Data Collection Guide for SPS WIM Sites

Version 1.0

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Long-Term Pavement Performance
Serving your need for durable pavements

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1 INTRODUCTION

1.1 BACKGROUND

The Long-Term Pavement Performance (LTPP) program is deficient in the quantity of traffic data collected at its study locations as well as in its knowledge of the quality of this data. A particular concern is the lack of this information for Specific Pavement Studies (SPS). The new construction experiments were designed with the intent to collect continuous weigh-in-motion data from open to traffic. The rehabilitation experiments were supposed to have continuous classification data from open to traffic in addition to four 1-week seasonal samples of weight data. Ten years into the program less than a quarter of these sites came close to meeting these levels of data collection. As a result, LTPP embarked on a effort with the support of the Traffic ETG to revise the traffic data collection procedures for SPS-1, -2, -5, -6 and -8 experiments. (SPS-1, -2 and -8 are new construction; SPS-5 and -6 are rehabilitation with AC overlays.) The effort consisted of two principal elements: shifting the data collection from highway agencies to a national, centralized effort and standardizing data collection equipment and procedures. The effort has been successful in that state agencies have agreed to the establishment of a national pooled fund effort to support data collection and processing as well as equipment purchases. Additionally, standards for pavement smoothness, for equipment calibration checks and for equipment model specifications have been developed.

1.2 OBJECTIVE

This document contains the guidelines for traffic data collection at SPS sites. It covers all aspects of the process from site selection through office processing of data. Some or all of these elements may remain the responsibility of the state agency depending on its degree of participation in the national pooled fund study for SPS Traffic Data Collection. It is strongly suggested that this document be circulated and encouraged as standard practice at all SPS WIM sites whether or not the agency has committed to participate in the pooled fund. Within this document there are three groups identified as participants in the process: FHWA, state agencies and data collectors. Data collectors may be variously referred to as profiler operators, validation field teams, site evaluators, acceptance test staff, or data processors.

Throughout this document the terms SPS projects/sites/locations refer to the SPS-1, -2, -5 and -6 sites and those SPS-8 experiments that have been targeted for intensive traffic monitoring activities.

1.3 SAFETY

Traffic data collection involves work in and adjacent to the traveled way. Data collectors and observers are to follow all FHWA, state and company policies for work on highway rights of way. Data collectors are responsible for keeping a list of policies applicable to each individual state. Where site-specific conditions involve special actions these should be included within that list. Those who fail to follow safety guidelines should be removed from the site.

1.4 ORGANIZATION OF GUIDE

This guide is divided into four major operational sections. They are Site Validation, Site Evaluation, Construction and Data Processing.

- Site Validation is the semi-annual weight verification with test trucks and an annual profile and long wavelength evaluation.
- Site Evaluation is done on the first visit to a site with an operational WIM. It is the inventory or fact gathering visit to collect all of the site information, contact names with telephone numbers and e-mail addresses (if appropriate). Concurrently, test truck and profiler runs over a wide range of temperatures are performed. It concludes with a site validation.
- Construction is the installation or re-installation of WIM equipment including calibration. Prior to WIM sensor installation the manual straightedge evaluation for smoothness is done. The LTPP Site Validation procedure is used for determining acceptance of the site for providing SPS traffic data.
- Data Processing is the office portion of the data collection where the WIM data is downloaded and processed through the LTPP Traffic software suite and results reported to the state at least monthly. These reports shall be used to monitor calibration and performance of the equipment.

2 SITE VALIDATION

2.1 SEMI-ANNUAL WEIGHT

Scale accuracy is central to the acceptance of traffic weight data. Site validation is the process by which trucks with known static weights are run over a site without adjusting any of the WIM and AVC equipment's operational parameters. Scales that meet the calibration tolerances (see Table 1 below) are accepted as meeting LTPP WIM requirements, independent of less than ideal site geometry or of any pavement smoothness failures. Site validation activities should not be initiated without verification of all relevant parameters.

2.1.1 SYSTEM PERFORMANCE REQUIREMENTS

The LTPP program requirements are documented in the document "WIM Calibration Check Specifications For LTPP Specific Pavement Studies Sites", which is included for reference in Appendix A of this guide. Basically, WIM scale systems used to collect data under the LTPP SPS traffic loading data collection program must meet ASTM E-1318 Type I data accuracy criteria. These criteria are given below in Table 1.

Table 1 – WIM System Calibration Tolerances

SPS-1, -2, -5, -6 and -8 Sites	95 Percent Confidence Limit of Error
Loaded single axles	±20 percent
Loaded tandem axles	±15 percent
Gross vehicle weights	±10 percent
Vehicle speed	±1 mph [2 km/hr]
Axle spacing length	± 0.5 ft [150 mm]

2.1.2 PERFORMANCE TESTING PROCEDURE

The scale accuracy tests are designed to verify the performance of the scale when temperature and vehicle speed vary. The test plan requires the test trucks to make multiple passes over the scale sensors during a single day at different speeds. Site visits are made during times of the year when the highest daily temperature variations are likely to be found at the test site. Statistical tests are performed to examine system accuracy for both the entire data collection period and for subsets of the data that represent particular environmental or operational conditions.

2.1.2.1 Equipment

When acquiring trucks, the specifications should be interpreted as follows:

Truck #1 must be a 3S2 (FHWA class 9) with standard tandems and air suspensions on tractor and trailer. It should have the capacity to be loaded between 76,000 and 80,000 pounds. All loads must be legal in terms of GVW and axle weights.

Truck #2 should be something other than a dump truck with the options in descending order of preference:

- Predominant truck (including dump trucks) for the particular SPS site, if it supplies a majority of the axle loads for the site, loaded within 4,000 pounds of the maximum legal weight for the truck and location. If this turns out to be the same type truck as Truck #1, then one of the following options should be used for Truck #2.
- FHWA class 9 truck (3S2) similar to truck #1 but loaded between 60,000 and 64,000 pounds.
- FHWA class 9 truck (3S2) similar to truck #1 but with steel suspension loaded to between 60,000 and 64,000 pounds.
- FHWA class 9 truck (3S2) similar to truck #1 but with steel suspension loaded to between 76,000 and 80,000 pounds.
- FHWA class 9 truck (3S2) similar to truck #1 but with a split tandem trailer (no load equalization between axles) loaded between 76,000 and 80,000 pounds.
- FHWA class 10 truck (3S3) with any suspension type loaded above 88,000 pounds.

All loads must be kept legal for the truck and location, so adjustments to the above loading may be necessary.

If more than two test vehicles are used, the third vehicle may be configured and loaded as desired, although the use of three- or four-axle single-unit dump trucks is still discouraged. It is recommended that additional trucks be added in the above order if possible. Single unit trucks are also an option.

The loads should be something that will not shift or change the axle weights during the test. Steel plates or beams or concrete blocks or beams securely attached so they do not move is the recommended load.

In addition to the test trucks, the calibration team requires at least three radios (CBs are okay), an infrared temperature measurement device, a computer, WIM interface software and appropriate cables to connect to the WIM processor for recording the WIM data. An air thermometer and an algorithm to estimate pavement temperature from air temperature may be used as substitute for the infrared temperature device. A radar (or laser) gun for collecting vehicle speeds is also required. Speed measurement accuracy is preferred to be within 0.25 mph, but must be no less accurate than 1 mph.

2.1.2.2 WEIGHING TRUCKS

The truck drivers should be briefed so that when weighing the vehicles on the certified scales, the brakes are not be engaged and the drive onto the scale is as smooth and easy as possible. The approach to the scale should be as smooth and level as possible to reduce inconsistencies in the weighing process.

When using a single full-truck scale, each axle should be weighed as it comes on the whole vehicle platform and as it comes off, giving at least two determinations for each axle's weight (either 1 actual weight + calculation, or 2 calculations). A total of three GVW weighings are needed, with the truck driving completely off of the scale and then back onto the scale. The GVW measured below is considered the first GVW. Individual axle weights are not required for the second and third GVWs during Pass #2 and Pass #3. The following weighing procedure should be used in these cases:

	Axle on Scale	Axle Weight Determinations
Pass #1		
	1	1
	1+2	2
	1+2+3	3 & drive tandem & tractor weight
	1+2+3+4	4
	1+2+3+4+5	5 & trailer tandem & GVW #1
	2+3+4+5	1

3+4+5	2
4+5	3 & trailer tandem
5	4 and 5

Pass #2

1+2+3+4+5	GVW #2

Pass #3

1+2+3+4+5	GVW #3

Using this procedure requires that the scale approach and leave be at the same level as the scale itself, and not be ramped. If using smaller scale, or scale that is not a single platform, adjust this procedure as necessary to get two determinations of each axle's weight and three GVWs. After the trucks are weighed, the mean and standard deviation are computed for the GVW and the mean for the axle weights. Standard deviations of GVW in excess of a third of the tolerance in Table 1 requires that additional passes be made to achieve an acceptable GVW standard deviation before the weighing session is terminated.
Pass #1, #2 and #3 are required prior to a site validation. Only Pass #1 is required post validation unless the change in GVW is greater than 1,000 pounds.

Lastly the characteristics of each truck shall be measured and recorded. These items include all axle spacing (from centerline to centerline of each axle/tire), body type, width and suspension type. Photographs should be used to record the suspension types. This information should be reported to the WIM data collection staff. The WIM staff needs the average weights before any runs over the WIM are performed.

2.1.2.3 Staff

At least four staff people are needed for this effort. Two will collect data at the WIM system. The others will drive the test trucks. As additional lanes of data collection or trucks are added, additional staff will be needed. Note that these are minimum requirements and that some site validations will require a third person for data collection.

2.1.2.4 Procedures

Once the test trucks have been weighed at a calibrated, certified static scale and the weights given to the WIM data collection staff, a preliminary determination of calibration is made by making at least 5 (preferably 10) passes over the scale to determine how previously collected data may be affected by the current (and past) WIM scale calibration. If appropriate, when the state agency agrees and the ability to change calibration is available, then the scale should be calibrated to match the test truck static weights. If calibration is done, a Traffic Sheet 16 is required to document its occurrence. After this initial calibration, an additional five passes should be made to check the WIM readings against the static weights.

While the test runs are being started, the data collection crew should use the radar gun or laser speed measurement system to determine whether the WIM system is correctly measuring traffic speeds. If the vehicle's speed is correct (within 1 mph), test runs can begin. If the vehicle's speed is incorrect, the scale may not be operating correctly, and the scale's input variables should be adjusted. It is not necessary to use trucks to evaluate vehicle speeds. Once the crew has established that the scale system is correctly measuring vehicle speed, additional speed data do not have to be collected other than for the test vehicles. The data collection staff should continue to enter speed values output by the WIM system for the test trucks, because this maintains the record of vehicle performance needed to analyze scale calibration under different vehicle operating speeds.

It is important to note the following points from "WIM Calibration Check Specifications For LTPP Specific Pavement Studies Sites".

- The test trucks should move at a constant speed.
- Vehicle passes must be made at a variety of speeds.
- At least three different speeds should be used.
- The trucks should not be operated at speeds above the posted limits and should not cause safety problems by operating too slowly.
- Note that "time of day" is actually a surrogate for temperature.
- To obtain a wide temperature variation, it may be necessary to collect data for more than 8 hours per day. Where possible, more than 12 test runs should be performed during each temperature range. These additional runs can be performed either by making additional runs at given vehicle speeds or by providing additional speed runs. (For example, if time is

available to make one additional pass per time period/temperature condition, the additional run might be made at the speed at which the majority of trucks operate.)

- It is also important to collect data after the temperature has started to decline to determine whether cooling of the upper pavement layers (while the lower layers stay warm) affects WIM sensor output.
- A total of 40 runs is the minimum required to have an acceptable data set for analysis. If turnaround times are such that two trucks between them cannot complete 40 runs in a 10-hour site visit (breaks included), additional trucks should be used.

For an example of this data collection effort, see Figure 1.

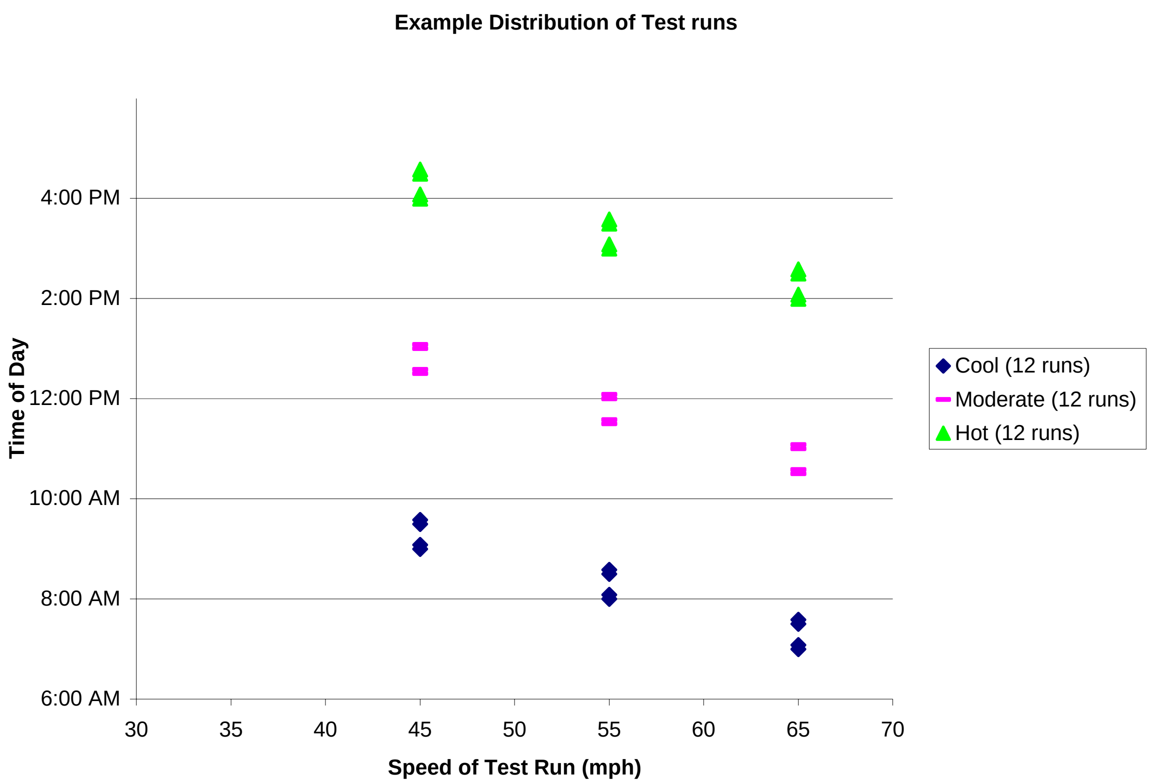

Figure 1 - Example Distribution of Test Runs by Vehicle Speed and Time of Day

For each vehicle pass, the field data collection staff should record the WIM system's output for axle weights and axle spacing. Each test vehicle's speed when crossing the sensor (collected with the radar gun) should also be obtained for comparison with the WIM system's output. The following data from the WIM system should be obtained:

- axle weights of the test trucks as they pass over the scale
- spacing between each axle on the test trucks
- speed of the test trucks
- pavement temperature at the time of the test run
- calibration factor used by the WIM scale.

These measured test truck attributes can be obtained by simply reading the values off the WIM scale display screen.[1] These data should also be stored permanently and retrieved later for confirmation that the hand entry at the site was correct. (Some WIM systems also allow these data to be printed from a portable printer or written to an ASCII file for later retrieval.)

Scheduling of runs and data collection must recognize the need for breaks for all personnel.

2.1.3 WIM DATA ANALYSIS

Once the data have been collected in the field, statistics must be computed to determine whether the WIM site meets the accuracy standards set by LTPP. The basic statistic required for this test is the error expressed as a percentage of the known value. These 'percentages of errors' computed from the data collected for each run are then used to compute a series of summary statistics which, in turn, are used to determine whether the scale is sufficiently accurate for LTPP use in providing data of acceptable quality.

The first set of tests requires data from all of the test runs performed at the site. It provides a general overview of system performance, given all of the environmental and vehicle speed conditions that were present during the testing. To perform these tests, the analyst should calculate the mean and standard deviation of the 'percentage of errors' for these variables:

- front axle weights of the test trucks
- weights of all tandem axles
- weights of all non-front axle single axles
- gross vehicle weights
- axle spacing
- speed

1 An Excel spreadsheet (**WIM 2 TRUCK)** has been created by FHWA-LTPP to assist in recording and analyzing the data collected.

For each of these values, the analyst should compute the absolute values of the 'percentage of errors' mean and the 95% confidence limits. (See formula below.)

Select the larger of

$$ABS\ (X + 1.96\ \sigma)$$

or

$$ABS\ (mean - 1.96\ \sigma)$$

where:

X = mean value of the percentage of error for each statistic

σ = standard deviation of that percentage of error

This value (for each variable) should then be compared with the values (from ASTM E1318-00) shown in Table 2. If any of these values exceeds the value in Table 2, the WIM system has failed the basic accuracy statistic for this test. If the largest of these absolute values is smaller than the values in Table 2, the system passes the basic accuracy test.

Table 2 – WIM System Calibration Tolerances – Large Sample

For SPS WIM Sites	ABS (X ± 1.96 σ)
Loaded single axles	±20 percent
Loaded tandem axles	±15 percent
Gross vehicle weights	±10 percent
Vehicle speed	±1 mph [2 km/hr]
Axle spacing length	± 0.5 ft [150 mm]

The scale being tested may pass the general accuracy test outlined above, but it still may not truly be able to accurately measure the vehicle weights of vehicles traveling at different speeds. Another set of tests examines the sensitivity of the scale system to changes in vehicle speed. To perform these tests, the runs should be sorted and grouped by vehicle speed (In the example three speed groups would be analyzed: 65 mph, 55 mph, and 45 mph as in Figure 1. Each group would consist of at least twelve runs, six by each of the two test trucks.) For each group of test vehicle runs, the mean and standard deviation of the percentage of error of each collected variable should be computed.

Because only a subset of test runs is performed at each speed range, there are fewer data points for this test than for the general performance test discussed above. To maintain confidence that the results of the test are still within the desired level of confidence, it is necessary to use the Students' *t* distribution, rather than the normal distribution in the statistical test. (Note, when the number of observations being tested reaches 30, these two tests become similar. This will occur for tandem axles when 15 3S2 test runs have been made, since each 3S2 has two sets of tandem axles.)

The formula used to compute the test statistic is similar to that shown above with the exception that the critical value of t is used for $\alpha = 0.025$ (Replace 1.96 with $t_{0.025}$). Appendix E contains critical values of $t_{0.025}$ for n-1 degrees of freedom, up to 30. While the computation of the test statistic changes to account for the smaller sample size, the criteria for passing the test do not change. These values (from ASTM E1318-00) are shown in Table 3.

Table 3 - WIM System Calibration Tolerances – Small Sample

For SPS-1, -2, -5 and -6 Sites	**ABS (X ± (*t* * σ))**
Loaded single axles	±20 percent
Loaded tandem axles	±15 percent
Gross vehicle weights	±10 percent
Vehicle speed	±1 mph [2 km/hr]
Axle spacing length	± 0.5 ft [150 mm]

where:

X = mean value of the percentage of error for each statistic

σ = standard deviation of those values

t = the Students' *t* statistic for $\alpha = 0.025$ and n-1 degrees of freedom

n = the number of samples available for that particular statistic under the conditions being tested.

A third set of tests examines the sensitivity of the scale system to changes in pavement temperature and subsequent changes in pavement performance. To perform these tests, the runs should be sorted and grouped by temperature range. Typically three ranges would be analyzed: a "cool" temperature range, represented by the morning test runs, a "moderate" range, represented by the early-afternoon test runs, and a "hot" range, represented by the late afternoon runs. The actual test run grouping should be based on actual recorded temperatures, not the timing of the individual test runs.)

For each group, the mean and standard deviation of the percentage of error for each of the test variables should be computed. These values are then used as input to the Students' *t* based test discussed above. The formula and values shown in Table 3 are again used to determine whether the errors measured by the field test fall within acceptable tolerance levels.
In addition to the basic statistical tests, the analyst should look for specific trends. For example, the scale may fall within acceptable error tolerances but show a marked bias toward extremely hot temperatures. Such a result would indicate that additional tests might be needed at higher temperature ranges. Testing would then be scheduled when hotter temperatures are expected.

2.1.4 CLASSIFICATION DATA

The vehicle classification algorithm to be used at each LTPP test site should be supplied by the state agency responsible for the operation of the roadway at that site. This agency should have performed a complete multi-hour test and evaluation of that classification algorithm prior to the site validation to ensure that it accurately classifies vehicles at that site.

The on-site test described below is not designed to fully test the algorithm. Instead, it will ensure that the installed equipment is functioning correctly and that no mistakes have been made in the installation of a previously approved algorithm on that particular set of data collection electronics. The field tests involve manually classifying vehicles crossing the WIM scale and comparing those classifications with the scale output. Classification algorithm verification must be done on a lane by lane basis. The minimum requirement is the LTPP lane.

To perform the analysis, the data collector must record classifications as vehicles cross the scale, and then record the classifications reported by the WIM system for those same vehicles. The analysis should include the full vehicle stream on the test lane rather than just heavy trucks. Classification codes are standard FHWA 13-bin codes as illustrated in figure C-1, Appendix C. It is recommended that the data collector have a copy of this figure in the field while conducting this test.

While performing the data collection, the staff person should look for specific types of errors that may be occurring, both to make sure that only limited errors are present and to identify specific limitations in the vehicle classification algorithm being used. For example, many automatic classification schemes have problems correctly differentiating between specific vehicle types because their axle spacing characteristics are similar. Consequently, the data collection crew should examine how well specific types of vehicles are classified, including the following:

- recreational vehicles
- passenger vehicles (and pick-ups) pulling light trailers
- long tractor semi-trailer combinations.

