speed had similar influences on the GVW measurement for each truck. However, the rate of increase of the measurement error with speed was grater for the Secondary truck. The figure illustrates that if only the Secondary truck was used for the validation, the outcome of the validation could have been different. Secondary truck shows higher measurement errors and it is possible that a calibration, based on the verification results provided by the Secondary truck alone, would be advisable. This is rather theoretical consideration, because it is unlikely that at a Secondary truck alone would be used for verification.

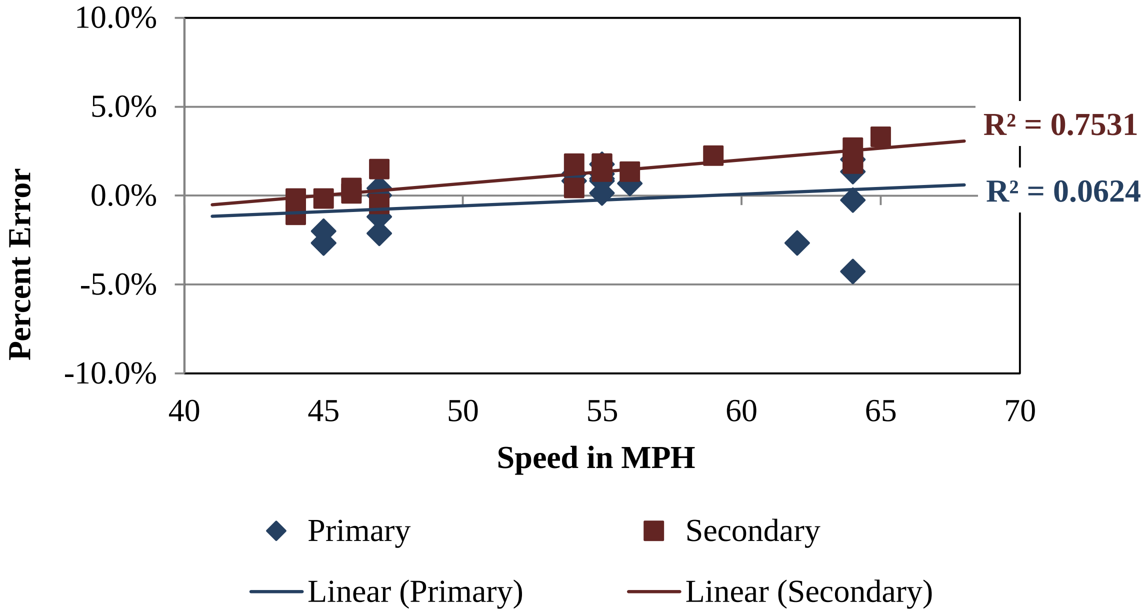


Figure 6-2– Influence of Speed on the GVW Measurement Error of Primary and Secondary Trucks

The use of two calibration trucks provided verification of the trends and speeded up the time required to obtain 40 pre-validation runs. However for this site, the use of only one of the trucks (Primary or Secondary) with 20 calibration runs would have resulted in different verification results based on trend differences observed errors for both trucks.

6.2 Misclassification Analysis

A post-visit analysis is typically conducted on the truck misclassifications identified during the validation conducted in the field. For this site, no heavy trucks (6 – 13) were misclassified by the equipment and so the post-visit misclassification analysis was not considered necessary and was not performed.

6.3 Traffic Data Analysis

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

7 Previous WIM Site Validation Information

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

7.1 Classification

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

Table 7-1 – Classification Validation History

Date	Misclassification Percentage by Class											Pct Unclass
	3	4	5	6	7	8	9	10	11	12	13	
30-Jan-07	-	-	0	0	-	0	0	-	0	-	-	0.0%
24-Jul-07	-	-	0	0	-	0	0	0	0	0	-	0.0%
25-Jul-07	-	-	0	0	-	0	0	0	0	0	-	0.0%
2-Dec-08	-	-	0	0	-	0	0	-	0	-	-	0.0%
4-Dec-08	-	100	0	9	-	0	0	-	-	-	0	0.0%
1-Mar-11	-	100	5	17	0	0	0	0	0	0	0	1.0%
2-Mar-11	-	100	18	0	0	0	0	0	0	0	0	1.0%
18-Oct-11	14	0	4	0	0	0	2	100	0	0	0	0.0%
25-Jun-13	100	100	5	0	0	0	0	0	0	0	0	3.0%

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 (if performed).

Table 7-2 – Weight Validation History

Date	Mean Error and 2SD		
	GVW	Single Axles	Tandem
30-Jan-07	0.7 ± 5.4	-2.6 ± 6.4	1.3 ± 6.9
31-Jan-07	-0.8 ± 5.5	-4.7 ± 5.4	-0.1 ± 7.2
24-Jul-07	-0.4 ± 6.2	-0.5 ± 8.4	0.4 ± 10.9
25-Jul-07	0.1 ± 6.1	-2.7 ± 10.3	0.9 ± 9.0
2-Dec-08	4.2 ± 2.7	0.8 ± 4.7	5.1 ± 5.7
4-Dec-08	1.0 ± 3.2	1.5 ± 5.0	1.2 ± 5.8
1-Mar-11	3.1 ± 3.4	1.8 ± 7.7	3.5 ± 4.5
2-Mar-11	-0.7 ± 3.7	-2.0 ± 5.2	-0.3 ± 5.1
18-Oct-11	-0.3 ± 2.2	-1.4 ± 4.6	0.0 ± 2.9
25-Jun-13	0.5 ± 3.4	0.3 ± 7.1	-0.1 ± 4.1