The classification data collection process can be performed when other calibration tasks are not being performed. Thus, it is not necessary for the data collection staff person to classify all vehicles crossing the scale during any given time period. (For example, the staff person can classify vehicles until the test truck approaches, stop classifying to assist in the data collection associated with the test truck run, and then return to classifying vehicles when the test truck has passed.) It is necessary, however, to enter both the manual classification and the WIM system's classification for each vehicle observed. While classification is proceeding, the staff should count all vehicles rather than pick and choose. If the volume is too high to allow this, the data collector may have to call out the classes while an additional staff member records the results. Vehicle classification should continue as long as the data collection crew is on site and are not otherwise busy. The sample must contain at least 100 trucks. If the classification check is done continuously, the minimum sample size is an hour. The classifier is considered to be working acceptably when:

- no more that 2 percent of the vehicles recorded are reported as "unclassified" by the WIM scale and
- the number of classification errors involving truck classifications is less than 2 percent.

2.1.5 Seasonal Temperature Effects

Pavement temperature affects different scale systems differently. This result of the mechanical properties of the weight sensors themselves and the interaction of those sensors with the pavement in which they are located requires that each WIM system be tested under different environmental conditions. To measure the effects of different environmental conditions on scale performance, the calibration of each scale that passes the first verification test must be verified under more than one set of environmental conditions. Tests should be performed in summer, winter, and spring where feasible, as these are times when:

- pavement strength varies as a result of different temperature and moisture conditions and;
- temperature variations (highs, lows, and maximum differences between highs and lows) differ significantly.

At most three data collection sessions are anticipated for the first year of scale operation at most sites (an evaluation and two validations). Where environmental conditions do not change significantly during the year, a minimum of two validation sessions should be performed each year. Once tests have proved that a given scale system (as installed) accurately accounts for environmental and highway operating conditions, only one validation test is required per year.[2]

FHWA-LTPP is responsible for selecting the dates on which field-testing will take place. These will be selected based on available environmental data after consultation with the state agency. Ideally, early morning temperatures during the test dates will be significantly different from temperatures found in the late afternoon. Seasonal differences in temperature variation and moisture will be handled by collecting data during different times of the year.

2.2 ANNUAL PROFILE

The profile validation will be done on an annual basis in accordance with the *Pavement Smoothness Specifications for LTPP WIM Locations*.[3] The profile data will be used for both short and long wavelength checks and will be collected in 25mm increments only. There are three options for this:

- The LTPP regional profiler will collect the profile data in conjunction with the validation visit collecting the data independently of the test truck runs.
- The LTPP regional profiler will collect sufficient data to meet short wave length evaluation requirements and then collect data for long wavelength needs by alternately following the test trucks.
- The LTPP regional profiler will collect the profile in conjunction with the regularly scheduled site profile visit.

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2 However, if the office monitoring process suggests calibration drift, additional system calibration will be required. A maximum of three checks a year is considered reasonable. If more checks are required due to drift then equipment replacement or additional validation resources will be required.

3 Pavement Smoothness Specifications for LTPP SPS WIM Locations – Version 1.0, August 31, 2001.

The pavement smoothness specifications contain detailed information on short wave length and long wavelength data collection and site marking.

2.2.1 EQUIPMENT FOR LONGITUDINAL PROFILING

The preferred equipment for collecting longitudinal profile data (long wavelength and short wavelength) is an inertial profiler meeting the Class 1 standards as specified in ASTM Standard E950-98. It shall satisfy the requirements set forth in the *Pavement Smoothness Specifications for LTPP WIM Locations – Attachment D*. Note that the sampling interval *should be set to 25mm ONLY*.

If a Dipstick® device is used for data collection, the requirements for longitudinal data collection are outlined in the *Distress Identification Manual for Long Term Pavement Performance Project – Appendix B.* Traffic Control will be required for this operation.

During all surveys, safety is the first and foremost consideration, as with any other field data collection activity. All participants must adhere to the practices and authority of the governing highway agency.

2.2.2 STRAIGHT EDGE PROFILING

Due to the requirement for lane closure, straightedge profiling is not recommended for site validation visits. If the agency requests it, and provides for the lane closure, the procedures in Section 4.2 in this guide should be followed.

2.3 PRE-TEST PREPARATION

Coordination with the FHWA, state agency and appropriate regional contractor is the first step in the site validation process. At this time agreement will be reached on the validation date, traffic sheets 17 and 18 will be reviewed and arrangements will be made to verify that the equipment is functioning on the day of the test. Traffic Sheet 17 is a site equipment inventory and contacts list maintained by the regional contractors. Traffic Sheet 18 is a site activities list that reflects the level of agency participation in various aspects of the SPS pooled fund study.

FHWA will issue notice to proceed and the lead contractor will make all necessary arrangements consistent with Traffic Sheet 18. It is expected that for the semi-annual validation process, a minimum of 30 days notice will be provided. For sites with calibration drift, two weeks notice is the expected minimum. It is expected that when calibration drift triggers a validation, a regional profiler will not be a part of the site validation process.

2.4 On-Site Visit

All data collection should be done during daylight hours and with consideration given to adjacent residences and expected periods of congestion.

It is strongly recommended that a briefing of all personnel be held prior to the site visit. Topics will include safety issues, scheduling, truck routes and profiling operations. Following the briefing, trucks should be loaded, weighed and measured. If profiling is split between short wave length and truck following operations, then short wavelength data collection should be done first.

WIM data collectors should be on site at least half an hour prior to beginning data collection to hook up equipment and perform speed validation.

It is preferred that profiling be done on the same day as a site validation. However, if scheduling conflicts exist, the required profiling should be done within 30 days of one of the site validations during that year.

2.5 Equipment Checklist

Table 4 shows the equipment considered necessary for a site validation. The initial site evaluation should determine whether the list requires refinement to include site-specific requirements that should be noted on Traffic Sheet 17.

Table 4 - Primary Equipment Required for WIM Site Validation

Item	**Provided By**
LTPP profiler	
Generator (If no A/C site power available)	
Canopy and or sun shade	
3.65 m. straight edge & disk (optional)	
Pavement marking paint	
Tape (duct, electrical tape)	
Clipboards & marking pens	
81/2 x 11 inch white board (for truck window ID ref. numbering)	
Metric/US Customary cloth and metal tape measures [6m. (20')]	
Chalk line and spare chalk – yellow keel markers	
Electrical extension power cords (110v.)	
Electrical power strip adapter with surge protection (110v.)	
Video camera with tripod and 4 tapes (optional)	
Digital camera or 35mm camera with 2 rolls of 100 ASA film	
Raytec handheld IR temperature device	
Laser or Radar gun for speed measurement	
Tire pressure gauges (2)	
Notebook PC with Win95/98 or NT OS and MS Excel 97	
Straightedge simulation software	
WIM equipment software to interpret sensor readings	
Serial cable or appropriate cable to connect to the WIM processor	
Air temperature thermometer	
WIM protocols and data collection sheets	
First Aid kit	
Utility knife, pliers, adjustable wrench, small screwdriver set, etc.	
Electrical multi-meter	
Hard hats, fluorescent safety vests and necessary safety equipment	
Appropriate clothing, sun block, bug spray, portable chairs	
Timepiece (set to local time zone)	
Sufficient drinking fluids to prevent dehydration	
Hand cleaner and paper towels	
Traffic control (if required)	
LTPP truck info cards	

2.6 REPORTING OF RESULTS

Following the visit, a site report is prepared. It consists of a memo from the lead data collection contractor and states whether the site is accepted as meeting LTPP WIM requirements and a copy of Traffic Sheet 16 for the validation session. If profiling is done concurrently with the validation, results of the short wavelength and long wavelength analysis (if applicable) will be included. The memo should include commentary on reasons for failures or suggested corrective actions as appropriate. If the problem requires re-calibration of the site and it can be done during site validation, that action should also be reported using Traffic Sheet 16. Hard copy print outs of any analysis should also be attached. The memo is sent to the FHWA LTPP Team with copies to the agency and the RSC within two weeks of the site visit. Copies of all electronic files and data collection sheets are forwarded to the RSC for retention in their site-specific files and for future disposition as AIMS data. The RSC is responsible for entering Traffic Sheet 16 data in the IMS within 30 days of the site visit. A sample memo is shown in Appendix F.

2.6.1 FAILURE CONDITIONS

If a site fails the classification check, the decision to continue with weight validation is left to the lead data collector. If the classification errors do not affect the test vehicle population, the weight validation should proceed. However, a recommendation that collection of data for LTPP purposes be suspended until the algorithm is corrected should be made.

If the site fails the weight validation checks due to a consistent bias and the data collection team has agency permission to adjust the equipment on site, it should be done. If this action is taken, a series of at least 10 validation runs at the same speed and temperature should be made to verify the adjustments. The agency should be notified immediately of the changes. A recommendation as to which data should be designated as of unknown quality will be required.

If the site fails the weight validation checks for precision and/or varying bias, a recommendation on remedial action should be made. Additionally, a recommendation as to which data should be designated as of unknown quality will be included. Data collection of classification information will continue uninterrupted as long as there are no problems with the calibration algorithm.

3 SITE EVALUATION

A site evaluation is the first visit to an SPS traffic data collection site and concludes with a site validation. All SPS-1, -2, -5 and -6 sites require such a visit to provide a snapshot in time of site conditions whether or not the site is monitored by the agency or LTPP. Any SPS-8 identified for intensive monitoring will also require a site evaluation.

3.1 WEIGHT VALIDATION

The weight validation process is identical to that for site validation. The principal difference is that the day selected need not be during a seasonal high or low for sites that will continue under LTPP monitoring. For sites at which agency data collection will continue, every effort should be made to find a 24-hour period during which significant temperature variation will exist. This may require doing both day and night time data collection subject to agency permission.

3.2 PROFILE MEASUREMENTS

To obtain the maximum amount of information on short wave length and long wavelength impacts on scale performance a regional profiler will be present during validation. There are two options for profiling. The first is preferred but may not be possible.

- Collect the long wavelength profiles while following the validation vehicles. The profiling runs should be split evenly between the trucks. Additional profile runs specifically for the collection of short wavelength data should be made either before or after the validation runs.

- Collect the profiles independent of the validation vehicles.

3.2.1 STRAIGHT EDGE PROFILING

Straight edge profiling is not recommended for site evaluation since lane closure is required. If the agency requests straightedge smoothness evaluation, it should be done either the day before or the day after the site validation runs.

3.3 EQUIPMENT CHECKLIST

The same equipment checklist used for site validation is used for site evaluation.

3.4 PRELIMINARY DATA

Prior to conducting a site evaluation, Traffic Sheets 17 and 18 should be completed. Completion of Traffic Sheet 18, WIM Site Coordination, is initiated by FHWA as a result of the agreements it has with agency.

Traffic Sheet 17, WIM Site Inventory, contains all the information on the WIM equipment location. It should include photographs and any information on test truck routes available. After completion of the site evaluation it should include maps of such routes, break areas and photos of the site and landmarks on the truck route. The latter is particularly important when the shortest route takes vehicles through commercial or residential neighborhoods.

3.4.1 PROFILE DATA

A preliminary short wavelength profile by the LTPP regional profiler is recommended to get a first estimate on smoothness so the WIM scale can be properly evaluated. Additionally, this visit will indicate if the 305 m section overlaps a core project section, reducing the ability to improve smoothness by grinding.

3.4.2 CLASSIFICATION AND SPEED DATA

Classification data is needed to determine the type of test trucks needed for the site. The classification data should exist in LTPP files. A 48-hour sample period covering the same days of the week as those proposed for testing should be extracted and a diurnal curve prepared for the individual truck classes. The data should be extracted from raw data files that have passed LTPP traffic QC.

Speed data is needed to design the test truck runs to meet the evaluation protocol. The speed data must be requested from the agency since it is not an element collected or required by the LTPP program.

3.4.3 DISTRESS IDENTIFICATION

Traffic Sheet 17 includes space to record distress surveys done at the site. The Distress Identification Manual for the Long Term Pavement Performance Project shall be used as the standard guide for interpretation, identification and rating of observed distresses.

3.5 PRE-TEST PREPARATION

The pre-test preparation is the same as for site validation. Additionally, where feasible, all drivers should be taken over the proposed truck route to verify that there are no conditions that would preclude using the route under test conditions.

3.6 ON-SITE VISIT

The same conditions for the on-site visit under site validation apply to site evaluation.

3.7 REPORTING OF RESULTS

The memo report used for site validation is also used for site evaluation.

4 CONSTRUCTION

4.1 SITE LOCATION (SELECTION)

Site selection should conform to guidelines in the *State's Successful Practices for Weigh-in-Motion* handbook. For LTPP purposes, several additional constraints exist: it needs to be in the LTPP lane without any major traffic generators between the WIM equipment and the LTPP test sections; it cannot be installed within a test section; and correcting pavement conditions before and or after the sensors cannot be done within LTPP test section limits.

4.2 SMOOTHNESS ACCEPTANCE

Site acceptance for smoothness following the construction of new pavement for WIM installation may be done only with a straightedge in accordance with *Pavement Smoothness Specifications for LTPP SPS WIM Locations* - Version 1.0, August 31, 2001. An inertial profiler and the straightedge simulation software may be used, if necessary, to identify the need for grinding of pavement near the sensor location.

4.2.1 EQUIPMENT FOR STRAIGHT EDGE PROFILING

The following equipment is necessary for performing field straightedge profiling of any pavement surface. This listing is a guide, and the equipment should be assembled prior to the site operations (consideration must also be given for local site conditions).

During the survey, safety is the first and foremost consideration, as with all field data collection activities. All participants must adhere to the practices and authority of the governing highway agency.

Table 5 - Equipment Checklist for Straightedge Smoothness Testing of Newly Constructed Pavements

Item	**Check**
Smoothness Specifications for LTPP SPS WIM Locations – Protocol	
Extra blank data sheets	
Sufficient writing implements (pens/pencils)	
LTPP Distress Identification Manual (DIM)	
Clipboard	
3.65m (12ft.) Straightedge device & sizing disk	
Chalk line (include spare chalk)	
Pavement marking keel (1 box yellow)	
Two tape measures, one at least 30m (100ft) and a metric ruler	
Calculator	
Hardhat, steel toed shoes and safety vest	
35mm camera	
Video camera with blank tapes	

4.3 EQUIPMENT ACCEPTANCE

The selected WIM sensors will be installed following acceptance of the pavement. The installer is responsible for the initial calibration of the equipment and for the verification of the classification algorithm. Calibration is done according to the methods recommended by the equipment manufacturer. When the installer is satisfied that the calibration is correctly meeting LTPP tolerances and that sufficient learning time has occurred for algorithms to develop any factors that are dependent on changes in speed or temperature, LTPP will verify that the necessary conditions are met by conducting a site evaluation.

5 DATA PROCESSING

Data processing of LTPP traffic data is required for three separate streams of information, CTDB data, IMS data, and AIMS information.

5.1 CTDB DATA

Data for the Central Traffic Database consists of classification and weight data generated by the equipment in Traffic Monitoring Guide format. The LTPP program can accept data in either the second or third edition formats. Data may be downloaded directly from the site by the RSCs subject to agency permission or it may be forwarded by the agency every two weeks. The data is processed through the Traffic QC software and then through the Traffic Analysis Software. A specific suite of graphs to check site performance and calibration drift are created and reviewed. Depending on the results of this review a site may continue to be monitored at the regular frequency or at more frequent intervals if a problem is suspected. No site should be out of service more than 30 days from the time a problem is detected and confirmed.

In order to perform these checks, baseline data sets are created from data collected immediately following a successful site evaluation or validation. The baseline data set includes a minimum of one week of data and at least 250 Class 9 trucks collected immediately after the site visit. The data for all trucks is aggregated for comparison purposes using the LTPP Traffic Analysis Software. It is possible for sites with strong seasonal variation in truck loading patterns to have more than one baseline comparison set.

5.2 IMS DATA

With the publication of the *Guide to LTPP Traffic Data Collection and Processing*[4], Traffic Sheet 16 was issued to record the details of site calibration and validation visits. This sheet is completed for every site visit at which trucks are run across the scale for calibration or validation purposes. The sheet should be submitted to the RSC within a month of the completion of the activity and the data entered in the regional IMS no more than 30 days after its receipt.

4 Guide to LTPP Traffic Data Collection and Processing, Federal Highway Administration Long Term Pavement Performance Division (FHWA-LTPP), Washington, D.C. March 2001

5.3 AIMS DATA

AIMS (Auxiliary Information Management System) data consists of information collected by LTPP for documentation of site conditions or subsequent processing into more commonly used statistics. All data classified as AIMS is available on request by data users subject to the data release policies of the LTPP.

SPS traffic data collection sheets 14, 15 and 17 through 21 are currently considered AIMS data. As such, these paper sheets or their electronic copies are to be retained by the regional contractors for future disposition and cataloguing. The spreadsheets used for evaluating classification and WIM results are AIMS data. The guidelines for storing them are found in Appendix D. Additionally, the p files containing the output of the LTPP profilers are considered offline data, of interest to a very limited number of researchers. These data are available in electronic form and stored according to the guidelines in the smoothness specifications for WIM sites.

6 REFERENCES

The SPS traffic data collection effort builds on existing LTPP and other standard practices. Unless otherwise indicated in the directives under which they are issued all changes to LTPP authored documents will automatically be incorporated in this document.

Incorporated by reference are the following documents:

6.1 LTPP DIRECTIVES

1. LTPP Directive GO-16 – "LTPP Regional Operations Review Plan - Traffic Program", December 3, 1998.[5]

6.2 LTPP PROTOCOLS

2. Pavement Smoothness Specifications for LTPP SPS WIM Locations - Version 1.0, August 31, 2001.[6]

3. WIM Calibration Check Specification Check for LTPP SPS Sites - Version 1.0, August 31, 2000.

6.3 LTPP GUIDELINES

4. LTPP Bending Plate Weigh-in-Motion System: Model Specifications for Equipment - Hardware and Software - Version 1.0, August 29, 2000.

5. LTPP Bending Plate Weigh-in-Motion System: Model Specifications for Pavement and Installation - Version 1.0, August 29, 2000.

6. Guide to LTPP Traffic Data Collection and Processing, April 11, 2000.

7. LTPP Manual for Profile Measurements Operational Field Guidelines, Version 3.1, January 1999.

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5 A draft to replace this directive is under development.

6 This document will be modified in late Fall 2001 pending completion of long wave length research.

8. LTPP Traffic QC Software: Volume I – Users' Guide, version 1.61, August 28, 2001.

9. LTPP Traffic Analysis Software: Volume I – Users' Guide, forthcoming December 2001.

10. LTPP Regional Operations Review Plan - Profile Measurements, Version 1.3, August 1997.

6.4 NON-LTPP DOCUMENTS

11. States' Successful Practices Weigh-in-Motion Handbook, FHWA, December 1997.

12. ASTM E1318-00: "Standard Specification for Highway Weigh-in-Motion (WIM) Systems with User Requirements and Test Methods"

7 SITE INVENTORY AND IDENTIFICATION

Responsibility for keeping site inventory and identification information current is split between FHWA and its LTPP SPS traffic data collection contractors. FHWA is responsible for the agency agreement. The data collectors are responsible for all other items.

7.1 AGENCY AGREEMENT

A formal agreement will exist between FHWA and the individual state agencies as to which services the agency will be provided for each year that they participate in the national pooled fund study for LTPP SPS Traffic data collection. FHWA will provide a current copy of Traffic Sheet 18 to the contractor as a part of the notice to proceed on site activities.

7.2 SITE INVENTORY

An initial site survey will be done for all SPS sites. A completed survey will include copies of the following:

- Traffic Sheet 14 (media and data base location to be determined)
- Traffic Sheet 15 (media and data base location to be determined)
- Traffic Sheet 17 with photos

A copy of Traffic Sheets 17 and 18 will accompany LTPP data collectors on every site visit.

7.3 NAMING LTPP WIM SITES

To simplify inclusion of WIM site data into the existing data processing streams for monitored traffic and profile data, each WIM site will be assigned a unique SHRP ID number. A SHRP ID is a 4-character code which, on an SPS, project reflects the experiment and the type of section to which the data applies. For SPS WIM sites the same convention will be followed. The first two characters will be that of the experiment. The last two characters will be '99' for the current WIM equipment installation. If the WIM sensors are relocated so that the original 152m (500 foot) section is no longer used then the second of these two characters will be decreased by one.

Example 1

An SPS-5 has a currently installed bare flat ceramic piezoelectric WIM system. This site will initially be identified with SHRP ID 0599. The sensors fail and the agency elects to install quartz piezoelectric sensors in the same location as replacements. After the installation of new sensors at the site, it retains the 0599 designation.

Example 2

Existing WIM equipment at a SPS-6 project (0699) some distance from the project limits must be replaced because it falls within a pavement rehabilitation project. The agency elects to put the replacement system closer to the SPS project. The new installation receives the SHRP ID of 0698.

7.4 MARKING THE LTPP WIM SITE

LTPP WIM sites may be marked permanently or temporarily depending on agency preference. Permanent markings will be marked according to the guidelines in Attachment F of *Pavement Smoothness Specifications for LTPP SPS WIM Locations* - Version 1.0, August 31, 2001. Marking of the WIM site with the letters “WIM” may be omitted at the agency's request.

8 SITE VISIT PLANNING & COORDINATION

Each specific activity that involves a site visit by LTPP personnel requires significant coordination efforts to ensure maximum productivity during the on-site activities. The following three sections outline the responsibilities of each participant at site visits for WIM evaluations, WIM validations and WIM construction. It also explains the use of some standardized checklists for ensuring that no detail is overlooked during these operations.

8.1 SITE VISITS – EVALUATION

Every active SPS-1, -2, -5 and -6 site with working WIM equipment will be visited at least once to provide baseline information on system operations and equipment. This visit is conducted with state consent and might be the only visit by LTPP personnel if the agency elects to continue traffic data collection activities independently. A site evaluation includes testing the WIM performance by operating test trucks with known weights over the sites, checking the classification performance of the equipment by comparing its generated results with manual observations, testing the short and long wavelength profile of the pavement at the approach to the WIM scale with a regional profiler and evaluating the site for problems due to pavement distresses or geometry. Each of these activities requires advance planning. The checklist to assist the data collectors with these activities is available in Appendix C.

8.2 SITE VISITS – VALIDATION

The site visit for WIM equipment validation is nearly identical in operational details as a visit for a site evaluation and hence will require the use of the same set of checklists to coordinate the activities of participants.

8.3 SITE VISITS – CONSTRUCTION

A site visit for the purpose of construction or reconstruction of pavement for the installation of WIM sensors will require a number of additional operations and hence a separate checklist has been developed for this process. The principle differences are related to overseeing any pavement grinding operations and using a straightedge device to ensure that the new pavement surface is sufficiently smooth for accurate WIM operation. There also may be a need to evaluate a location prior to construction for suitability as a WIM site candidate.

APPENDIX A

WIM Equipment Verification Procedure For LTPP SPS Sites

A. WIM EQUIPMENT VERIFICATION PROCEDURE FOR LTPP SPS SITES

This document provides guidelines for verifying the accuracy of weigh-in-motion (WIM) systems for collecting LTPP traffic data at SPS 1, 2, 5, and 6 sites. It provides a performance specification that must be met by all WIM systems purchased by either state highway agencies (SHAs) or the Federal Highway Administration's Long-Term Pavement Performance Program Team (FHWA-LTPP) for data collection at those SPS WIM sites.

The verification process consists of two parts, field data collection and ongoing office review of collected data. This document only discusses the field tests required to certify that a WIM system performs with the accuracy required by the LTPP tests. The office procedures reviewing the data collected from the WIM system are discussed separately.

A.1. INTRODUCTION

The intent of the LTPP SPS WIM data collection effort is to improve the quality and reliability of the WIM data collected at the most important LTPP test sites. LTPP has decided that a central contractor will be responsible for collection and processing of data WIM data at LTPP SPS sites 1, 2, 5, and 6.[1] However, the equipment used to collect these data will not always be the same. In some cases, the equipment will be purchased and installed under specifications provided by FHWA-LTPP. In other cases, the SHA will have already installed a WIM scale, and the scale may not be the same as those selected with the FHWA-LTPP equipment specification. To ensure that high quality data will be collected under this program, all WIM devices used for this program will be required to meet performance specifications for data accuracy and reliability. Both types of scales (FHWA-LTPP provided or SHA provided) must meet the same performance specifications. These specifications are presented below.

A.2. SYSTEM PERFORMANCE REQUIREMENTS

The LTPP program requires that WIM scale systems used to collect data under the LTPP SPS traffic loading data collection program meet accuracy and reliability standards similar to those listed in ASTM E-1318 for Type I scale systems. The criteria adopted by LTPP are given below in Table A-1.

[1] Note: there are cases where the state highway agencies (SHA) will continue to perform these tasks. However, the SHA must be able to meet all of the guidelines and instructions set forth in this document.

Table A-1-- WIM System Tolerances[2]

SPS-1, -2, -5, and -6 Sites	95 Percent Confidence Limit of Error
Single axles	" 20 percent
Tandem axles	" 15 percent
Gross vehicle weights	" 10 percent
Vehicle speed	" 1 mph [2 km/hr]
Axle spacing length	" 0.5 ft [150 mm]

Because collection of accurate traffic loading rates throughout the year is necessary to provide the loading rates needed for SPS test section research, the WIM systems used in this effort must meet the ASTM criteria all year long. Historically, many WIM systems have had problems accurately weighing vehicles when environmental conditions have changed from those that were present when the equipment was last calibrated. Changes in pavement strength at the scale location (often caused by changes in pavement temperature or moisture content) are known to cause problems with WIM system sensor accuracy. Because vehicle dynamics change with vehicle speed, it is also necessary to ensure that the WIM systems are able to accurately weigh trucks at the variety of speeds trucks will travel at each scale site.

All WIM systems currently on the market use one or more “calibration factors” as part of the process for converting axle sensor information into axle and vehicle weight estimates. These “calibration factors” are increased if the scale under-estimates static weights or decreased if the scale over-estimates static weights. In addition, many sales use an “auto-calibration” process that adjusts scale calibration based on monitored inputs. These adjustments are designed to take into account changing sensitivity of the scale sensors and electronics to changing environmental conditions and the aging sensors.

The goal of the verification specification is to prove that the scale system will produce accurate vehicle weights under expected highway operating and environmental conditions. This includes proving that the scale system does not produce outputs that are biased by temperature and/or vehicle speed and that the calibration factors are correctly set.

The recommended scale performance verification process involves weighing trucks of known weight with the WIM scale, and then comparing the WIM system’s measurements with the known weights. The conditions under which vehicles are weighed by the WIM system are controlled to demonstrate that the system operates accurately under the majority of conditions expected to occur during LTPP data collection. During testing, the scale should be operated in

2 These tolerances are taken from ASTM standard E1318-00.

its "normal" manner. That is, if auto-calibration settings are normally "on" then they should also be "on" during the verification tests.

The primary verification testing can be done with a minimum of two test trucks. Once a scale system has proved to be unaffected by vehicle speed and temperature over the course of a year, it is also permissible to verify scale calibration by comparing the statically measured weights of vehicles pulled from the traffic stream at static scales with WIM system weights for those same trucks. Note that this document describes only the use of test vehicles.

A.3. OUTLINE OF PERFORMANCE TESTING PROCEDURE

The scale accuracy tests are designed to verify the performance of the scale as temperature and vehicle speed vary. The test plan requires the test trucks to make multiple passes over the scale sensors during a single day. Passes are made at different speeds and on days during the year when the highest daily temperature variations are likely to be found at the test site. Statistical tests are performed to examine system accuracy for both the entire data collection period and for subsets of the data that represent particular environmental or operational conditions.

The accuracy and reliability of data produced by the scale are computed by comparing the measured axle weights collected under these varying conditions with the known weight characteristics of the test vehicles. These basic test runs are then repeated two or three times during the year to make sure that the scale works accurately during the expected environmental conditions at that site.[3]

A.3.1. EQUIPMENT NEEDED

A minimum of two test trucks are required to perform the scale verification tests. These two vehicles should not have the same loading and/or configuration. One of the test vehicles should be a 3S2 (tractor, semi-trailer) with an air suspension system on all tandem axles. The air suspension should be in good condition. This vehicle should be loaded to approximately 80,000 pounds with a load that will not shift during the calibration test runs.

The second vehicle to be used in the calibration may be either a second 3S2 with a lighter load (less than 70,000 pounds) or a truck of an entirely different axle configuration. A good choice for the second vehicle is whatever vehicle configuration is supplying a large percentage of the axle loads to the SPS test pavement. Three- or four-axle single unit dump trucks <u>should not be</u>

[3] Additional runs may also be required, if concerns about the accuracy of the scale under different temperature conditions are not fully resolved by the initial tests, or if calibration drift is detected by routine quality assurance tests.

used for calibration checking[4] unless they are a major component of the traffic load experienced at that site. The second test truck should also be loaded to near its legal limit (unless it is a 3S2, as stated earlier), and should also have a suspension in good condition (air bag suspensions are preferred, but are not required for this second vehicle.)

If more than two test vehicles are used, the third and successive vehicles may be configured and loaded as desired, although the use of three- or four-axle single-unit dump trucks is still discouraged. All trucks should have suspension systems in excellent working condition. A mix of loaded and unloaded or lightly loaded trucks is recommended.

The loads on all test trucks should be stable. For example, the loads should not be liquids (water) that shift within a tank. Such shifting causes the axle weights to vary with time and reduces the accuracy of the tests. If natural resource materials are used to load the test trucks, these loads should be covered to prevent adverse weather from adding to the weight of the load. Loads which are fastened to the vehicle to prevent moving should have their initial positions marked and the loads checked for movement during and after the verification process.

The trucks' tires should have a conventional highway tread pattern, not an off-road pattern, as a "knobby" tread can cause unusual sensor readings from some WIM systems. After being loaded and with full fuel tanks, both test trucks should proceed to a certified commercial scale[5] to have their axle weights measured. Trucks should be weighed so that either three measurements of each axle plus the gross weight or two measurements of each axle weight and three measurements of the gross weight are obtained. The average weight should be written down and passed along to the WIM data collection crew. This process should be repeated at the end of the testing session.

Last, the axle spacings (from centerline to centerline of each tire) should be measured for each test vehicle and reported to the WIM data collection staff.

In addition to the test trucks, the calibration team requires at least three radios, an infrared thermometer for measuring pavement temperature, and a computer for collecting the WIM data.

[4] Conventional dump trucks tend to have unusual suspension characteristics. These characteristics result in inappropriate calibration settings. Therefore, they should not be used for most calibration efforts. Where these trucks make up the majority of heavy vehicles on a given roadway, it may be appropriate to use such a vehicle as one of the calibration trucks (along with the 3S2). If this is the case, consult with FHWA-LTPP before selecting vehicles to be used in the calibration check.

[5] The state weighing certification for that scale should be current, and the accuracy of that scale should have been checked within the last year. The test trucks can also be weighed for these tests with a state weight enforcement scale.

A radar (or laser) gun for collecting vehicle speeds is also important.[6] (Suitable substitutions to these devices are acceptable, so long as the data collection requirements are met.)

A.3.2. STAFF NEEDED

A minimum of four staff people are needed for this effort. Two staff collect data at the WIM system. The remaining staff drive the test trucks.

A.4. BASIC PROCEDURES

A.4.1. TEST TRUCK OPERATION

Once the test trucks have been weighed at a calibrated, certified static scale that meets Handbook 44[7] specifications, they should make repeated passes over the WIM scale. The test trucks should initially operate at the mode (most common) speed of traffic currently using the roadway. The test trucks should move at a constant speed when they cross the scale (i.e., they should not be accelerating or decelerating), and they should be as centered in the lane as possible when crossing the scale. In most cases, this means that the test trucks will drive a continuous loop around the scale. After traveling over the scale, they should proceed to the next safe location where they can turn around. They should then pass back past the scale and proceed to the next safe location to turn around again. Once a truck has turned around and is accelerating back on the main roadway, the driver should contact the data collection crew to provide an estimated time for crossing the scale. This allows the data collection crew to prepare for the truck's arrival.

When approaching the WIM scale, drivers should hold the vehicle speed steady. After crossing the WIM scale, they should report to the collection crew the speed at which they were moving as they crossed the site. (This contact should take place after they have completely crossed the scale, as radio system broadcasts can cause interference with the WIM system outputs, causing false readings.)

Vehicle passes must be made at a variety of speeds. The speed range to be tested should include the speeds at which roughly 80 percent of the truck traffic at that site travel when they cross the scale. At least three different speeds should be used. If more than 40 miles per hour separate the highest speed from the lowest speed to be tested, four different speeds should be tested. A minimum of a 15-mph spread should exist between the highest and lowest speed to be tested.

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[6] Other independent, calibrated, speed measuring devices can also be used, so long as the tests of measured vehicle speed specified can be accomplished.

[7] "Specifications, Tolerances and Other Technical Requirements for Weighing and Measuring Devices": National Institute of Standards and Technology (NIST) Handbook 44, U.S. Government Printing Office Superintendent of Documents, Mail Stop: SSOP Washington, D.C. 20402-9328, ISBN 0-16-046313-7.

Test runs should be made starting at the fastest speed selected for each test vehicle. The second run for each vehicle should be at the next slower test speed, with this pattern continuing until one run has been performed at each test speed. Then, the highest test speed should be used again. This rotating pattern of speeds should continue until the end of the data collection effort. As many test runs as possible should be performed. The targeted minimum is 40 runs for all trucks combined. This pattern will increase the sample size for each of the speed-temperature combinations.

If congestion or other factors limit the ability of a driver to make a specific test run at a given speed, the driver should attempt to make that run at the next slower speed, while keeping a constant speed as the test truck passes over the scale. When the intended speed can not be maintained, the driver should attempt to make the next test run at the originally intended speed.

A.4.2. DATA COLLECTION AT THE WIM SCALE

For each vehicle pass, the field data collection staff should record the WIM system's output for axle weights and axle spacings. Each test vehicle's actual speed when crossing the sensor should also be obtained for comparison with the WIM system's output.

The following data from the WIM system should be obtained:

- the axle weights of the test trucks as they pass over the scale
- the spacings between axles on the test trucks
- the speed of the test trucks
- the sequence number of the test run8
- the temperature at the time of the test run9 (if not part of the system outputs will need to be obtained by other methods)
- the date of the test run
- the time of the test run
- the calibration factor used by the WIM scale.

These measured test truck attributes can be obtained by simply reading the values off of the WIM scale display screen.[10] These data should also be stored permanently and retrieved later for confirmation that the hand entry at the site was correct. (Some WIM systems also allow these data to be printed to a portable printer or written to an ASCII file for later retrieval.) Where differences in system recorded and observer recorded weights occur (that is the screen of the

[8] This is the reference number used by the WIM system software to indicate this particular weight record. It may also be called the "record number" or "WIM assigned vehicle number."

9 Pavement temperature is preferred. Use of air temperature will require conversion to pavement temperature using generally accepted practices and may require collecting of additional data.

computer on-site rounds up a value that is carried to more significant digits in the main WIM system record), the main WIM system record should be used in the analysis effort.

While the test runs are being started, the data collection crews should use the radar gun[11] to determine whether the WIM system is correctly measuring traffic speeds. The data collection crew should also observe the measured tandem axle spacings of the drive tandems on 3S2 vehicles. If the vehicle's speed is correct (within 1 mph), and if the observed drive tandem spacing is approximately 4.4 feet, then test runs can begin. If either of these values are incorrect, the scale may not be operating correctly, and the scale's input variables should be adjusted.

Once the crew has established that the scale system is correctly measuring vehicle speed, additional speed data do not have to be collected other than for the test vehicles. However, the data collection staff should continue to record speed values output by the WIM system, since this maintains the record of vehicle performance needed to analyze scale calibration under different vehicle operating speeds and environmental conditions.

For each calibration truck run the pavement temperature must be recorded. Measurements should be made near but not on the sensor.

A.5. ANALYSIS OF THE WIM DATA

Once the data have been collected in the field, the statistics must be computed to determine whether the WIM site meets the accuracy standards set by LTPP. The basic statistic required for this test is the percentage of error for each of the variables measured. The percentages of errors computed from the data collected for each run are then used to compute a series of summary statistics. These summary statistics are then used to determine whether the scale is sufficiently accurate for LTPP use.

A.5.1. OVERALL SYSTEM ACCURACY TESTS

This first set of tests requires data from all of the test runs performed at the site. It provides a general overview of system performance, given all of the environmental and vehicle speed conditions that were present during the testing. To perform these tests, the analyst should calculate the mean and standard deviation of the percentage of errors for the following variables:

- the front axle weights of the test trucks

(continued…)

10 An Excel spreadsheet (**WIM 2 TRUCK**) has been created by FHWA-LTPP to assist in recording and analyzing the data collected.

11 Or other calibrated, independent speed measurement system, with an accuracy of better than ±0.25 mph.

- all tandem axles
- all non-front axle single axles
- GVWs
- axle spacings
- vehicle speeds.

For each of these values, the analyst should compute the absolute values of the mean, plus or minus two standard deviations. The actual formula is given below. Select the larger of

$$ABS\ (X + 1.96\ \sigma) \text{ or } ABS\ (X - 1.96\ \sigma)$$

This value (for each variable) should then be compared with the values shown in Table A-2. If any of these values exceeds the value in Table A-2, the WIM system has failed the basic accuracy statistic for this test. If the largest of these absolute values is smaller than the values in Table A-2, the system passes the basic accuracy test.

Table A-2 --WIM System Tolerances[12]

For SPS-1, -2, -5, and -6 Sites	**ABS (X "1.96 s) should be less than these values**
Single axles	" 20 percent
Tandem axles	" 15 percent
Gross vehicle weights	" 10 percent
Vehicle speed	" 1 mph [2 km/hr]
Axle spacing length	" 0.5 ft [150 mm]

where:

X = mean value of the error for each statistic

σ = the standard deviation of that error

A.5.2. SPECIALIZED TESTS – SENSITIVITY TO SPEED

The scale being tested may pass the general accuracy test discussed above, but still may not be able to accurately measure the weights of vehicles traveling at different speeds. Another set of analyses examines the sensitivity of the scale system to changes in vehicle speed.

To perform this test, the test runs should be sorted by vehicle speed so that the data are grouped by the speed at which the test runs were performed. If three different test speeds were used (e.g., 65 mph, 55 mph, and 45 mph), three different accuracy computations will need to be made. Each speed analysis would consist of a summary of errors for all test truck runs performed at the

12 These tolerances are taken from ASTM standard E1318-00.

speed in question. For each group of test vehicle runs, the mean and standard deviation of the percent error of each of the collected variables should be computed.

Because only a subset of test runs is performed at each speed range, there are fewer data points for this test than for the general performance test discussed above. To maintain confidence that the results of the test are still within the desired level of confidence, it is necessary to use the Students' *t* distribution, rather than the normal distribution in the statistical test. (Note, when the number of observations being tested reaches 30, these two tests become identical. This will occur for tandem axles when 15 3S2 test runs have been made, since each 3S2 has two sets of tandem axles.)

The formula used to compute the test statistic is similar to that shown above, only instead of using the value 1.96, the critical value of *t* is used for $\alpha = 0.025$. (These values are given in the appendix.) While the computation of the test statistic changes to account for the smaller sample size, the criteria for passing the test do not change. These values are shown in Table A-3.

Table A-3--WIM System Tolerances[13]

For SPS-1, -2, -5 and -6 Sites	**ABS (X " (*t* * s)) should be less than these values**
Single axles	"20 percent
Tandem axles	"15 percent
Gross vehicle weights	"10 percent
Vehicle speed	"1 mph [2 km/hr]
Axle spacing length	" 0.5 ft [150 mm]

where:

X = mean value of the error for each statistic
σ = the standard deviation of that error
t = the Students' *t* statistic for $\alpha = 0.025$ and n-1 degrees of freedom
n = the number of samples available for that particular statistic under the conditions being tested.

Lastly, in addition to the Students' *t* test discussed above, a plot of percent measurement error versus vehicle speed should be created for each of the test variables. An analysis of this plot will also indicate if and how speed effects weight measurements.

13 These tolerances are taken from ASTM standard E1318-00.

A.5.3. Specialized Tests – Sensitivity to Temperature

A third set of tests examines the sensitivity of the scale system to changes in pavement temperature and subsequent changes in pavement performance. To perform these tests, the test runs should be sorted and grouped by temperature range. Because the field test can not control actual pavement temperatures, the grouping process is not as structured as the tests for speed sensitivity discussed above.

The recommended grouping process splits the day's test runs into three groups. Take the highest and lowest temperatures measured during the tests. The difference in these measurements gives the range of temperatures observed. Divide the range by three. This value allows splitting the observed temperatures into three even range groups, cool, moderate, and warm, where "cool" is the lowest third (from minimum temperature to minimum plus one third the range), and "warm" is the highest (from maximum temperature to maximum minus one third the range.)

Specific test groups are then created by sorting test runs into each of these three test groups based on the pavement temperatures measured at the time of the test run.

For each group, the mean and standard deviation of the percentage of error for each of the test variables should be computed. These values are then used as input to the Students' *t* based test discussed above. The formula and values shown in Table 3 are again used to determine whether the errors measured by the field test fall within acceptable tolerance levels.

In addition to the basic statistical tests, the analyst should look for specific trends. For example, the scale may fall within acceptable error tolerances but show a marked bias toward extremely hot temperatures. Such a result would indicate that additional testing may be needed at higher temperature ranges. Such testing would then be scheduled when hotter temperatures are expected. As with the speed sensitivity tests, this can be accomplished by plotting percent error against pavement temperature.

A.6. Vehicle Classification Data Collection and Testing

The vehicle classification algorithm to be used at each LTPP test site should be supplied by the SHA responsible for the operation of the roadway at that site. The SHA should have performed a complete multi-hour test and evaluation of that classification algorithm to ensure that it accurately classifies trucks in that state.

The on-site test that is described below is not designed to fully test the algorithm. Instead, it is designed to ensure that the installed equipment is functioning correctly and that no mistakes have been made in the installation of a previously approved algorithm on that particular set of data collection electronics. The field test involves manually classifying vehicles crossing the WIM scale and comparing those classifications with the scale output.

To perform the analysis, the data collector must enter classifications as vehicles cross the scale, and then enter the classifications reported by the WIM system for those same vehicles.

While performing the data collection, the staff should look for specific types of errors that may be occurring, both to make sure that only limited errors are present and to identify specific limitations in the vehicle classification algorithm being used. For example, many automatic classification schemes have problems correctly differentiating among specific vehicle types because their axle spacing characteristics are similar. Consequently, the data collection crew should examine how well specific types of vehicles are classified, including the following:

- recreational vehicles
- passenger vehicles (and pick-ups) pulling light trailers
- long tractor semi-trailer combinations.

The classification data collection process can be performed when other calibration tasks are not being performed. Thus, it is not necessary for the data collection staff person to classify all vehicles crossing the scale during any given time period. (For example, the staff person can classify vehicles until the test truck approaches, stop classifying to assist in the data collection associated with the test truck run, and then return to classifying vehicles when the test truck has passed.) It is necessary, however, to enter both the manual classification <u>and</u> the WIM system's classification for each vehicle observed.

Vehicle classification should continue as long as the data collection crew is on site and are not otherwise busy.