The variability of the GVW errors appear to have decreased since the site was first validated. From this information, it appears that the system demonstrates a tendency for the equipment to move toward an overestimation of GVW 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
- Validation Sheet 16 – Site Calibration Summary
- Validation Sheet 20 – Classification and Speed Study

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

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

WIM System Field Calibration and Validation - Photos

Virginia, SPS-1
SHRP ID: 510100

Validation Date: June 25, 2013

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

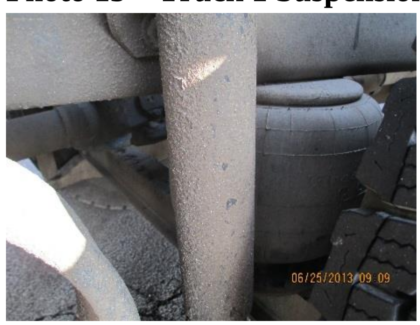


Photo 16 – Truck 1 Suspension 2

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 26 – Truck 2 Suspension 4

Photo 27 – Truck 2 Suspension 5

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 51 SPS WIM ID: 510100 DATE (mm/dd/yyyy) 6/25/2013

SITE CALIBRATION INFORMATION

1. DATE OF CALIBRATION {mm/dd/yy} 6/25/13

2. TYPE OF EQUIPMENT CALIBRATED: Both

3. REASON FOR CALIBRATION: LTPP Validation

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

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

5. EQUIPMENT MANUFACTURER: IRD iSINC

WIM SYSTEM CALIBRATION SPECIFICS

6. CALIBRATION TECHNIQUE USED: Test Trucks

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

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

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

Mean Difference Between -

Dynamic and Static GVW:	0.5%	Standard Deviation:	1.7%
Dynamic and Static Single Axle:	0.3%	Standard Deviation:	3.5%
Dynamic and Static Double Axles:	-0.1%	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	-	44.0	to	51.0	14
b.	Medium	-	51.1	to	58.1	15
c.	High	-	58.2	to	65.0	11
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 51 SPS WIM ID: 510100 DATE (mm/dd/yyyy) 6/25/2013

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3314 | 3314

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	-	5.0
FHWA Class 8:	20.0	FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 0.0%

Validation Test Truck Run Set - Pre

Person Leading Calibration Effort: **Dean Wolf**

Contact Information: Phone: 717-975-3550

E-mail: dwolf@ara.com

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES					STATE CODE: SPS WIM ID: DATE (mm/dd/yyyy)			51 510100 6/25/2013	

Count - 100 Time = 2:19:53 Trucks (4-15) - 99 Class 3s - 1

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
56	5	50753	53	5	64	9	50896	63	9
58	**5**	**50754**	**56**	**4**	64	6	50905	64	6
64	9	50756	64	9	60	9	50909	61	9
64	9	50765	64	9	61	9	50911	62	9
65	5	50769	65	5	64	8	50921	64	8
60	6	50779	61	6	69	5	50922	69	5
65	9	50789	65	9	66	5	50926	67	5
62	9	50796	62	9	66	8	50950	67	8
60	**5**	**50797**	**63**	**3**	60	9	50966	62	9
64	5	50803	62	5	65	9	51033	66	9
57	9	50811	58	9	64	9	51034	64	9
66	9	50817	65	9	54	5	51037	54	5
67	9	50822	67	9	70	5	51041	70	5
62	9	50832	62	9	63	8	51056	63	8
59	5	50834	59	5	61	8	51057	60	8
63	9	50838	63	9	64	9	51058	63	9
64	9	50839	65	9	45	5	51059	43	5
67	9	50843	68	9	64	9	51062	65	9
70	6	50845	72	6	66	5	51064	66	5
67	9	50848	67	9	36	5	51080	36	5
60	9	50871	62	9	57	6	51086	55	6
69	9	50873	68	9	67	9	51090	66	9
68	9	50875	68	9	66	9	51091	66	9
66	9	50880	66	9	67	6	51093	68	6
60	9	50882	61	9	65	8	51094	67	8

Sheet 1 - 1 to 50 Start: 9:38:38 Stop: 10:45:32

Recorded By: kt Verified By: djw

Validation Test Truck Run Set - Pre

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 51 SPS WIM ID: 510100 DATE (mm/dd/yyyy) 6/25/2013

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
63	9	51100	63	9	67	9	51332	67	9
62	9	51107	61	9	65	6	51335	65	6
62	5	51108	61	5	57	5	51356	59	5
56	10	51118	56	10	70	9	51357	69	9
66	9	51120	66	9	63	9	51358	63	9
59	9	51124	58	9	70	9	51359	70	9
64	9	51127	64	9	62	9	51367	61	9
65	9	51141	67	9	62	9	51374	62	9
64	9	51153	65	9	62	5	51377	63	5
57	9	51155	57	9	60	9	51378	60	9
60	5	51160	60	5	62	5	51381	62	5
63	9	51162	62	9	65	5	51386	65	5
62	9	51167	62	9	64	9	51389	63	9
66	9	51168	66	9	49	9	51390	49	9
64	9	51173	65	9	64	9	51392	63	9
65	9	51201	65	9	**61**	**8**	**51405**	**61**	**5**
61	5	51202	62	5	60	9	51407	60	9
62	9	51203	62	9	66	6	51408	66	6
61	9	51213	62	9	61	9	51412	60	9
66	9	51215	67	9	64	9	51420	66	9
65	9	51220	64	9	59	9	51426	60	9
72	9	51232	72	9	60	5	51427	59	5
66	6	51249	66	6	64	9	51429	63	9
70	11	51251	70	11	64	9	51432	63	9
59	9	51305	58	9	60	9	51435	60	9

Sheet 2 - 51 to 100 Start: 10:46:24 Stop: 11:58:31

Recorded By: kt djw

Validation Test Truck Run Set - Pre