The classifier is considered to be working acceptably when -

1) no more than 2 percent of the vehicles recorded are reported as "unclassified" by the WIM scale
2) the number of classification errors involving <u>truck</u> classifications is less than 2 percent.

A.7. SELECTION OF DAYS DURING THE YEAR FOR TESTING

Because temperature affects different scale systems differently, as a result of the mechanical properties of the weight sensors themselves and the interaction of those sensors with the pavement in which they are located, it is necessary to test each WIM system under different environmental conditions. To measure the effects of different environmental conditions on scale performance, the calibration of each scale that passes the first verification test must be verified under more than one set of environmental conditions. Tests should be performed in the spring, summer, and winter, as these are times when

- pavement strength varies as a result of different temperature and moisture conditions
- temperature variations (highs, lows, and maximum differences between highs and lows) differ significantly.

A maximum of three data collection sessions are anticipated for the first year of scale operation at most sites. Where environmental conditions do not change significantly during the year, a minimum of two calibration verification sessions should be performed each year. Once tests have proved that a given scale system (as installed) accurately accounts for environmental and highway operating conditions, only two calibration verification tests are required each year.[14]

FHWA-LTPP is responsible for selecting the days on which field testing will take place. These days will be selected on the basis of available environmental data and consultation with the SHA. Days will be selected when early morning temperatures are expected to be significantly different from temperatures found in the late afternoon. The intent is to allow collection of data during a single day when pavement temperatures (and consequently pavement strength) vary during the day.

Seasonal differences in temperature variation and moisture will be accounted for by collecting data during different times of the year.

A.8. APPENDIX - SAMPLE SIZE VERSUS ACCEPTABLE STANDARD DEVIATION

The number of test runs affects the confidence that results from the test results obtained. The simple statistical tests presented in this paper assume a normal distribution of errors and independence in the measurement of those errors. Neither of these assumptions is true. However, by developing a testing program that requires changing speeds (which change the effect of vehicle dynamics), temperatures (which affect pavement profile and strength), and different suspension types (through the use of more than one test vehicle), LTPP has created a test situation with a limited number of test vehicles that is likely to contain a greater degree of variation than would be found with a purely random sample of trucks. Therefore, the use of these statistical formulations is considered to be an acceptably conservative approach.

However, when the statistical tests are applied to subsets of the test data, the sample size involved can be quite small. As a result, the Students' *t* distribution has to be used rather than the normal distribution for statistical tests. Note that the sample size used to determine the appropriate number of degrees of freedom will change with each variable tested. This is because the test procedure assumes that each axle group is an independent measure of performance. Thus, if four test runs are made with 3S2 trucks, the sample size for the GVW test will be four, but the sample size for the tandem axle test will be eight.

The Students' *t* statistic for a 95 percent confidence interval is a function of the sample size. The appropriate value for *t* is given in Table A-4 below.

Table A-4 Values of Students' *t* Statistic for Different Sample Sizes[15]

Sample Size	t
12	2.201
14	2.16
16	2.131
18	2.11
20	2.093
22	2.08
24	2.069
26	2.06
28	2.052
30	2.045
31 or greater	1.96

A.9. NOTES

A.9.1. NUMBER OF TEST RUNS REQUIRED

A minimum of 36 test runs are required. Four test runs are needed at each of three test speeds within each of three temperature ranges (4 x 3 x 3 = 36). However this is an absolute minimum. Additional test runs are encouraged whenever possible.

(continued…)

[14] However, if the office monitoring process suggests calibration drift, additional system calibration will be required.

[15] Taken from Introduction to Probability and Statistics, 4th Edition, by William Mendenhall, 1975, Duxbury Press.

If two test trucks can not make the required 36 runs during one day of testing, either a second day of testing must be performed or additional test trucks should be used. Both methods for obtaining these test runs are acceptable. The total number of test vehicles to be used can be determined prior to the tests by determining the route each test vehicle will follow and calculating the time required to make one "circuit" of that route. This figure can be used to determine the maximum number of runs each test vehicle can make during the time period for which that vehicle is available.

Additional runs may also be necessary if conditions at the site prevent some scheduled runs from being performed at the desired speeds or if traffic conditions cause improper weights to be obtained (for example the test vehicle must brake to avoid another vehicle while approaching the scale sensors.). In addition, some flexibility is allowed in the order in which runs of different speeds are made. The intent is simply to obtain a sufficient number of runs at each speed and within each temperature range.

To obtain a wide temperature variation, it may be necessary to collect data for more than 8 hours per day. Given the cost of bringing test vehicles and personnel to a WIM site, it is often less expensive to extend a single day's testing than it is to schedule tests for more than one day. FHWA-LTPP and the SHA should consult prior to the scheduling of the field tests on the timing and duration of those tests.

A.9.2. CALIBRATION CONDITION PRIOR TO TESTING

Each Weigh-in-Motion system to be tested should be calibrated prior to the verification tests discussed in this document. For systems that require temperature adjustments to their calibration factors, a complete set of (calibrated) temperature adjustments should be in-place prior to the start of verification testing and/or the start of data collection for LTPP purposes. (It is permissible for a state to calibrate the scale using these same basic procedures immediately prior to the start of the verification tests.)

A.9.3. CONSEQUENCES OF FAILING THE VERIFICATION TESTS

No single remedy or consequence is appropriate for all sites where the verification tests described in this document show that the WIM system's outputs are not reliable.

In those cases where a single minor adjustments to the existing scale calibration factors can be shown to place the WIM scale in proper calibration, those adjustments, (if agreed to by both the state highway agency and the LTPP) will be made and the scale will be considered to have passed the calibration verification tests. However, where more than one adjustment is needed (for example, the scale appears to be temperature sensitive, and more than one temperature adjustment needs to be made), additional testing (calibration efforts under different environmental conditions) on the part of the state highway agency may be required, and LTPP reserves the right to require retesting of the scale to determine if data are sufficiently accurate for LTPP usage.

Where the scale passes some but not all tests (e.g., the scale passes the GVW and single axle load tests, but not the tandem axle load tests), LTPP will consult with its technical experts (including the Traffic ETG) before deciding whether to accept or reject use of that scale. Included in this decision will be an analysis of pavement conditions at that site, as well as other mitigating circumstances.

Where tests results indicate that the current scale is not sufficiently accurate and a simple calibration adjustment does not bring the scale back into calibration, LTPP will work with the state to determine the appropriate course of action. This could include, replacement of the scale sensors, modification of the pavement containing the sensors (e.g., grinding), or other improvements suggested by the LTPP, the state highway agency, or consultants advising these organizations.

A.9.4. TEMPERATURE MEASUREMENT

Because not all test sites are expected to be equipped with accurate pavement temperature sensors, pavement temperature readings must be collected at each site throughout the testing process. These temperatures will be used to estimate pavement temperature using a process previously adopted by LTPP. Where pavement temperature readings from the WIM scale are also available, these readings should also be obtained for use in the analysis effort.

A.9.5. LACK OF TEMPERATURE VARIATION

While every effort will be made to select a day when pavement temperatures will vary widely during the testing procedure, it is possible that during the selected test day(s) little temperature variation will occur. Successful tests taken under these “less than desired” conditions will still be considered “validation” of the scale’s calibration. However, it is expected that additional tests focusing on the scale’s temperature sensitivity will be conducted at that site as quickly as practical, given the available project budget and staff scheduling.

A.9.6. DEFINITION OF THE TERM “SCALE”

In this document, the term “scale” is assumed to include all components involved in the collection of vehicle weight data, unless otherwise specifically stated. The term “scale” is assumed to be synonymous with "Scale System." The term "scale" is not restricted in meaning to those components (sensors) that physically measure axle forces. It includes sensors, the electronics and software that interpret sensor signals, and converts that data into estimates of axle weights.

APPENDIX B

PAVEMENT SMOOTHNESS SPECIFICATIONS FOR LTPP WIM LOCATIONS

B. PAVEMENT SMOOTHNESS SPECIFICATIONS FOR LTPP WIM LOCATIONS

B.1. INTRODUCTION

The Long Term Pavement Performance (LTPP) Program is a study of pavement performance at approximately 2,400 in-service pavement sections throughout North America. The specific objectives of the LTPP program are to:

1. Evaluate existing design methods;
2. Develop improved design methods and strategies for the rehabilitation of existing pavements;
3. Develop improved design equations for new and reconstructed pavements;
4. Determine the effect on pavement distress and performance of loading, environment, material properties, construction quality, and maintenance levels;
5. Determine the effects of specific design features on pavement performance, and
6. Establish a national long-term pavement performance database.

The LTPP program will collect data on in-service pavement sections over a twenty year period. The data collected at the test sections are stored in the LTPP Information Management System (IMS) database. These data will be used to achieve the objectives of the LTPP program. Traffic data is an important parameter that is required for the analysis of pavement performance. A major data collection effort of the LTPP program is the collection of traffic load data using Weigh-In-Motion (WIM) scales located prior to LTPP test sections. Accurate recording of truck axle weights is required at the WIM sites in order to provide accurate data for pavement performance analysis. Accuracy of the load data collected by WIM scales is affected by the dynamic motion of trucks. The load applied to the surface of a road by a truck, called the dynamic load, is the sum of the static load carried by the truck and a continuously varying load. This continuously varying load is related to the dynamic motions induced in the vehicle due to road roughness. The dynamic load applied by a tire to the pavement can be either greater or less than the static load carried by that tire. Truck dynamic motions are affected by pavement roughness, which is caused by both short and long wavelengths present in the pavement. The short wavelength roughness affects the axle motions, while the long wavelength roughness contributes to the body bounce of the vehicle.

As truck dynamic motions affect the accuracy of the load data recorded at WIM scales, the usual practice is to provide a smooth pavement section prior to the WIM scale to minimize those motions. As the vehicle passes the WIM scale, the motion of the front of the vehicle can affect the dynamic motions at the back of the vehicle. Therefore, a smooth pavement section must also be provided for at least one truck length past the WIM scale. Maintaining a smooth pavement in front of and beyond the WIM scale (at least one truck length) can minimize the dynamic motions that are induced in the truck due to roughness caused by short wavelengths. However, dynamic motions may still be induced on the truck if the pavement sections contain long wavelengths that affect the body bounce of the vehicle.

To obtain accurate axle load data at WIM scales, the pavement section must meet smoothness specifications that will limit the effect of dynamic vehicle motions induced by short wavelengths. In addition, an assessment of the dynamic loads that are caused by long wavelengths in the pavement is needed to verify the accuracy of the load data collected at the WIM scales.

This document describes smoothness specifications that must be met at selected LTPP SPS WIM sites. Adherence to these specifications will help ensure that accurate data are being collected at LTPP WIM sites.

This document describes smoothness specifications that are applicable to the following three cases:

1. Verification of existing WIM sites

7. Acceptance of new WIM sites

8. Annual check of existing WIM sites accepted into the LTPP program.

B.2. WEIGH-IN-MOTION (WIM) SECTIONS

A Weigh-In-Motion (WIM) section is defined as a section of pavement that is 305 m long, with the distance from the centerline of the WIM scale to the beginning of the test section being 275 m and the distance from the centerline of the WIM scale to the end of the test section being 30 m.

The surface type of the pavement within the section can fall into one of the following three categories:

1. Portland Cement Concrete (PCC)

2. Asphalt Concrete (AC)

3. AC lead in followed by PCC pavement followed by AC pavement.

The last category occurs at sites where a portion of the existing AC pavement was replaced by a PCC pavement for the purposes of installing WIM sensors.

B.3. SMOOTHNESS SPECIFICATIONS FOR WIM SITES

In the LTPP program, smoothness evaluation of WIM sites can fall into one of the following categories:

1. Verification of existing WIM sites: These WIM sites are already in operation, but they will be evaluated to determine if they satisfy the specified smoothness criteria.

2. Acceptance of newly constructed WIM sites: Newly constructed WIM sites will be evaluated to determine if they satisfy the specified smoothness criteria.

3. Annual check of WIM sites: Newly constructed WIM sites that are accepted into the LTPP program, as well as existing WIM sites that have been verified and accepted into the LTPP program, will be monitored once a year to determine if they satisfy the specified smoothness criteria.

Table 1 provides an overview of the smoothness specifications that must be satisfied for each of the above three WIM site categories. This table presents the applicable specifications and the equipment used to obtain measurements for each specification.

The following is a detailed description of the specifications that need to be satisfied at the WIM sites, presented separately for each category.

B.3.1. VERIFICATION OF EXISTING WIM SITES

Three options are available for verification of existing WIM sites. Parties responsible for verification may follow any of the following options to verify an existing WIM site.

Option 1

- Short Wavelength Smoothness Specification - Profiler: An inertial profiler is used to evaluate pavement. Data collection and evaluation shall be performed in accordance with specifications presented in Attachment D - Short Wavelength Smoothness Specification - Profiler. Lane closure is not required.

- Long Wavelength Specification: An inertial profiler is used to evaluate pavement. Data collection and evaluation shall be performed in accordance with specifications presented in Attachment C - Long Wavelength Smoothness Specification. Lane closure is not required.

Option 2

- Short Wavelength Smoothness Specification - Profiler: An inertial profiler is used to evaluate pavement. Data collection and evaluation shall be done in accordance with specifications presented in Attachment D - Short Wavelength Smoothness Specification - Profiler. Lane closure is not required.

- Long Wavelength Specification: An inertial profiler is used to evaluate pavement. Data collection and evaluation shall be done in accordance with specifications presented in Attachment C - Long Wavelength Smoothness Specification. Lane closure is not required.

- Transverse Profile Specification - Straightedge: A straightedge is used to evaluate transverse profile of pavement. Data collection and evaluation shall be done in accordance with specifications presented in Attachment B - Transverse Profile Specification - Straightedge. Lane closure is required.

Table 1. Overview of Smoothness Specifications

Test Condition	Specifications	Equipment	Location of Specification In Document
Acceptance of New WIM Sites	1. Short Wavelength Smoothness Specification	Straightedge	Attachment A
	2. Transverse Profile Specification	Straightedge	Attachment B
	3. Long Wavelength Specification	Profiler or Dipstick	Attachment C
Verification of Existing WIM Sites	1. Short Wavelength Smoothness Specification	Profiler	Attachment D
	2. Long Wavelength Specification	Profiler	Attachment C
	3. Optional: Transverse Profile Specification	Straightedge	Attachment B
	4. Optional: Short Wavelength Smoothness Specification (Note 1)	Straightedge	Attachment A
Annual Check of WIM Sites	1. Short Wavelength Smoothness Specification	Profiler	Attachment D

Note 1: If short wavelength smoothness specification for the straightedge is used (Attachment A), the short wavelength smoothness specification for the profiler (Attachment D) need not be performed. However, the long wavelength smoothness specification (Attachment C) should be evaluated using data collected by a profiler or Dipstick

Option 3

- Short Wavelength Smoothness Specification - Straightedge: A straightedge is used to evaluate pavement. Data collection and evaluation shall be done in accordance with specifications presented in Attachment A - Short Wavelength Smoothness Specification B Straightedge. Lane closure is required.

- Transverse Profile Specification - Straightedge: A straightedge is used to evaluate transverse profile of pavement. Data collection and evaluation shall be done in accordance with specifications presented in Attachment B - Transverse Profile Specification B Straightedge. Lane closure is required.

- Long Wavelength Specification: Either the Dipstick® or an inertial profiler is used to collect data. Data collection and evaluation shall be done in accordance with specifications presented in Attachment C - Long Wavelength Specification. Lane closure is required if data collection is performed with Dipstick®.

B.3.2. ACCEPTANCE OF NEWLY CONSTRUCTED WIM SITES

- Data collection and evaluation shall be done in accordance to the specification presented in Attachment A - Short Wavelength Smoothness Specification - Straightedge. Lane closure is required.

- Transverse Profile Specification - Straightedge: A straightedge is used to evaluate transverse profile of pavement. Data collection and evaluation shall be done in accordance with specifications presented in Attachment B - Transverse Profile Specification - Straightedge. Testing shall be performed at same time pavement is tested for short wavelength smoothness.

- Long Wavelength Specification: Either the Dipstick® or an inertial profiler is used to collect data. Data collection and evaluation shall be done in accordance with specifications presented in Attachment C - Long Wavelength Specification. Lane closure is required if data collection is performed with Dipstick®.

Note: An inertial profiler may be used to evaluate pavement in accordance with specifications presented in Attachment D – Short Wavelength Smoothness Specification – Profiler. However, evaluation of transverse profile of pavement using a straightedge, in accordance with specifications contained in Attachment B, is still required.

B.3.3. ANNUAL CHECK OF WIM SITES

An annual check of WIM sites accepted into the LTPP program shall be done to verify that those sites satisfy the short wavelength smoothness specifications. The procedures presented in Attachment D - Short Wavelength Smoothness Specification - Profiler shall be used to perform the annual site checks. The LTPP profiler shall be used to collect the profile data required for these annual checks.

Note: Evaluation of pavement long wavelengths is performed after a WIM site has just been constructed (i.e., new WIM site) or during the initial verification of an existing WIM site. Long wavelengths at a WIM site that affect vehicle motions are not generally expected to change over time and therefore, an annual verification of the long wavelength specifications is not required. However, verifications may be performed using specifications contained in Attachment C in those cases where long wavelength changes are suspected.

B.4. PAVEMENT MARKINGS

WIM sites shall be marked in accordance with the specifications provided in Attachment F - Site Marking at WIM Locations.

B.5. DATA STORAGE

Data collected at WIM sites for purposes of evaluating pavement smoothness specifications fall into the following categories:

1. Short Wavelength Smoothness Specification - Straightedge: Data collected for evaluation of short wavelength smoothness specifications are recorded in Form A-1 (see Attachment A).

2. Transverse Profile Specification - Straightedge: Data collected for evaluation of transverse profile specifications are recorded in Form B-1 (see Attachment B).

3. Longitudinal Profile Data for Long Wavelength Evaluation - Dipstick®: Data collected for evaluation of long wavelength specifications using the Dipstick® are recorded in standard forms included in Appendix II of the LTPP Manual for Profile Measurements, Operational Field Guidelines, Version 3.1.

4. Longitudinal Profile Data for Short and Long Wavelength Specification - Profiler:

Data collected for evaluation of short and long wavelength specifications using an inertial profilers are recorded in electronic data files.

Party(ies) responsible for data collection shall maintain an organized filing system for storage of data forms collected under data categories 1 through 3. A copy of all data forms collected at a WIM site shall be forwarded to the appropriate LTPP Regional Coordination Office within three (3) months of data collection.

Party(ies) collecting longitudinal profile elevation data (data category 4) shall keep original data files collected at WIM sites as well as a backup copy of those data files in their office. A copy of the data files shall be forwarded to the appropriate LTPP Regional Coordination Office within three (3) months of data collection. Also, a log shall be maintained that describes the data file names, associated WIM site, and position of testing (i.e., wheel path, left of wheel path, right of wheel path, etc).

Profile data collected for evaluation of pavement smoothness specifications will not be stored in the LTPP IMS database. However, an IMS data summary sheet shall be prepared to store key summary information for each WIM location evaluated. The data summary sheet shall, as a minimum, contain the following information items:

1. State Code

5. SHRP ID associated with WIM location

6. Date Tested

7. Test reason (i.e., verification, acceptance testing, annual check)

8. Method used to collect long wavelength data (i.e., profile or Dipstick)

9. Did WIM location pass long wavelength criteria, if evaluation required on date tested? If not, report deviations from criteria.

10. Method used to collect short wavelength data (i.e., straightedge or profile)

11. Did WIM location pass short wavelength criteria? If criteria were not met, report percentage of locations where failure occurred.

12. Did WIM location pass transverse profile criteria, if evaluation required on date tested? If criteria were not met, report percentage of locations where failure occurred.

B.6. RESPONSE TO FAILURES

The following smoothness specifications were described in this document:

1. Short wavelength smoothness specification - Straightedge

2. Transverse profile specification - Straightedge

3. Short wavelength smoothness specification - Profiler

4. Long wavelength smoothness specification

Each specification lists requirements that must be satisfied in order for the WIM location to be acceptable. If a WIM site fails any of the specified requirements, the results obtained shall be evaluated by a group of knowledgeable persons identified by the Federal Highway Administration LTPP team and specifically chosen for this task.

A variety of pavement and environmental conditions at the time of testing can influence the results obtained for the short wavelength smoothness specifications. These conditions, which are recorded on the appropriate field data forms, include:

1. Temperature and moisture effects on PCC pavements that lead to slab curling or warping

5. Crack sealing and joint sealing within WIM section

6. Localized distresses (e.g., spalling for PCC pavements)

In the event the short wavelength smoothness specifications fail (either straightedge or profiler), the effect of the above factors as well as other factors that could have had on impact on the test results shall be evaluated. Based on the results of this evaluation, an appropriate corrective response to the failure shall be formulated. Possible actions that will be considered include:

7. Pavement remediation measures to achieve required smoothness level, such as diamond grinding of pavement surface.

8. Removal of existing WIM scale, reconstruction of pavement and re-installation of WIM scale.

9. Discontinuing collection of WIM data at location and collecting only vehicle classification data.

10. Discontinuing both WIM and vehicle classification data collection at the site.

In deciding on the final resolution, the age of the equipment as well as the anticipated life of the pavement in which the WIM is installed shall be considered.

In the event the long wavelength specifications fail, further analysis of the profile data shall be performed to evaluate the impact on the loads recorded by the WIM scale, and an appropriate resolution to the failure shall be formulated.

Attachment A
Short Wavelength Smoothness Specification – Straightedge

A.1. Introduction

This specification describes a procedure to determine if short wavelengths that affect dynamic motions of vehicles are acceptable on a roadway by using a straightedge as the measuring device. Lane closure is required to perform the measurements.

This procedure consists of:

1. Marking wheel paths on pavement using a chalk line.
2. Placing a 3.65 m straightedge at specified locations along wheel path and at an offsets from wheel path.
3. Determining if a circular plate, 3 mm thick and 150 mm in diameter, can be passed below straightedge at locations where straightedge is placed.

This specification describes procedures for laying out the site, specifies the locations to place the straightedge, and requirements to evaluate if the site satisfies the smoothness criteria.

A.2. Measuring Equipment

A straightedge that is 3.65 m in length and has a mark at the center of the straightedge and a circular plate that is 3 mm in height and 150 mm in diameter are needed to perform this test. The bottom rectangular surface of the straightedge shall be at least 19 mm but not more than 75 mm wide in the measurement plane. The maximum out-of-trueness of the bottom surface of the straightedge in the measurement plane and along the width shall be less than $\pm$ 0.40 mm/m.

A.3. Site Layout

The site layout consists of identifying the wheel paths, and then marking the wheel paths using a chalk line. All cases assume a 3.65 m lane. If another lane width is encountered the measurements indicated below should be adjusted to correctly identify the center of the lane. The wheel paths are marked for 30 m after the scale sensor and 122 m prior to it.

The pavement must be clean of any debris before the site layout is performed.

The wheel paths at a site are defined to be at a distance of 0.838 m from the center of the travel lane. Use following procedure to locate the center of the travel lane:

Case I: Where wheel paths are easily identified, midway point between two wheel paths shall be used as center of lane. In a newly diamond ground pavement it will not be possible to identify the wheel paths, and either Case II or Case III shall be used to identify the center of the travel lane.

Case II: If wheel paths are not clearly identifiable, but two lane edges are well defined, center of travel lane is considered to be midway between the two lane edges.

Case III: Where wheel paths are not apparent and only one lane edge can be clearly distinguished, center of lane should be established at 1.825 m from that edge.

Once the center of travel lane has been identified, use the following procedure to layout the site:

1. Determine location of start of WIM section.

   i. If site is marked according to procedures described in Attachment F, station 153+00 for the evaluation section is referenced from the leave edge of the white stripe at the beginning of the WIM section.

   ii. If site is not marked, the beginning of the section for straight edge testing shall be determined with respect to the sensor itself. The beginning of the section to be evaluated is located 122 m from the centerline of the WIM scale. This length of 122 m shall be accurately measured using a tape measure (measurement wheels are not acceptable).

2. Identify location of two longitudinal elevation survey lines 0.826 m from center of lane. Mark these locations at intervals equal to length of chalk line used for marking. Use chalk line to mark a straight line between previously established points. The chalk lines shall be marked till the end of the evalution section, which is 152 m from the beginning of the section.

A.4. Measurement Procedure

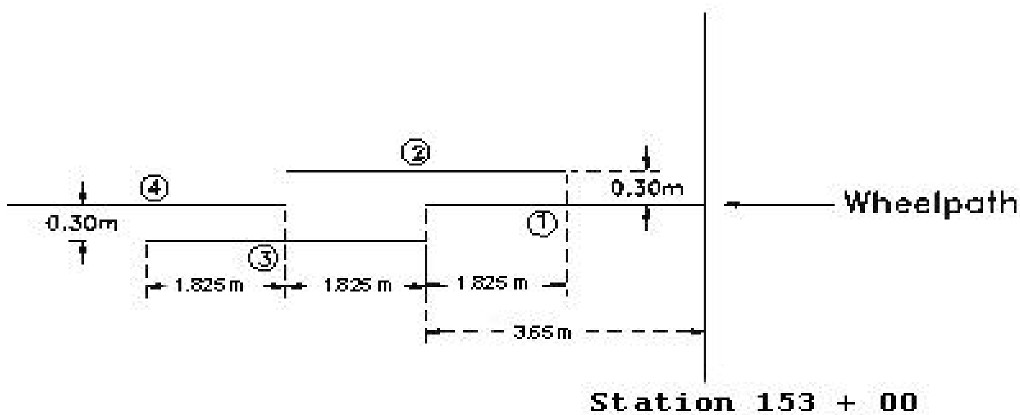
The measurement procedure consists of laying down the 3.65 m long straightedge on the pavement at locations that are described in this section, and determining if a circular plate that is 3 mm thick and 150 mm in diameter can be passed below the straightedge (i.e., between the straightedge and the pavement surface) at any location within the limits of the straightedge.

The following procedure shall be followed in obtaining measurements within the WIM section.

1. Go to start of the straight edge test section (Station 153+00) and lay down straightedge on left wheel path on top of the chalk line, with one end of the straightedge (back end) at Station 153+00 and the other end (front end) extending into the WIM section. The position of the straightedge is shown as Position 1 in Figure A-1. Mark location of front end of the straightedge on the chalk line using a lumber crayon. Determine if the specified disk can be freely passed below the straightedge, and note the result of the test in Form A-1.

2. Pick up straightedge and place it so that it is parallel to the wheel path but offset 0.3 m to the right of the wheel path, and with the center of the straightedge being in line

Figure A-B-1 Position of Straightedge



with the mark that was placed on the pavement with lumber crayon in the previous step. The location of the straightedge shall correspond to Position 2 in Figure A-1. At this position, 1.825 m of the straightedge overlaps into the previously measured portion of the pavement. Use lumber crayon to put a mark in the wheel path that is in line with the front end of the straightedge. Determine if the specified disk can be freely passed below the straightedge, and note the result in Form A-1.

3. Pick up straightedge and place it so that it is parallel to the wheel path but offset 0.3 m left of the wheel path, with the center of the straightedge being in line with the mark on the pavement that was made with lumber crayon in the previous step. The location of the straightedge shall correspond to Position 3 in Figure A-1. In this position, 1.825 m of the straightedge overlaps into the previously measured length of the pavement. Use lumber crayon to put a mark in the wheel path that is in line with the front end of the straightedge. Determine if the specified disk can be freely passed below the straightedge, and note the result in Form A-1.

4. Pick up straightedge and place it on the wheel path, such that the center of the straightedge is in line with the mark on the pavement that was made with lumber crayon in the previous step. The location of the straightedge shall correspond to Position 4 in Figure A-1. In this position, 1.825 m of the straightedge overlaps into the previously measured length of the pavement. Use lumber crayon to put a mark in the wheel path that is in line with the front end of the straightedge. Determine if the specified disk can be freely passed below the straightedge, and note the result in Form A-1.

5. Repeat steps 2, 3 and 4 in sequence until the end of the WIM section is reached.

6. Repeat steps 1 through 5 for the right wheel path.

If during diamond grinding, multiple measurements are performed on the test section, submit the data form (Form A-1) for the final measurements that are performed at the WIM section.

A.5. Smoothness Criteria

The smoothness of the pavement at each position of the straightedge is evaluated by determining if a circular plate that is 3 mm thick and 150 mm in diameter can be freely passed below the straightedge (i.e., between the straightedge and the pavement surface) at any position within the limits of the straightedge. If the specified plate can be passed below the straightedge, the smoothness requirement is considered to have failed at that location.

In order for a WIM section to satisfy the short wavelength smoothness criteria, the specified smoothness criteria shall not fail at any location within the WIM section. If the specified criteria fail at any location within the WIM section, the WIM section is considered to have failed the “Short Wavelength Smoothness Specification B - Straightedge”.

Note: Maximum out-of-trueness specification of straightedge in measurement plane is considered realistic for this type of field equipment. Nonetheless, temperature effects may result in false failures at locations or in the acceptable results that should have failed. In addition, a stringent failure criterion was knowingly selected for use in this specification. Accordingly, both temperature effects and failure criterion will be carefully evaluated based on the results of the pilot studies and changes made as appropriate.

Form A-1 Straightedge Measurements – Longitudinal Direction

State Code: Date:
LTPP WIM
Section: Completed by:
Route:

Station for Back End of Straightedge	Location of Straightedge	Can Disk be freely Passed (Y/N?)	Station for Back End of Straightedge	Location of Straightedge	Can Disk be freelyPassed (Y/N?)
153.000	Wheel Path		227.825	0.3 m Left	
154.825	0.3 m Right		229.650	Wheel Path	
156.650	0.3 m Left		231.475	0.3 m Right	
158.475	Wheel Path		233.300	0.3 m Left	
160.300	0.3 m Right		235.125	Wheel Path	
162.125	0.3 m Left		236.950	0.3 m Right	
163.950	Wheel Path		238.775	0.3 m Left	
165.775	0.3 m Right		240.600	Wheel Path	
167.600	0.3 m Left		242.425	0.3 m Right	
169.425	Wheel Path		243.250	0.3 m Left	
171.250	0.3 m Right		246.075	Wheel Path	
173.075	0.3 m Left		247.900	0.3 m Right	
174.900	Wheel Path		249.725	0.3 m Left	
176.725	0.3 m Right		251.550	Wheel Path	
178.550	0.3 m Left		253.375	0.3 m Right	
180.375	Wheel Path		255.200	0.3 m Left	
182.200	0.3 m Right		257.025	Wheel Path	
184.025	0.3 m Left		258.850	0.3 m Right	
185.850	Wheel Path		260.675	0.3 m Left	
187.675	0.3 m Right		262.500	Wheel Path	
189.500	0.3 m Left		264.325	0.3 m Right	
191.325	Wheel Path		266.150	0.3 m Left	
193.150	0.3 m Right		267.975	Wheel Path	
194.975	0.3 m Left		269.800	0.3 m Right	
196.800	Wheel Path		271.625	0.3 m Left	
198.625	0.3 m Right		273.450	Wheel Path	
200.450	0.3 m Left		275.275	0.3 m Right	
202.275	Wheel Path		277.100	0.3 m Left	
204.100	0.3 m Right		278.925	Wheel Path	
205.925	0.3 m Left		280.750	0.3 m Right	
207.750	Wheel Path		282.575	0.3 m Left	
209.575	0.3 m Right		284.400	Wheel Path	
211.400	0.3 m Left		286.225	0.3 m Right	
213.225	Wheel Path		288.050	0.3 m Left	
215.050	0.3 m Right		290.875	Wheel Path	
216.875	0.3 m Left		291.700	0.3 m Right	
218.700	Wheel Path		293.525	0.3 m Left	
220.525	0.3 m Right		295.350	Wheel Path	
222.350	0.3 m Left		297.175	0.3 m Right	
224.175	Wheel Path		299.000	0.3 m Left	
226.000	0.3 m Right		300.825	Wheel Path	

Note: Station 153.00 is at the beginning of the section being evaluated

Attachment B
Transverse Profile Specification B Straightedge

B.1. Introduction

Variations in the transverse profile within a WIM section may induce dynamic motions in the vehicle that can affect the weight that is measured at the WIM scale. This specification describes a procedure for checking the transverse profile at WIM sections using a straightedge to check if it meets the specified profile criteria. Lane closure is required for performing this test. The measurements for this test shall be performed at the same time the section is being evaluated for AShort Wavelength Smoothness Specification - Straightedge".

This procedure consists of:

1. Marking specified longitudinal distances from the centerline of the WIM scale.
2. Placing a 3.65 m long straightedge transversely across the lane at each of the specified longitudinal locations, in a direction that is perpendicular to the direction of travel.
3. Determining if a circular plate that is 150 mm in diameter and 3 mm thick can be passed below the straightedge (i.e., between the straightedge and the pavement) at any location within the limits of the straightedge.

This specification describes procedures for laying out the site, specifies the locations where the straightedge is to be placed to obtain measurements, and the requirements that have to be met in order to pass the transverse profile criteria.

B.2. Measuring Equipment

A straightedge that is 3.65 m in length and a circular plate that is 3 mm in thickness and 150 mm in diameter is required for this test. The bottom rectangular surface of the straightedge shall be at least 19 mm but not more than 75 mm wide in the measurement plane. The maximum out-of-trueness of the bottom surface of the straightedge in the measurement plane and along the width shall be less than $\pm$ 0.40 mm/m.

B.3. Site Layout

The site layout consists of marking off specified distances from the centerline of the WIM scale. The pavement must be clear of any debris before the site layout is performed.

Lumber crayon should be used to place marks on the pavement surface along the inside and outside lane edges at the following distances from the center line of the WIM scale in the direction upstream of the WIM (i.e., towards the beginning of the WIM section): 0 (centerline of the WIM scale), 5, 10, 15, 20, 25, 50, 75 and 100 m. The specified distances shall be measured using a measuring tape (measuring wheel not acceptable).

B.4. Measurement Procedure

The following procedure shall be used to check the transverse profile of the pavement.

1. At first longitudinal location that was marked on the pavement (station 0, centerline of the WIM scale), place one end of the straightedge at the inner edge of the lane and the other end of the straightedge on the outer edge of the lane, such that left face of the straightedge is flush with the lumber crayon markings on the inner and outer lane edges. At this position, the straightedge will be perpendicular to the traffic direction of the lane.

2. Determine if circular plate that is 3 mm in height and 150 mm in diameter can be freely passed below the straightedge (i.e., between the straightedge and the pavement surface) at any location within the limits of the straightedge. Note the result of this test in Form B1.

3. Repeat procedure described in step 2 at all other locations marked on the pavement surface (i.e., 5, 10, 15, 20, 25, 50, 75 and 100 m). Note results of this test in Form B-1.

B.5. Profile Requirements

The transverse profile at each position of the straightedge is evaluated by determining if a circular plate that is 3 mm thick and 150 mm in diameter can be freely passed below the straightedge (i.e., between the straightedge and the pavement surface), at any position within the limits of the straightedge. If the specified plate can be passed below the straightedge, the transverse profile requirement is considered to have failed at that location.

In order for a WIM section to satisfy the transverse profile criteria, the specified transverse profile criteria shall not fail at all test locations. If the specified transverse profile criteria fails at any test location, the WIM section is considered to have failed the specification “Transverse Profile Specification **B** Straightedge@.

Note: The maximum out-of-trueness specification of straightedge in the measurement plane is considered realistic for this type of field equipment. Nonetheless, temperature effects may result in false failures at locations or in the acceptable results that should have failed. In addition, a stringent failure criterion was knowingly selected for use in this specification. Accordingly, both temperature effects and failure criterion will be carefully evaluated based on the results of the pilot studies and changes made as appropriate.

Form B-1
Straightedge Measurements - Transverse Direction

State Code:

WIM LTPP Section:

Route:

Date:

Collected by:

Distance from Centerline of WIM (m)	Can Disk Be Freely Passed Below Straightedge ?
0.0	Y / N
5.0	Y / N
10.0	Y / N
15.0	Y / N
20.0	Y / N
25.0	Y / N
50.0	Y / N
75.0	Y / N
100.0	Y / N

Attachment C
Long Wavelength Specification

C.1. Introduction

Long wavelengths in the pavement induce body bounce of trucks (1.5 to 4 Hz), which induce dynamic loads on pavements. The presence of long wavelengths in the pavement prior to the WIM scale that affects the body bounce of the vehicle can affect the loads that are recorded by the WIM scale. In this specification, an evaluation of the dynamic loads that are applied by trucks at the WIM scale location is made.

This procedure consists of:

1. Collecting longitudinal profile data within test section using an inertial profiler. A Dipstick may be used to collect longitudinal profile data if an inertial profiler is not available.

2. Analyzing the profile collected versus the long wavelength index which reflects the distribution of wavelengths that are considered not to significantly affect the precision of the WIM sensor response.

C.2. Equipment Used

The preferred equipment for collecting longitudinal profile data is an inertial profiler. The profiler shall meet the requirements outlined in Section D.2 (Measuring Equipment) in Attachment D - Short Wavelength Smoothness Specification - Profiler. If a Dipstick is used to collect profile data, it shall meet the requirements outlined in Section 1.2 (Measuring Equipment) in Attachment E - Procedure for Longitudinal Data Collection Using Dipstick.

C.3. Measurement Procedure

If profile data is collected at the site to evaluate Specification D - Short Wavelength Smoothness Specification Profiler, no additional data collection is required. The same profiles will be used for both purposes. If the site is being profiled specifically to evaluate the long wavelength specification, collect profile data along the wheel paths using the procedures outlined in Section D.3 (Profile Data Collection) in Attachment D - Short Wavelength Smoothness Specification – Profiler. If the Dipstick is used, collect data according to procedures outlined in Attachment E - Procedure for Longitudinal Data Collection Using Dipstick using a 305 m section length.

C.4. Data Analysis

The data analysis will utilize one of two methods depending on the site and the point in time which the data is collected. The first method involves vehicle dynamics modelling and the second software developed for LTPP following multiple truck simulations using Class 9 vehicles with various dynamic properties and loadings on a variety of pavement profiles.

Note: The final decision on the data analysis method will be made following completion of on-going study.

For site profile and truck specific analysis, the profiler will follow the validation trucks. The profile information will be stored for a 305 m section as specified in C.3. The 25 mm profile data and the scale measurements will be provided along with the truck information described in the SPS Traffic Field Manual.

The software results from an analysis is intended to provide an indication of the characteristics of a profile which preclude a WIM scale from meeting the performance criteria in the equipment specifications. (See Table C-1.) An index is computed using the profile information and truck data and compared against a measure which indicates the probability of meeting the conformance requirements.

Table C-1. Tolerance Limits

Case	Tolerance for 95% Probability of Conformity
Loaded Single Axle	+/- 20 percent
Loaded Tandem Axle	+/- 15 percent
Gross Vehicle Weights	+/- 10 percent

Note: Values obtained from ASTM Standard E 1318

C.5. Long Wavelength Criteria

TO BE DETERMINED FOLLOWING STUDY COMPLETION

Attachment D
Short Wavelength Smoothness Specification B Profiler

D.1. Introduction

This specification presents a method to determine, using data collected by an inertial profiler, if short wavelengths that can induce dynamic motions on vehicles are present at a WIM site. The presence of such short wavelengths will be investigated by simulating the placement of a 3.65 m straightedge on the profile data at specified locations and determining if a simulated circular plate, 3 mm thick and 150 mm in diameter, can be freely passed below the straightedge. If the circular plate cannot be passed, it is considered that such short wavelengths are not located within the limits of the straightedge.

The longitudinal profile data collected during initial verification testing of existing WIM sites and during annual WIM visits will be used to check the requirements specified in this specification.

Profile data collected at three lateral positions are used to evaluate the presence of short wavelengths within the WIM section. The three lateral positions along which the profiler shall be driven to collect the data are: along the wheel paths, close to the shoulder (right of the wheel path), and close to the inner edge of the lane (left of the wheel path).

The equipment requirements for the profiler, measuring procedures, data analysis procedure, and smoothness criteria are described in this specification.

D.2. Measuring Equipment

An inertial profiler meeting the Class I standards as specified in ASTM Standard E950-98 shall be used to collect longitudinal profile data. In addition to the requirements specified in E950, the profile equipment shall specifically meet the following requirements.

1. Sensors: Profiler shall be equipped with either laser or infra-red sensors.

2. Number of Sensors: Profiler shall be equipped with two sensors located on either side of the center of the vehicle, equidistant from the center of the vehicle. The center to center distance between the two sensors shall be 1,676 mm ± 5 mm. The profiler may have an additional sensor that is located at the center of the vehicle, but it is not pertinent to this specification.

3. Photocell: Profiler shall be equipped with either a horizontal or a vertical photocell that can automatically trigger profile data collection using a mark on the pavement

(for vertical photocell) or a target placed on the shoulder of the pavement (for horizontal photocell).

4. Sampling Interval: Profiler shall be capable of recording profile data at 25 mm intervals. A moving average shall not be performed on the data that is recorded.

5. Distance Measuring System: Profiler shall be equipped with a distance measuring system.

D.3. Profile Data Collection

Profile data within the LTPP program are currently collected using K.J. Law Model T6600 profilers. Detailed procedures used for collecting profile data for the LTPP program are described in the ALTPP Manual for Profile Measurements, Operational Field Guidelines, Version 3.1.@ This document describes procedures to be followed for calibration of equipment, daily checks on the equipment, and data collection procedures. Updates on profile data collection activities are described in LTPP profile directives that are issued by the FHWA. Although some of the procedures described in the LTPP Profile Manual are only applicable to K.J. Law Model T6600 profilers, many of the general procedures are applicable to any inertial profiler.

The profile data collection at WIM sites shall be performed following the procedures outlined in the LTPP Manual for Profile Measurements and applicable LTPP Profile Directives, except that the procedure for profiling a site and the number of acceptable runs that are required at a WIM site are different from the procedures described in the manual. Detailed procedures for profiling a WIM site, and the number of profile runs that are required at a WIM site are presented later in this section.

The following procedures shall be followed by all profilers that collect profile data at WIM sites.

1. Height sensors, accelerometers, and distance measuring system shall be calibrated.

2. Any applicable daily checks shall have been performed on the equipment (e.g., bounce test) prior to data collection.

3. Highway agency procedures relating to safety issues shall be strictly followed (i.e., flashing signal bar on etc.).

4. Operating speed for collecting profile data shall be 80 km/h.

5. Data collection at the WIM site shall be initiated using photocell.

6. Termination of data collection at a WIM site shall be made by specifying the distance of data collection to be 305 m from initiation of data collection for sites at which only short wave length evaluation is done.

The following procedure shall be used to obtain an acceptable set of profile runs at a WIM site for short wave length and long wave length evaluated by software:

1. Obtain five profile runs by driving the profiler along the wheel paths.

2. Perform data collection by aligning the vehicle such that the right tire of the vehicle is approximately 0.5 m from the white stripe along the edge of the lane. Obtain five runs following this procedure. Every effort shall be made to obtain all five runs along a consistent path.

3. Perform data collection by following a path that is left of the wheel path, and close as much as possible to the left edge of the traffic lane. The driver of the profiler shall judge the path to be followed based on the site conditions, such that the path followed does not cause any safety concerns. Obtain five runs following this procedure, making every effort to obtain all five runs along a consistent path.

4. After completing data collection, compare the five profile runs that were collected at each specific path. Evaluate the profiles for equipment related spikes following the procedures outlined in the LTPP Manual for Profile Measurements. If the operator is confident that at least one error free run has been obtained at the site, terminate data collection. Maintain a log of the runs that the operator considers to be error free.

5. If the operator believes that at least one error free run has not been obtained for given path, repeat data collection along that path and evaluate the profile data using the procedures described in Step 4.

6. Prepare a log indicating file names and paths followed (i.e., wheel path, left of wheel path, right of wheel path). Note the runs that are considered to be error free. For profile runs performed left of the wheel path, indicate the approximate offset from the wheel path. Back up the data to disks prior to leaving the site.

The following procedure shall be used to obtain an acceptable set of profile runs at a WIM site for vehicle dynamics modelling:

1. Obtain five profile runs for each truck by driving the profiler behind it following the same path as the truck.

2. After completing data collection at the first temperature, compare the five profile runs that were collected for each truck for each temperature. Evaluate the profiles for equipment related spikes following the procedures outlined in the LTPP Manual for Profile Measurements. If the operator is confident that at least one error free run has been obtained at the site, terminate data collection. Maintain a log of the runs that the operator considers to be error free.

3. Obtain a second set of five runs for each truck later in the day at a different pavement temperature.

4. After completing data collection at the first temperature, compare the five profile runs that were collected for each truck for each temperature. Evaluate the profiles for equipment related spikes following the procedures outlined in the LTPP Manual for Profile Measurements. If the operator is confident that at least one error free run has been obtained at the site, terminate data collection. Maintain a log of the runs that the operator considers to be error free.

5. Prepare a log indicating file names, trucks followed and temperature conditions (i.e., truck 1 low temperature, truck 2 high temperature). Note the runs that are considered to be error free. Back up the data to disks prior to leaving the site.

If more than two trucks are being used at the site the loaded truck with the air suspension and one other are the only runs required. Runs for other trucks are optional.

The filenaming convention for profiles is dependent on the reason and process for collecting them. If profiles are collected for short wave length and or long wave length direct evaluation the file name is of the form SSDXLPEV where

SS is state code in FIPS format

D is direction for non-SPS lane (E, W, N, S), and the first character of the SPS project ID otherwise

X is the experiment number (1, 2, 5, 6, 8)

L is the lane outer, center, inner (O, C, I). In the event that more than 3 lanes exist the values for C will be successively 2, 3, 4 where 1 is taken as the outer lane.

P is the path, Right, Center, Left (R, C, L).

E is experiment type, W for WIM in this case for use by the Proqual software.

V is visit A, B, C.

If the data is being collected specifically for use in vehicle dynamics modelling the file name is of the form SSDXLPTV where all items are the same except the 7th character T which is the number of the truck being followed.

D.4. Data Analysis

Profile data collected along each longitudinal path will be analyzed to determine if short wavelengths that affect the dynamic motion of vehicles are present in the pavement. The procedure that will be used to determine the presence of short wavelengths is to simulate the placement of a straightedge that is 3.65 m in length on the profile data at specific positions, and then determining if a disk that is 3 mm in height and 150 mm in diameter can be freely passed below the straightedge. If the disk can be freely passed below the straightedge, the short wavelength criteria is considered to have failed at that specific position.

Data collection along the three paths described in the previous section will result in six longitudinal profiles for a profiler with two sensors (one along each wheel path) and nine longitudinal profiles for a profiler with three sensors (a sensor along each wheel path and a sensor along the center of the vehicle).

The following procedure shall be used to simulate the straightedge along each longitudinal path.

1. For a specific longitudinal path, data collected for three profile runs are available. Select a path to be analyzed, and for that path select profile data corresponding to first error free profile run for use in analysis. The first 153 m of profile data are removed from the file prior to data analysis.

2. Simulate placement of a 3.65 m long straightedge on the profile data with one edge of the straightedge (back end) at the start of the short wavelength section (station 153+00) and the other end (front end) extending into the WIM section. The simulation of the straightedge shall be performed using a computer program. The computer program shall be capable of determining the stable position at which the straightedge will rest on the profile data.

3. Determine if a circular plate that is 3 mm thick and 150 mm in diameter can be freely passed below simulated straightedge (i.e., between the straightedge and the pavement) at any location within the limits of the straightedge. If the disk can be freely passed, the short wavelength criterion is considered to have failed at this placement of the simulated straightedge.

4. Thereafter, simulate the placement of the straightedge such that the edge of the

straightedge that was at the beginning of the WIM section (back end) is now at 154.825 m from the start of the section. At this position, half of the straightedge (1.825 m) will overlap onto the portion that was covered by the straightedge previously.

5. At this position of straightedge, follow procedure described in Step 3.

6. Computer program shall keep moving straightedge along section. At each position, the straightedge shall overlap 1.825 m into the previous position of the straightedge. At each simulated position, the procedure described in Step 3 shall be performed.

7. Once the front end of the straightedge reaches the end of the section, the program shall terminate, and it shall output the stations at which the specified criteria (step 3) failed. These reported stations shall correspond to the station at which the back end of the straightedge was located.

   For the specific profile path that was analyzed, two outcomes are possible:
   (a) If specified criteria did not fail at any position, the analyzed path is considered to have passed the short wavelength specification.
   (b) If specified criteria failed at one or more locations, and additional error free profile runs are not available for that path, the analyzed path is considered to have failed the short wavelength specification.

8. If specified criteria failed at one or more locations, and additional error free runs are available for that path, repeat steps 2 through 7 using data from the second error free run that was collected along the same path. If data from second run does not fail specified criteria at any location, then the analyzed path is considered to have passed the short wavelength criteria. If data for second run fails the specified criteria at one or more locations, and a third error free run is not available for that path, the analyzed path is considered to have failed the short wavelength specification. If data for second run fails criteria at one or more locations, but data for a third error free run are available for that path, repeat steps 2 through 7 using data from the third error free run. If data for third run does not fail the specified criteria at any location, then the analyzed path is considered to have passed the short wavelength smoothness specification for the analyzed path. If the data for the third error free run fails the specified criteria at one or more locations, that path is considered to have failed the smoothness specification.

9. Repeat analysis (Steps 1 through 8) for the other paths for which profile data was collected. For data collected with a profiler having two sensors, there will be a total of six paths, while for data collected with a profiler having three sensors, data for a total

of nine paths are available.

D.5. Data Reporting

1. For each profiled path, indicate if profile passed or failed specified smoothness criteria.

2. If smoothness criteria failed for a specific path, indicate stations where criteria failed (give station for back end of straightedge) for all three runs that were analyzed.

D.6. Smoothness Criteria

If smoothness criteria pass for all six paths surveyed, the WIM section is considered to have passed the short wavelength smoothness specification.

If the smoothness criteria failed for any of the analyzed paths, the WIM section is considered to have failed the short wavelength smoothness specification.

Note: LTPP requirements stipulate that test sections be on flat grade. Vertical grades are not allowed but this issue (which could have impact on WIM measurements) has not yet been fully investigated at SPS WIM locations. In addition, a stringent failure criterion was knowingly selected for use in this specification. Accordingly, both vertical grade effects and failure criterion will be carefully evaluated based on the results of pilot studies and changes made appropriate.

Attachment E
Procedure for Longitudinal Data Collection Using the Dipstick[7]

E.1 Introduction

Long wavelengths at WIM sites may induce dynamic vehicle motions that can cause errors in the weights that are measured at WIM scales. The longitudinal profile of the WIM section is required in order to assess the potential impact of long wavelengths on dynamic motions of the vehicle. This analysis is performed when newly constructed WIM sites are evaluated and, if possible, also when verification of existing WIM sites are performed. The preferred method for collecting the longitudinal profile elevation data for analysis is to use an inertial profiler. However, a Dipstick[7] may be used to collect longitudinal profile data at a WIM section if an inertial profiler is not available.

E.2 Equipment Used

Data collection shall be performed using Face Technologies Dipstick[7]. Automated Dipsticks[7] that collect data by recording the data values in the computer shall not be used to collect the data. If automated Dipsticks[7] are used, they shall be used in the manual mode (i.e., computer shall not be connected and data should be read off from display and recorded on data sheets). The distance between the two feet of the Dipstick[7] shall be set to 305.8 mm.

E.3 Data Collection Procedure

Detailed procedures for collecting longitudinal profile data using the Dipstick[7] are described in Section 3.3 of the LTPP Manual for Profile Measurements, Operational Field Guidelines, Version 3.1. The following items are covered in the manual:

- General Background (Section 3.3.1)
- Site Inspection and Layout B Longitudinal Profile Measurements (Section 3.3.2)
- Pre-operational checks on Dipstick[7] (Section 3.3.1.1)
- Longitudinal Profile Measurement (Section 3.3.3.2)
- Post Data Collection Check (Section 3.3.3.3)

The longitudinal elevation data for the site shall be collected using the procedures outlined in Section 3.3 of the LTPP Manual for Profile Measurements, Operational Field Guidelines, Version 3.1.

E.4 Data Reporting

Dipstick[7] data shall be recorded in the data sheets that are provided in Appendix II of the LTPP Profile Manual. The data shall be organized and filed. A copy of the data sheets shall be forwarded to the appropriate LTPP Regional Coordination Office.

E.5 Profile Requirements

Dipstick[7] data that is collected will be used to assess the impact of long wavelengths on vehicle dynamics, and its effect on the loads that are recorded at WIM scales. The analysis of the Dipstick[7] data will be performed using the procedures described in Attachment C - Long Wavelength Specification.

Attachment F
Site Markings at WIM Locations

WIM sites shall be marked as shown in Figure F-1. The test section shall be marked by two white stripes, nominally 150 mm wide, across the test lane. The stripe at the beginning of the test section shall be located 275 m prior to the centerline of the WIM scale for long wavelength data collection. The stripe at the end of the test section shall be located 30 m after the centerline of the WIM scale. If necessary to mark for shortwave length data collection only, a stripe shall be located 122 m prior to the scale instead of 275 m.

At the beginning of the test section, one of the following shall be painted near the outside shoulder for permanently marked sites: the letters WIM, the 4-digit project ID or PP99 where PP is the Project ID and 99 is the section number assigned for WIM beginning with 99 and decreasing for every new or separate location at which WIM or AVC eqiupment is installed for the project. Monuments (in the form of nails, spikes, or re-bars) shall be installed in the shoulders, exactly at the beginning and end of the test section, as shown in Figure F-1. Markers are needed at the beginning of the section for both short wave and long wave length section lengths. These monuments will serve as a section markers in case of pavement paint wear. Also a delineator with two blue reflector shall be installed at the end of each test section for short wave length measurements.

Marking of sites not included in the national SPS program or undergoing initial evaluation shall be temporarily marked by tape or other means which are appropriate to the requirements of the equipment to trigger the start of data collection.

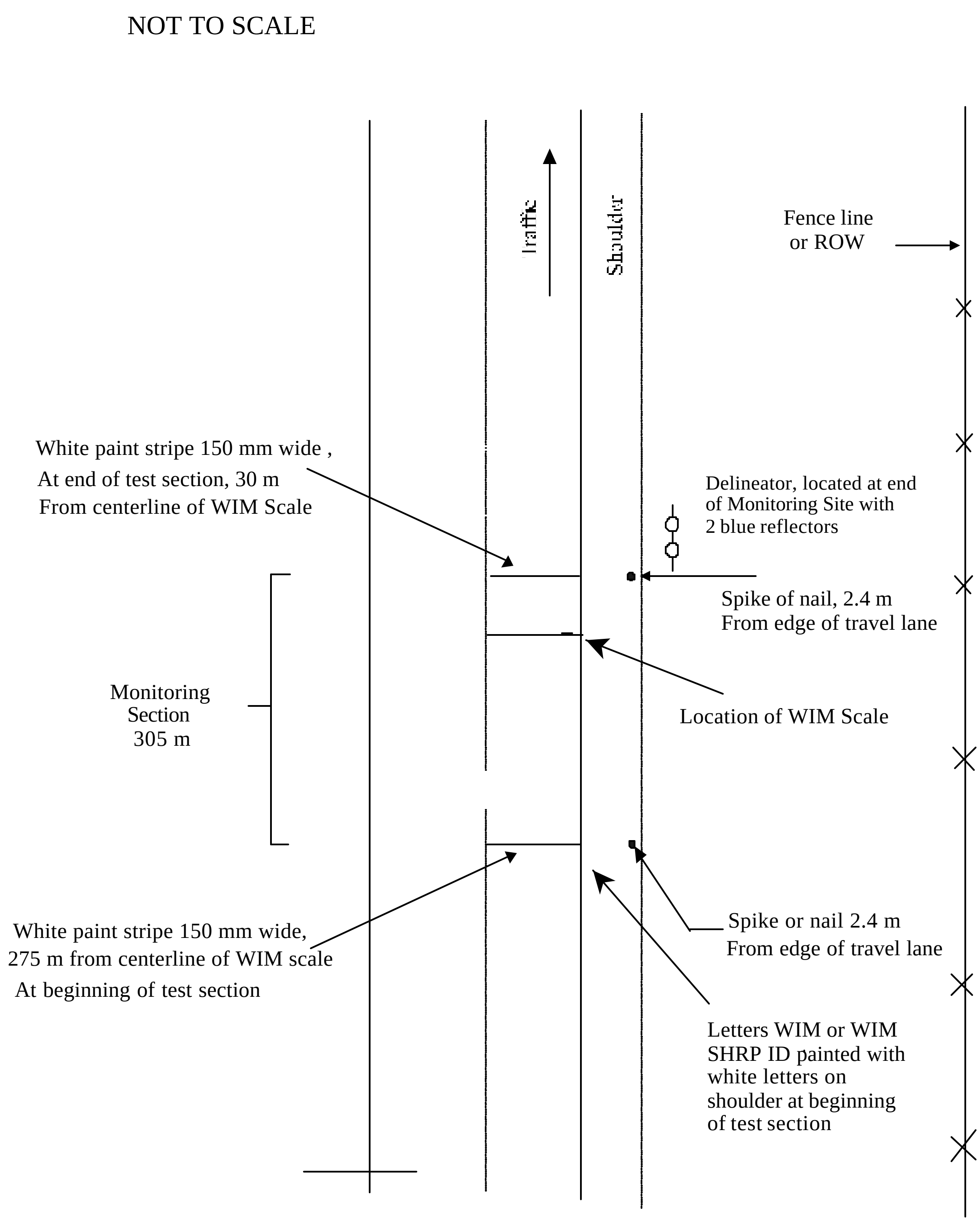


Figure F-1. Site markings at WIM site

Attachment G
Specifications for Straightedge and Disk

The straightedge measuring device specifications are base upon the following criteria. A straightedge that is 3.65 m in length and has a mark at the center of the straightedge and a circular plate that is 3 mm in height and 150 mm in diameter are needed to perform this test. The bottom rectangular surface of the straightedge shall be at least 19 mm but not more than 75 mm wide in the measurement plane. The maximum out-of-trueness of the bottom surface of the straightedge in the measurement plane and along the width shall be less than ± 0.40 mm/m.

FHWA-LTPP has constructed a Beta version that is constructed from two magnesium-engineered levels connected with an aluminum handle and cradle assembly. These are connected together with four refastening screws. The 3mm x 150mm sizing disk is made from machined aluminum. The device is stored for shipment in a PVC carrying case. The shop drawings and specifications for the FHWA-LTPP device are listed below.

[We had to make modifications to the beam assembly for strength and durability. This has been completed and the beam is at the office. As such, the drawing had to be changed slightly and the supplier is making the edits to the AutoCAD drawings (a deliverable to his work order).]

Note: Maximum out-of-trueness specification of straightedge in measurement plane is considered realistic for this type of field equipment. Nonetheless, temperature effects may result in false failures at locations or in the acceptable results that should have failed. In addition, a stringent failure criterion was knowingly selected for use in this specification. Accordingly, both temperature effects and failure criterion will be carefully evaluated based on the results of the pilot studies and changes made as appropriate.

APPENDIX C

SPS TRAFFIC DATA COLLECTION FORMS

C. SPS TRAFFIC DATA COLLECTION FORMS

C.1. TRAFFIC SHEET 17 - SITE INVENTORY

A Traffic Sheet 17 is to be completed for each WIM equipment installation at SPS-1, -2, -5 or -6 projects regardless of whether it is included in the SPS pooled fund study. SPS-8 sites will require a sheet 17 only when included for monitoring by LTPP contractors rather than the agency. A Traffic Sheet 17 will be completed when equipment is replaced at a project except when sensors or electronics are reinstalled in exactly the same location. Such maintenance information is to be reported using sheet 15.

Sheet 17 is filled out on project basis. For multiple-choice items, the correct answer is either circled or shaded. For all items with underscores, a numerical value, text or "N/A" must be used to complete the form. All measurements may be done with a measuring wheel. If more precise measurements are needed, they are to be deferred until lane closure is made available for the project.

Item 1 – Route, Milepost and LTPP Direction

Route should be identified by alphanumeric designation such as I-10, US 101, State 234. Milepost should be identified using agency conventions with the units included. Direction is the direction of travel for road on which the LTPP lane is located not the compass direction of travel at the site.

Item 2 – Site Description

Site Description information should identify all elements of the location which may affect WIM performance either positively or negatively.

Distance measurements are to be made with a measuring wheel. Distance measurements requiring access to the travel lane may be omitted in the field and the relevant information taken from other LTPP data sheets. If field measurements must be omitted due to safety concerns, notes as to which measurements were omitted and how the necessary estimates were obtained are to be included in the Comments section of sheet 17. Information on grade may be taken from construction drawings if available.

The nearest SPS section is defined as the last SPS section a vehicle enters before it passes over the WIM sensor. This section may or may not be a core section. The intent of locating and identifying this section is to determine whether or not there are obstacles to treating a site for smoothness failures.

Item 3 – Lane Configuration

This section includes additional site geometry and is used to compare the information from Traffic Sheet 1 with existing conditions. If a sheet 1 does not exist, this sheet and the information in this section should be sufficient for data entry into TRF_BASIC_INFO.

Item 4 – Pavement Type

This item refers to the general layer characteristics at the location where the WIM sensor is installed. It includes information on the type of analysis and layer structure that would be appropriate for performing ESAL calculations for the pavement at the WIM site.

Item 5 – Distress Survey

A formal distress survey is part of a site evaluation the SPS WIM site. Such an activity is done in accordance with LTPP protocols. The date of the survey and filename for the distress map are recorded. Additional surveys done for site diagnostic purposes are also noted on this sheet.

If a profile is done prior to the site evaluation, the date of that activity is entered here.

Item 6 – Sensor Sequence

This element is included to verify the information contained in the traffic database. It also provides a record of sensor type. The types of sensors installed in the road should be listed in sequence in the direction of traffic. For example, if the first item the vehicle runs over in a system of loops and piezoelectric sensors is a loop then the entry could read loop, loop, piezo. The piezoelectric sensor would not be first listed because it was not the first sensor to record the presence of the vehicle.

Item 7 – Pavement Replacement or Grinding

This item is completed when the pavement was replaced or ground after initial constrution.

Item 8 – Ramps and Intersections

Intersection location affects the speed of vehicles going over the sensor. An intersection or heavily used driveway within the section limits implies that vehicles will be accelerating or decelerating over the scale. The use of the shoulder for turns or passing indicates the potential of a large underweight population because not all of the vehicles are captured or only one wheel load is measured.

Item 9 – Drainage

The ability to clean out the space under bending plates and load cell installations is a maintenance concern. If it is not possible to clean out the area the sensors will respond poorly.

Item 10 – Cabinet

Information on the cabinet will identify possible safety concerns and visibility issues when attempting to record speed information on validation trucks. This section also alerts data collectors to coordination issues for cabinet access when planning a site validation or evaluation.

Item 11.– Power

This item gives two pieces of information, the first is whether additional power may be needed to run laptops and so forth while on site visits. It also gives an initial point of contact to get service restored in the event of power failure.

Item 12 – Telephone

This item requires three pieces of information, the first is the physical location and type of connection.

Item 13.– System

This item requires information on the type of software needed when doing a site visit. LTPP may or may not have all of the most recent versions of software to review data on site. The issue of a computer connection indicates what kind of ports and cables must be available on the laptop brought to the site.

Item 14 – Turnaround time

Based on these values, a determination will be made on the number of trucks required to finish site activities in a single day.

Item 15 – Photo Info

Other pieces of information considered useful about the immediate vicinity of the WIM scale can be noted in the COMMENTS section.

To insure that users know where to find things, a series of digital photographs are required. The photo files should be named with state code, SHRP_ID, date and an abbreviation for content. The photos are to include the location of power and phone, the cabinet, the installation in the road. These photographs are to be included with the sheet 17 when a traffic data collector goes to the site. Any changes noted should be reflected on traffic sheet 15 and new photographs are to be taken as required. It is suggested that a picture of the LTPP lane, clearly labeled with the LTPP lane number and direction, be posted in the cabinet.

The last page of the sheet includes a sketch of the equipment layout on the road. The site layout should include the dimensions and spacing of the sensors. It need not be to scale. Additionally, this sheet should include a site map of a scale suitable to locate the route the test trucks will follow. The map should also clearly show the locations of any staging areas.

C.2. AGENCY COORDINATION CHECKLIST

This list is used to organize each individual site visit for Site Evaluations and Validations.

C.3. CONSTRUCTION

This list is used to organize each individual site visit for Construction.

Sheet 17	*STATE_CODE __ __
LTPP Traffic Data	*SPS PROJECT ID __ __ __ __
WIM SITE INVENTORY	*SPS WIM_ID __ __ __ __

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1.* ROUTE _____________ MILEPOST _________ LTPP DIRECTION - N S E W

2.* WIM SITE DESCRIPTION - Grade ________ % Sag vertical Y / N

Nearest SPS section upstream of the site ___ ___ ___ ___

Distance from sensor to nearest upstream SPS Section ___ ___ ___ ___ ft

3.* LANE CONFIGURATION

Lanes in LTPP direction ____ Lane width __ __ ft

Median -
1 – painted
2 – physical barrier
3 – grass
4 – none

Shoulder -
1 – curb and gutter
2 – paved AC
3 – paved PCC
4 – unpaved
5 – none

Shoulder width ___ ___ ft

4.* PAVEMENT TYPE _________________________

5.* PAVEMENT SURFACE CONDITION – Distress Survey

Date ______________________________ Distress Map Filename _________________

Date ______________________________ Distress Map Filename _________________

Date ______________________________ Distress Map Filename _________________

6. * SENSOR SEQUENCE ____

7. * REPLACEMENT AND/OR GRINDING __ __ __ / __ __ / __ __ __ __

REPLACEMENT AND/OR GRINDING __ __ __ / __ __ / __ __ __ __

REPLACEMENT AND/OR GRINDING __ __ __ / __ __ / __ __ __ __

8. RAMPS OR INTERSECTIONS

Intersection/driveway within 300 m upstream of sensor location Y / N distance __________

Intersection/driveway within 300 m downstream of sensor location Y / N distance __________

Is shoulder routinely used for turns or passing? Y / N

9. DRAINAGE (*Bending plate and load cell systems only)*

1 – Open to ground
2 – Pipe to culvert
3 – None

Clearance under plate ___ ___ . ___ in

Clearance/access to flush fines from under system Y / N

10. * CABINET LOCATION

Same side of road as LTPP lane Y / N   Median Y/ N   Behind barrier Y / N
Distance from edge of traveled lane __ __ ft
Distance from system __ __ __ ft
TYPE ____________________________

CABINET ACCESS controlled by LTPP / STATE / JOINT ?
Contact - name and phone number _______________________________________
Alternate - name and phone number _______________________________________

11. * POWER

Distance to cabinet from drop ___ ___ ___ ft   Overhead / underground / solar / AC in cabinet?
Service provider ______________________   Phone number ______________________

12. * TELEPHONE

Distance to cabinet from drop ___ ___ ___ ft   Overhead / under ground / cell?
Service provider ______________________   Phone Number ______________________

13.* SYSTEM (software & version no.)- ____
Computer connection – RS232 / Parallel port / USB / Other ____________________

14. * TEST TRUCK TURNAROUND time _______ minutes   DISTANCE ___ ___ mi.

15. PHOTOS	FILENAME	
Power source	________________________	
Phone source	________________________	
Cabinet exterior	________________________	
Cabinet interior	________________________	
Weight sensors	________________________	
Classification sensors	________________________	
Other sensors	________________________	Description _______________________________

Downstream direction at sensors on LTPP lane _____________________
Upstream direction at sensors on LTPP lane _____________________

COMMENTS ____
____

COMPLETED BY _________________________________

PHONE ____________________   DATE COMPLETED __ __ /__ __ / __ __ __ __

Sheet 17	*STATE_CODE __ __
LTPP Traffic Data	*SPS PROJECT ID __ __ __ __
WIM SITE INVENTORY	*SPS WIM_ID __ __ __ __

Rev. 09/25/01

Sketch of equipment layout

Site Map

LTPP – State Agency Coordination – Evaluation & Validation Checklist (C.2)

Prior to Visit	**Y / N?**	**Comment**
Contact Name & Phone for trucks/drivers/loads		
Contact Name & Phone for scale		
Contact Name & Phone for WIM cabinet & electronics access		
Contact Name & Phone for profiler		
Contact Name & Phone for enforcement (if required)		
Contact Name & Phone for traffic control (if required)		
Test truck #1 with trailer and proper air suspension		
Complete Traffic Sheet 17		
Test truck #2 with trailer & different load/configuration		
Are appropriate loads available?		
Facilities for adjusting loads to get correct (legal) axles weights		
Certified scale nearby. Are its hours of operation compatible?		
Drivers for both trucks available. What are their hours?		
Will the turnaround loop allow sufficient runs in 1 day?		
Can the trucks get to speed at the WIM site?		
Will the site allow operation without acceleration or deceleration?		
Arrange a suitable staging area for measuring trucks		
Is there room at the site to setup next to the cabinet		
Is the site congested? Will it allow the chosen truck speeds?		
Locations for staging, site, scale, etc. mapped & distributed		
Profiler available from the RSC		
Site marked for profiling? WIM location is known?		
State or vendor person to access cabinet and WIM electronics		
Is AC power available at the site?		
Is there space to park vehicles at the site?		
Is LTPP authorized to alter calibration of the equipment?		
Are all participants available for weather contingency day?		
Site Visit	**Y / N**	**Agency**
Pre-test Meeting		LTPP, State, RSC
Briefing – Drivers (route, # of runs, speeds, etc.)		LTPP, Drivers
Mark site for long & short wavelength profiles		RSC, LTPP
Short wavelength profiles – profiler		RSC
Short wavelength profiles – straight edge (if required)		LTPP

Perform short wavelength simulation (divotometer software)		LTPP
Load & ready trucks		Drivers
Digital Photos as required (trucks, site, WIM equipment)		LTPP
Weigh & measure trucks – before runs		LTPP, Drivers
Verify WIM equipment operation& communication with laptop		LTPP, State
Classification & speed measurement tests		LTPP, State
WIM Test – include speed & temperature measurements		LTPP, State
Long wavelength profiles – follow trucks		RSC
Weigh Trucks – after runs (complete traffic sheet 19)		LTPP, Drivers

LTPP – State Agency Coordination – Construction Checklist (C.3)

Prior to Visit	**Y / N?**	**Comment**
Contact Name & Phone for state		
Contact Name & Phone for WIM contractor		
Contact Name & Phone for pavement contractor		
Contact Name & Phone for traffic control (if required)		
Verify the construction & installation schedule		
Determine if the proposed WIM site meets requirements (see 4.1)		
Site Visit	**Y / N?**	**Agency**
Grind approach pavement for smoothness		State or Contractor
Perform straightedge profiling		LTPP
Install WIM		State or Contractor
Verify classification algorithm		State or Contractor
Calibrate WIM		State or Contractor
Complete Traffic Sheet 17		LTPP
Schedule Site Evaluation		LTPP

C.4. TRAFFIC SHEET 18 – WIM SITE COORDINATION

This sheet consists of six sections documenting the division of responsibilities between FHWA-LTPP and a highway agency for any SPS project subject to intensive monitoring. The sections are Equipment, Site Visits – Evaluation , Data Processing, Site Visits - Validation, Site Visit – Construction, and Special Conditions.

Item 1 – Equipment

This section provides a general reference as to the organizational responsibilities for various aspects of equipment operation and maintenance for sites which are being monitored through the SPS Traffic Pool Fund. For each item of information the current option should be circled or shaded. For additional information such as contacts, a separate sheet yet to be developed is required.

The maintenance item is relevant to those sites from which LTPP is directly acquiring data.

The purchase item applies only when new or replacement equipment is installed.

The installation item also applies only to new equipment.

The calibration item applies to new equipment. If LTPP is responsible for calibration (as opposed to validation) then section 5 will be completed with the relevant information.

The pavement item indicates the level of investment the agency is willing to put in to sites which fail validation and for which the corrective action in improving pavement smoothness.

Power is for reference in identifying equipment needed on site visits.

Communication is for reference for contractors downloading data.

Item 2 – Site Visits – Evaluation

Every active SPS –1, -2, -5 and –6 site with working equipment will be visited at least once to provide baseline information on system operations and equipment. This visit is conducted with state consent and may be the only visit made by LTPP personnel if the agency has elected to continue traffic data collection activities independently. Items which are multiple choice are either circled or shaded. Underscored items must be filled with either name and phone or fax or e-mail or marked as N/A.

The first group of items includes information relevant to trucks and weights. The number of days advance notice for the agency to marshal its resources is necessary for scheduling purposes. Then the number of trucks and the providers are identified. The source of loads and drivers needs to be identified. If the state has any recommendations on sources for these items, LTPP will make every effort to include them in the selection process.

The second group of items deals with profiling. Unless the site is going to be included in the SPS pooled fund, it is highly unlikely that it will be permanently marked for the site evaluation.

The third group of data is pre-visit data. These include all of the traffic operational conditions and data needed to defined the test runs as well as the individuals who must be notified of the evaluation.

The section ends with space to include any special conditions which may include items such as working hours, prohibited routes, safety gear or signing.

Item 3 – Data Processing

This section is completed for every SPS-1, -2, -5 and –6 location. The responsible party in each case is shaded in. Download refers to taking the data directly off the machine. Data review is the process of verifying that the equipment is operational and that the information passes QC. Data submission for QC identifies the party that is responsible for delivery of data to the RCOC for complete processing up to and including entry into the IMS.

Item 4 – Site Visit – validation

Every active SPS –1, -2, -5 and –6 site which is included in the SPS Traffic Pool fund for the purposes of twice yearly validation and annual profiling will have this section completed. Items which are multiple choice are either circled or shaded. Underscored items must be filled with either name and phone or fax or e-mail or marked as N/A.

The first group of items includes information relevant to trucks and weights. The number of days advance notice for the agency to assemble the resources associated with its participation. Then the number of trucks and the providers are identified. The source of loads and drivers needs to be identified. It is expected that the site evaluation process will have indicated whether the selected sources are suitable for continued use. Additionally, the nearest commercial scale is identified.

The second group of items deals with profiling. Depending on state wishes the site may or may not be permanently marked. This item is included to that the profiler operator knows if time must be allowed to put out temporary markings. If the run up to a WIM site overlaps an SPS section it may not be possible to permanently mark it for long wave length analysis without creating data quality problems for LTPP's routine profiling operations.

The third group of data is pre-visit data. These include all of the traffic operational conditions and data needed to defined the test runs as well as the individuals who must be notified of the evaluation.

The section ends with space to include any special conditions which may include items such as working hours, prohibited routes or signing.

Item 5 – Site Visit – Construction

This section is only filled out when pavement reconstruction is required to install a new or replacement WIM system. Items which are multiple choice are either circled or shaded. Underscored items must be filled with either name and phone or fax or e-mail or marked as N/A. Depending on LTPP's level of involvement in the installation process LTPP contractors may or may not be required on site for the grinding and calibration testing of new sites. Once the site is certified to be operational and calibrated, LTPP will schedule an acceptance test. The site evaluation process is used for this site visit and the groups of items in this section parallel those in Site Visits – Evaluation.

Item 6 – Special Conditions

If there are any conditions which the agency puts on its participation or the LTPP program's involvement that will affect contractor work they will appear in this section. Such conditions may include restrictions on night work, the number of site visits permitted or the protocols for contacting agency personnel for support.

1. Equipment –
   - Maintenance – contract with purchase / separate contract LTPP / separate contract State / state personnel
     Contact ____

   - Purchase by LTPP / State
   Constraints on specifications (sensor, electronics, warranties, maintenance, installation)

   - Installation – Included with purchase / separate contract by State / state personnel / LTPP contract

   - Calibration – Vendor / State / LTPP

   - Manuals and software – State / LTPP

   - Pavement PCC/AC – always new / replacement as needed / grinding and maintenance as needed / maintenance only / no remediation

   - Power - overhead / underground / solar billed to State / LTPP / N/A

   - Communication - Landline / Cellular / Other billed to State / LTPP / N/A

2. Site visits – Evaluation

   - WIM Validation Check - advance notice required _____ days / weeks

   - Trucks – air suspension 3S2 State / LTPP
     2nd common State / LTPP
     3rd common State / LTPP
     4th common State / LTPP
     Loads State / LTPP
     Contact ______________________________________

     Drivers State / LTPP
     Contact ______________________________________

     Contractors with prior successful experience in WIM calibration in state:
     ____
     Nearest static scale (commercial or enforcement)
     ____

   - Profiling – short wave -- permanent / temporary site marking
     -- long wave – permanent / temporary site marking

   - Pre-visit data
     – Classification and speed: Contact ______________________________

--Typical operating conditions (congestion, high truck volumes)
Contact ____
-- Equipment operational status: Contact ____________________________

- Access to cabinet
  State only / Joint / LTPP   Key / Combination

- State personnel required on site Y / N
Contact information ____

- Enforcement Coordination required Y / N
Contact information ____

- Traffic Control Required Y/ N
Contact information ____

- Maximum number of personnel on site ___;
  Invitees __________________________

- Authorization to calibrate site -- State only / LTPP

- Special conditions ____

3. Data Processing
- Down load   State only / LTPP read only / LTPP download / LTPP download and copy to state
- Data Review   State per LTPP guidelines / State weekly / LTPP
- Data submission for QC   State - weekly; twice a month; monthly / LTPP

4. Site visits – Validation

- WIM Validation Check - advance notice required _____ days / weeks
  LTPP Semi-annually / Sate per LTPP protocol semi-annually / State other

- Trucks – air suspension 3S2   State / LTPP
  2nd common   State / LTPP
  3rd common   State / LTPP
  4th common   State / LTPP
  Loads   State / LTPP
  Contact ____

  Drivers   State / LTPP
  Contact ____

  Contractors with prior successful experience in WIM calibration in state:
  ____

- Profiling – short wave -- permanent / temporary site marking
  -- long wave – permanent / temporary site marking

- Pre-visit data
  – Classification and speed: Contact ______________________________
  -- Equipment operational status: Contact ____________________________

- Access to cabinet
  State only / Joint / LTPP Key / Combination

- State personnel required on site Y / N

Contact information ____

- Enforcement Coordination required Y / N

Contact information ____

- Traffic Control Required Y/ N

Contact information ____

- Authorization to calibrate site -- State only / LTPP

- Special conditions ____

5. Site visit – Construction

- Construction schedule and verification – Contact _________________________

- Notice for straightedge and grinding check - ______ days / weeks

On site lead to direct / accept grinding – State / LTPP

- WIM Calibration - advance notice required _____ days / weeks
  Number of lanes -- ______
  LTPP / State per LTPP protocol / State Other _________________

- Trucks – air suspension 3S2 State / LTPP
  2nd common State / LTPP
  Loads State / LTPP
  Drivers State / LTPP

  Contractors with prior successful experience in WIM calibration in state:
  ____

- Profiling – straight edge -- permanent / temporary site marking
  -- long wave – permanent / temporary site marking

- Pre-visit data
  – Classification and speed: Contact ______________________________
  -- Equipment operational status: Contact ____________________________

- Access to cabinet
  State only / Joint / LTPP Key / Combination

- State personnel required on site Y / N

Contact information ____

- Enforcement Coordination required Y / N

Contact information ____

- Traffic Control Required Y/ N

Contact information ____

- Authorization to calibrate site -- State only / LTPP

- Special conditions ____

6. Special conditions
    - Funds and accountability
    - Reports
    - Other

C.5. TRAFFIC SHEET 19 - TEST TRUCK INFORMATION

This sheet consists of two parts, the first summary information the vehicle and second the raw weight data and computations. Part I consists of three sections documenting the axle weights, geometry and suspension characteristics of all trucks used in SPS WIM site performance testing. Part II consists of a set of tables for truck weighing using a full platform scale and a set of tables if individual axle weights can be directly read from the scale.

All asterisked (*) items are required for the sheet to be considered complete.

A separate sheet 19 must be completed for each test truck used in the WIM validation or verification process.

HEADER INFORMATION - To be entered on all 4 pages of the sheet.

STATE_CODE – The 2-digit FIPS identification code for the state.

SPS PROJECT ID – The SHRP_ID ending in 00 which indicates the SPS project that uses this equipment. If more than one project uses the data, enter the second project ID next to the first.

CALIBRATION TEST TRUCK – The unique identifying number for the truck. Typically the truck numbers will be single digit identifiers beginning with #1 and increasing in increments of 1.

DATE – The date the initial weighing session occurred.

PART I.

Item 1 – FHWA Class

Identify the type of truck according to the FHWA 13-bin classification scheme (see Section 4, Appendix A, of the FHWA 3d edition of the Traffic Monitoring Guide, February 1995).

Item 2 – Number of Axles

Record the total number of axles on the test truck.

Item 3 – Empty Truck Axle Weights

If given the opportunity, record the weights of each truck axle while the truck is empty. Space is provided for up to six axles. It is not expected that any test truck will have more than six axles. Make sure that the units have been indicated in the lis next to AXLES. All measurements must be done in the same unit system.

Item 4 – Pre-Test Average Loaded Axle Weights

Compute the average weights of each truck axle prior to the WIM performance testing. Do this after the truck has been fully loaded and ensure that the truck's configuration does not change through adjustment of fifth wheel or axle positions between weighing and WIM performance testing. If the GVW or axle weights exceed legal limits, make any necessary adjustments and then repeat the entire process from the beginning to compute the revised average weight measurements in these spaces. All weight measurements should be done on state certified scales. Make sure that the units have been indicated in the lis next to AXLES. All measurements must be done in the same unit system.

Item 5 – Post-Test Average Loaded Axle Weights

Compute the weights of each truck axle immediately after the WIM performance testing. All weight measurements should be done on state certified scales. Make sure that the units have been indicated in the list next to AXLES. All measurements must be done in the same unit system.

Item 6 – Measured Directly or Calculated?

If the axle was weighed individually on a state certified scale, then enter "D". If the weight is calculated by subtracting or dividing the weights of axle groups, then enter "C". Typically, axles that make up tandem groups cannot be directly weighed. In these cases, the weight of the axle may be calculated by dividing the axle group weight by two.

Item 7 a-d – Gross Vehicle Weight (GVW)

The gross vehicle weight is reported in the same units as the axles. If possible the empty weight (a) should be obtained. The average GVW before and after the testing is entered in items b and c respectively. The difference ended in (d) should reflect the final measurements and meet the acceptance criteria for the weight differential

Item 8 a, b – Tractor Information

Circle in (a) "Cab Over Engine" if the tractor's cab is positioned over the engine.These cabs have a predominantly square profile. "Conventional" cabs have the engine positioned ahead of the driver compartment.

Circle "Y" in (b) if the tractor cab is equipped with sleeping facilities for the driver. Circle "N" otherwise.

Item 9 a, b – Make and Model

The tractor's make (a) and model information (b) will usually be found on a sticker at the back edge of the driver door. The driver should be able to supply this information if it cannot be found on the truck.

Item 10 – Trailer Load Distribution Description

Indicate the type of trailer used (box, flatbed, dump, etc) and describe the load and the way in which it is distributed. Specifically, try to describe how the load is distributed longitudinally and if it is concentrated at any particular location. Also note how high the load is stacked and whether the height is even along the trailer's length.

Item 11 – a, b - Tractor and Trailer Tare Weight

Individually record the empty weight of both the tractor (a) and the trailer (b) while they are uncoupled if given the opportunity. Include the units used.

Item 12 – Axle Spacing

Circle the units of measurement used. Use a tape measure to obtain the longitudinal distances between each axle. Use two people to get precise center-to-center measurements. Note that axle A denotes the front steering axle of the truck with axles B and C, etc. being the next axles as you move toward the rear. Space has been provided for trucks with up to six axles. It is not expected that larger trucks will be used for WIM site performance testing.

Include the measurement from the first to the last and the computed total. The allowable difference between the two values is 150 mm, 6 inches, 0.5 feet depending on the units used for measurement.

Item 13 – Kingpin Offset From Axle B

Measure the distance from the center of axle B to the articulation point of the tractor-trailer combination. On a five-axle combination, this point will typically be between axles B and C. If the articulation point (kingpin) is behind axle B, the distance will be positive.

Item 14 – Tire Size

Record the nominal tire size for each axle. These can usually be found stamped on the tire and will look something like "11R22.5" or "445/65R22.5".

Item 15 – Suspension Description

Note whether the axle is a single or part of a tandem group. Also determine the suspension type (air, leaf spring, etc.). If it is a leaf spring suspension, count the leaves and determine if it they are flat or tapered. Tapered leaf springs get thinner near their end while flat springs have a constant thickness. Photographs of these suspension parts should be taken.

Item 16 – Cold Tire Pressures

For each of the test trucks, measure cold tire pressures prior to any test runs to ensure that the tires have not warmed to operating temperatures. Record the pressures for each axle starting with the rightmost tire and moving left. There should be four measurements per axle and except steering axles which will have two.

PART II.

Table 1 – Axle and GVW computations – pre-test

This table provides the space to compute the differences which result in the axle weights to be averaged to be used for comparison. If the truck has more or fewer axles, change the equations in the left hand cells for each axle affected and mark out any unused blocks.

Table 2 – Raw Axle and GVW measurements

This table is used to record all of the total and fractional truck measurements needed for a 5-axle vehicle on a full truck scale. If more or fewer axles exist, the table should be updated or a similar table created and attached to the Sheet 19 set for this truck. The extra pages should be identified on the face of this table. The table contains 4 columns, the first for pre-test and the last for post-test weights. The remaining columns are available if additional series need to be done.

Table 3 – Axle and GVW computations –

This table is the same as Table 1. It provides the space to compute the differences in the event a second Pass 1 weight series is required pre-test due to a failure or a day or more's break in testing. The table heading should be labeled with the reason (i.e. 2^{nd} trial, snow day break etc.)

Table 4 – Axle and GVW computations – post-test

This table is the same as Table 1. It provides the space to compute the differences which result in the axle weights used to check for significant weight changes over the course of the weight session. If the value of GVW is within 1000 pounds of the initial value, there will be no entries of items X and XI.

Table 5 – Raw data – Axle scales – pre-test

This table is used to enter the individual axle weights from scales which are capable of providing such values directly. If the scale is designed specifically for 5-axle tractor-trailers with a single and two tandems, record the first tandem as Axle B-C and the second tandem as Axle D-E.

Table 6 – Raw data – Axle scales –

Same as Table 5 and used when a complete weighing cycle must be repeated. Enter pre-test or post- test as applicable. This table may also be used if there is a break in the weigh session over a day or more to provide the reference values for the remaining set of truck runs.

Table 7 – Raw data – Axle scales – post-test

Same as Table 5 and used after all test runs have been completed.

PART I.

1.* FHWA Class ________ 2.* Number of Axles ________

AXLES - units - lbs / 100s lbs / kg

	3. Empty Truck Axle Weight	4.* Pre-Test Average Loaded Axle Weight	5.* Post-Test Average Loaded Axle Weight	6.* Measured D)irectly or C)alculated?
A	______________	______________	______________	D / C
B	______________	______________	______________	D / C
C	______________	______________	______________	D / C
D	______________	______________	______________	D / C
E	______________	______________	______________	D / C
F	______________	______________	______________	D / C

GVW (same units as axles)

7. a) Empty GVW _______________

*b) Average Pre-Test Loaded weight _______________
*c) Post Test Loaded Weight _______________
*d) Difference Post Test – Pre-test _______________

GEOMETRY

8 a) * Tractor Cab Style - Cab Over Engine / Conventional b) * Sleeper Cab? Y / N

9. a) * Make: ____________ b) * Model: ______________

10.* Trailer Load Distribution Description:

____

____

____

____

11. a) Tractor Tare Weight (units): _______________(__________)_

b). Trailer Tare Weight (units): _______________(__________)_

Sheet 19	*STATE_CODE __ __
LTPP Traffic Data	*SPS PROJECT ID __ __ __ __
*CALIBRATION TEST TRUCK #____	*DATE __ __ __ / __ __ / __ __ __ __

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12.* Axle Spacing – units m / feet and inches / feet and tenths

A to B _____________ B to C _____________ C to D _____________

D to E _____________ E to F _____________

Wheelbased (measured A to last) ______________ Computed _____________

13. *Kingpin Offset From Axle B (units) ________________(____________)__
(+ is to the rear)

SUSPENSION

Axle	14. Tire Size	15.* Suspension Description (leaf, air, no. of leaves, taper or flat leaf, etc.)
A	_________	____
B	_________	____
C	_________	____
D	_________	____
E	_________	____
F	_________	____

16. Cold Tire Pressures (psi) – from right to left

Steering Axle	Axle B	Axle C	Axle D	Axle E
_______	_____________	_____________	_____________	_____________
	_____________	_____________	_____________	_____________
	_____________	_____________	_____________	_____________
_______	_____________	_____________	_____________	_____________

Sheet 19	*STATE_CODE __ __
LTPP Traffic Data	*SPS PROJECT ID __ __ __ __
*CALIBRATION TEST TRUCK #____	*DATE __ __ __ / __ __ / __ __ __ __

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PART II

Table 1. Axle and GVW computations - pre-test

Axle A		Axle B		Axle C		Axle D		Axle E		GVW	
I		II -I		III -II		IV -III		V -IV		V	
V -VI		VI- VII		VII- VIII		VIII- IX		IX`		X	
										XI	
Avg.											

Table 2. Raw Axle and GVW measurements

Axles	Meas.	Pre-test Weight			Post-test Weight
A	I				
A + B	II				
A + B + C	III				
A + B + C + D	IV				
A + B + C + D + E (1)	V				
B + C + D + E	VI				
C + D + E	VII				
D + E	VIII				
E	IX				
A + B + C + D + E (2)	X				
A + B + C + D + E (3)	XI				

Table 3. Axle and GVW computations - post -test

Axle A		Axle B		Axle C		Axle D		Axle E		GVW	
I		II -I		III -II		IV -III		V -IV		V	
V -VI		VI- VII		VII- VIII		VIII- IX		IX`		X	
										XI	
Avg.											

Sheet 19	*STATE_CODE __ __
LTPP Traffic Data	*SPS PROJECT ID __ __ __ __
*CALIBRATION TEST TRUCK #____	*DATE __ __ __ / __ __ / __ __ __ __

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Table 4 . Axle and GVW computations -

Axle A		Axle B		Axle C		Axle D		Axle E		GVW	
I		II -I		III -II		IV -III		V -IV		V	
V -VI		VI- VII		VII- VIII		VIII- IX		IX`		X	
										XI	
Avg.											

Table 5. Raw data – Axle scales – pre-test

Pass	Axle A	Axle B	Axle C	Axle D	Axle E	Axle F	GVW
1							
2							
3							
Average							

Table 6. Raw data – Axle scales –

Pass	Axle A	Axle B	Axle C	Axle D	Axle E	Axle F	GVW
1							
2							
3							
Average							

Table 7. Raw data – Axle scales – post-test

Pass	Axle A	Axle B	Axle C	Axle D	Axle E	Axle F	GVW
1							
2							
3							
Average							

Measured By ________________________________ Verified By _____________________________

C.6. TRAFFIC SHEET 20 – SPEED AND CLASSIFICATION CHECKS

This sheet is provided as an alternative to a software application to compare the WIM or AVC equipment algorithms. It is possible to do the speed and or the classification checks with this sheet. The critical information to be collected along with the observer's measurements is the record number assigned to that vehicle by the WIM system. The output from the WIM system can be entered later from the permanent record or by a second individual watching the equipment output.

The sheet header is entered as for any other LTPP data sheet. Note that since more than one sheet will be required to record all the observations needed for a minimum sample size, the information on the number of sheets in a set and which one of the set as well as the recorder are important to keep a set of observations together.

The information at the bottom of the sheet, direction, lane is important to separate the sheets if multiple lanes are done. The information on time is critical since many WIM systems reset vehicle record numbers on the hour.

Sheet 20	* STATE_CODE __ __
LTPP Traffic Data	*SPS PROJECT_ID __ __ __ __
Speed and Classification Checks * ____ of* ____	* DATE __ __ / __ __ / __ __ __ __

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WIM speed	WIM class	WIM Record	Obs. Speed	Obs Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs Class

Recorded by _______________ Direction _____ Lane ____Time from _______ to ________

C.7. TRAFFIC SHEET 21 – WIM TRUCK RECORD DATA

Sheet 21 is provided as an alternative to using WIM 2 TRUCK or another software application to record truck data in real time.

The header is filled out as for any other LTPP data sheet. Since at least 3 sheets will be needed to collect the data for the minimum number of passes the entries on the sheet number in the sequence in the header is important.

The minimum information is the Truck number, the time and the Record number from the WIM system.

The pavement temperature and radar speed (Pvmt temp, Radar Speed) may be kept initially on the same sheet or done on two separate sheets and then consolidated. If separate sheets are used all sheets must be retained as part of the raw data packet. The transfer from the original sheet must be checked by some one other than the individual transferring the data.

The information from the WIM system may be entered in real time or from the permanent record from the equipment. In either case a se the data recorded on this sheet must be independently checked by another individual against the permanent record.

Sheet 21	* STATE_CODE __ __
LTPP Traffic Data	*SPS PROJECT_ID __ __ __ __
WIM System Test Truck Records * ____ of* ____	* DATE __ __ / __ __ / __ __ __ __

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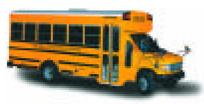
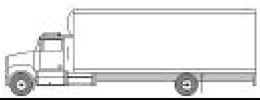
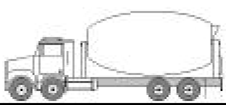
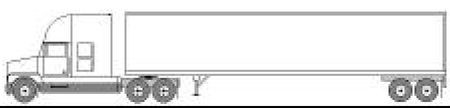
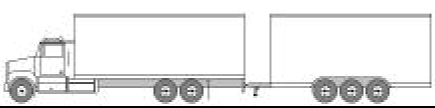
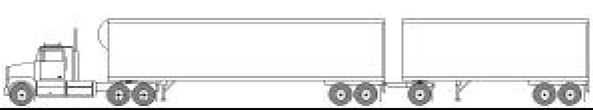
Pvmt temp	Radar Speed	Truck	Pass	Time	Record No.	WIM Speed	Axle A weight.	Axle B weight.	Axle C weight.	Axle D weight.	Axle E weight.	Axle F weight	GVW	A-B space	B-C space	C-D space	D-E space	E-F space

Recorded by ________________________ Checked by ______________________

Figure C-1 – FHWA Vehicle Classification Scheme

Class	Illustration	Description
1		Motorcycles
2		Passenger Cars
3		Pickups/Vans
4	 	Buses
5	  	6 tire two-axle single unit trucks
6	 	Three axle single unit trucks
7	 	Four or more axle single unit trucks
8		Four or fewer axle truck and trailer combinations
9		Five axle truck and trailer combinations
10		Six or more axle truck and trailer combinations
11		Five or fewer axle multis
12		Six axle multis
13		Seven or more axle multis
14		Errors/Unknown

FHWA VEHICLE CLASSES WITH DEFINITIONS

1. ***Motorcycles*** – All two or three-wheeled motorized vehicles. Typical vehicles in this category have saddle type seats and are steered by handlebars rather than steering wheels. This category includes motorcycles, motor scooters, mopeds, motor-powered bicycles, and three wheel motorcycles. This vehicle type may be reported at the option of the State.

2. ***Passenger Cars*** – All sedans, coupes, and station wagons manufactured primarily for the purpose of carrying passengers and including those passenger cars puling recreational or other light trailers.

3. ***Other Two-Axle, Four-Tire Single Unit Vehicles*** – All two axle, four-tire vehicles, other than passenger cars. Included in this classification are pickups, panels, vans, and other vehicles such as campers, motor homes, ambulances, hearses, carryalls, and minibuses. Other two axle, four-tire single-unit vehicles pulling recreational. Or other light trailers are included in the classification.

4. ***Buses*** – All vehicles manufactured as traditional passenger- carrying buses with two axles and six tires or three or more axles. This category includes on traditional buses (including school buses) functioning as passenger-carrying vehicles. Modified buses should be considered to be a truck and should be appropriately classified.

5. ***Two-Axle, Six-Tire, Single-Unit Trucks*** – All vehicles on a single frame including trucks, camping and recreational vehicle, motor homes, etc.., with two axles and dual rear wheels.

6. ***Three-Axle, Single-Unit Trucks*** – All vehicles on a single frame including trucks, camping and recreational vehicles, motor homes, etc., with three axles.

7. ***Four or More axle Single-Unit Trucks*** – All trucks on a single frame with four or more axles.

8. ***Four or Fewer Axle Single-Trailer Trucks*** – All vehicles with four or fewer axles consisting of two units, one of which is a tractor or straight truck power unit.

9. ***Five Axle Single-Trailer Trucks*** – All five-axle vehicles consisting of two units, one of which is a tractor or straight truck power unit.

10. ***Six or More Axle Single-Trailer Trucks*** – All vehicles with six or more axles consisting of two units, one of which is a tractor or straight truck power unit.

11. ***Five or fewer Axle Multi-Trailer Trucks*** – All vehicles with five or fewer axles consisting of three or more units, one of which is a tractor or straight truck power unit.

12. ***Six-Axle Multi-Trailer Trucks*** – All six-axle vehicles consisting of three or more units, one of which is a tractor or straight truck power unit.

13. ***Seven or More Axle Multi-Trailer Trucks*** – All vehicles with seven or more axles consisting of three or more units, one of which is a tractor or straight truck power unit.

APPENDIX D

SUPPORTING SOFTWARE

D. SUPPORTING SOFTWARE

There are three software applications used to analyze data for SPS WIM sites: WIM 2 TRUCK.xls, CLASSMACRO.xls and the straight edge simulation software. This section discusses the use of the two spreadsheet applications. The straight edge simulation software is discussed in Pavement Smoothness Specifications for LTPP SPS WIM Locations.

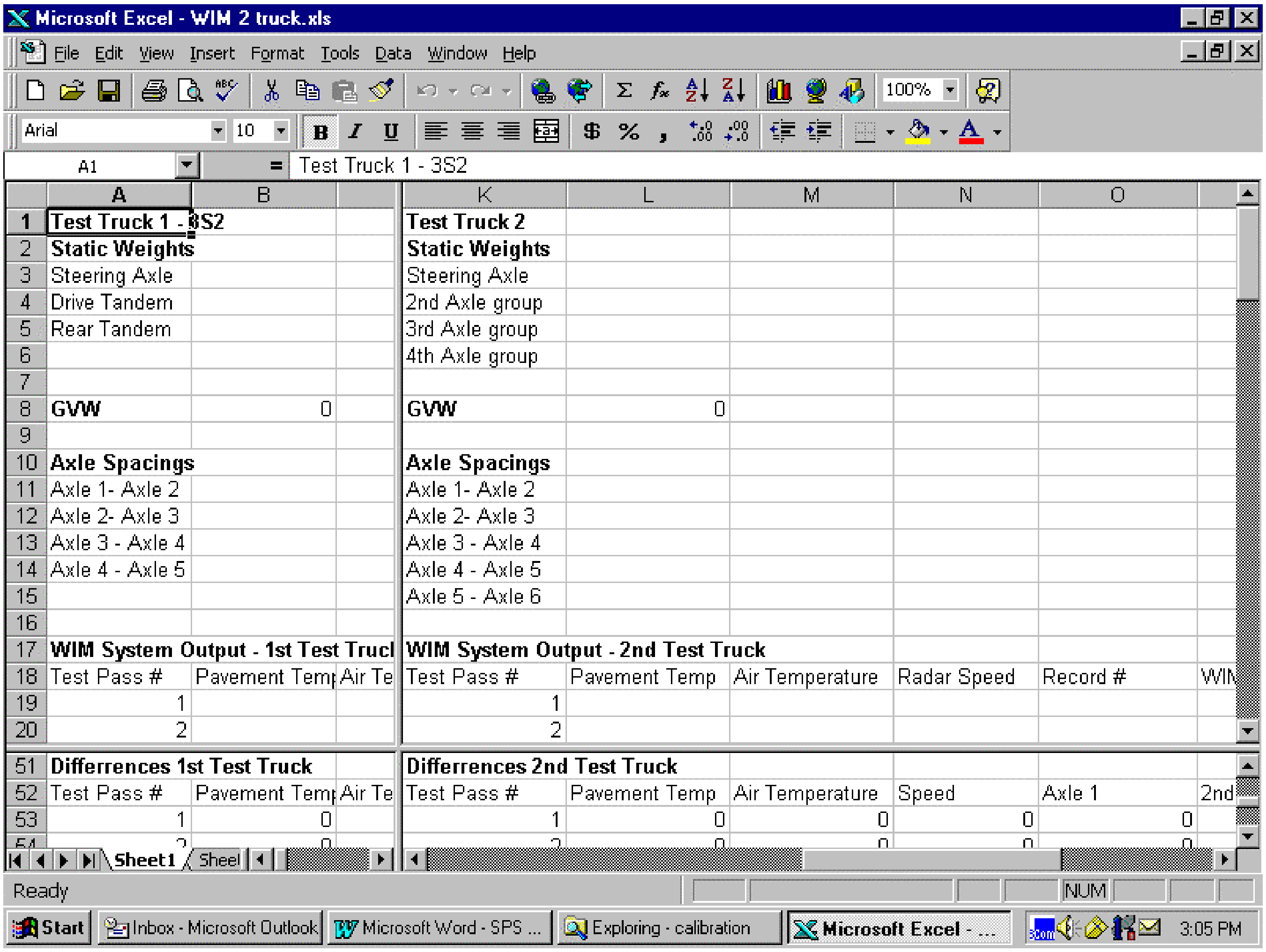
D.1. WIM 2 TRUCK. XLS

This spreadsheet is designed to store the data from the test truck runs across the scale and, at the end of the weighing session, compute differences for graphing. The spreadsheet is divided into four quadrants as shown in Table D-1. In the upper left corner, the data on the mandatory air suspension 3S2 are entered. In the upper right corner the data for the second truck are entered. These are the values from weighing the truck with a full gas tank and physically measuring the axle spacings. Note that the spreadsheet does not identify specific axle groups for the second truck. The user will need to label them as single, tandem, split tandem, tridem, and so forth. If additional vehicles are used, the section of the spreadsheet for the 2nd truck should be copied as many times as necessary.

Below the static values are locations to enter the temperature, speeds and weights recorded as the trucks pass over the scale. Provision is made to enter pavement temperature and or air temperature. Pavement temperature is preferred. The user enters the speed of the vehicle from the radar gun, the record number assigned to the truck by the WIM system, the speed reported by the WIM system and the weights of the individual axles. The spreadsheet will compute the gross vehicle weight. To allow the user sufficient time to enter the data, the trucks should be widely spaced rather than following closely.

The spreadsheet should be saved after every other truck run. The naming convention for spreadsheets will be “WIM” followed by the state code and SHRP_ID of the site followed by the data collection date. For example if the SPS-6 site in Michigan were validated on July 15th, the file name would be WIM_260699_071501.xls.

When data collection is complete, the user must ensure that the ranges for the means and standard deviations for the data set as a whole are correct. The computed differences with their associated temperatures and speeds may then be analyzed by subgroup in a separate work sheet and graphed if desired.



	A	B		K	L	M	N	O	
1	Test Truck 1 - 3S2			Test Truck 2					
2	Static Weights			Static Weights					
3	Steering Axle			Steering Axle					
4	Drive Tandem			2nd Axle group					
5	Rear Tandem			3rd Axle group					
6				4th Axle group					
7									
8	GVW	0		GVW	0				
9									
10	Axle Spacings			Axle Spacings					
11	Axle 1- Axle 2			Axle 1- Axle 2					
12	Axle 2- Axle 3			Axle 2- Axle 3					
13	Axle 3 - Axle 4			Axle 3 - Axle 4					
14	Axle 4 - Axle 5			Axle 4 - Axle 5					
15				Axle 5 - Axle 6					
16									
17	WIM System Output - 1st Test Trucl			WIM System Output - 2nd Test Truck					
18	Test Pass #	Pavement Temp	Air Te	Test Pass #	Pavement Temp	Air Temperature	Radar Speed	Record #	WIN
19	1			1					
20	2			2					
51	Differences 1st Test Truck			Differences 2nd Test Truck					
52	Test Pass #	Pavement Temp	Air Te	Test Pass #	Pavement Temp	Air Temperature	Speed	Axle 1	2nd
53	1	0		1	0	0	0	0	
54	2	0		2	0	0	0	0	

Table D-1 - WIM 2 Truck on Opening

APPENDIX E

CRITICAL VALUES OF STUDENT'S *t* DISTRIBUTION FOR $\alpha = 0.025$

E. CRITICAL VALUES OF THE STUDENT'S *T* DISTRIBUTION

FOR a = 0.025

Degrees of Freedom (n-1)	$t_{0.025}$
1	12.706
2	4.303
3	3.182
4	2.885
5	2.571
6	2.447
7	2.365
8	2.306
9	2.262
10	2.228
11	2.201
12	2.179
13	2.160
14	2.145
15	2.131
16	2.120
17	2.110
18	2.101
19	2.093
20	2.086
21	2.080
22	2.074
23	2.069
24	2.064
25	2.060
26	2.056
27	2.052
28	2.048
29	2.045
30	2.042

APPENDIX F

SAMPLE REPORT

F. SAMPLE REPORT

A memo (letter report) is prepared after each site visit. Its distribution is as follows:

> TO: LTPP Team Traffic Lead
> FROM: Lead WIM Site Verification Team
> CC: LTPP Team Leader, RSC, Agency Contact

The mandatory attachments are Traffic Sheets 16 and 17. For sites which are not acceptable an analysis report and all supporting data must be included.

F.1. SUCCESSFUL VALIDATION

The following includes the minimum information for the memo when no problems are noted.

> A WIM site validation was conduction at the SPS A site in Wild West, STATE on date. As of this time the site meets LTPP WIM requirements. The existing baseline comparison data should continue to be used / be updated. [Reason to keep or change baseline comparison data.]
>
> Short wave length profiling was done as a part of the site validation. The site passed/ failed. [The reason for failure is …]
>
> OR
>
> Short wave length profiling was not done as part of the site validation. The profiling requirement for the year was completed on… / is scheduled for ….
>
> Long wave length analysis was not done / done as a part of the site validation. [The site value is … which meets/ does not meet LTPP requirements.]
>
> The next site validation is anticipated in Summer / Winter 200x.

F.2. SITE NOT MEETING LTPP WIM REQUIREMENTS

The following is a possible response to a problem.

> A WIM site validation was conduction at the SPS *B* site *in Long Lost, STATE* on *date*. Tables 1 – 3 show the computations for all trucks, the speed subgroups and the temperature subgroups.

Table 1 All vehicle results vs. LTPP SPS WIM tolerances

Characteristic	95% Confidence Limit of Error	Computed Value	Pass/Fail
Axle Weights			
All single axles	"20 percent	+3.2% " 18.8%	FAIL
Steering axles	"20 percent	-2.1% " 5.1%	PASS
Other single axles	"20 percent	+9.8% " 21.4%	FAIL
Tandem axles	"15 percent	-3.5% " 28.9%	FAIL
Gross Vehicle Weights	"10 percent	+3.0% " 14.0%	FAIL
Vehicle Speed	"1 mph	+1.5 " 4.2	FAIL
Axle spacing			
All lengths	"0.5 feet	+0.3 " 1.6	FAIL
Tandem axles	"0.5 feet	+0.1 " 0.6	FAIL

Table 2 Computations for LTPP SPS WIM tolerances by speed range

Characteristic	95% Confidence Limit of Error	Low Speed 45-50 mph	Medium Speed 51-57 mph	High Speed 58-67 mph
Axle Weights				
All single axles	"20 percent	-3.1% " 40.9%	-3.9% " 32.8%	-4.2% " 27.6%
Steering axles	"20 percent	-18.0% " 25.9%	-14.8% " 25.0%	-12.3% " 25.9%
Other single axles	"20 percent	17.1% " 20.6%	8.82% " 23.9%	5.5% " 17.6%
Tandem axles	"15 percent	-4.8% " 23.7%	--	-0.6% " 40.4%
Gross Vehicle Weights	"10 percent	5.1% " 16.5%	2.4% " 15.5%	2.0% " 12.1%
Vehicle Speed	"1 mph	2.5 " 5.9	1.0 " 2.7	1.2 " 4.0
Axle spacing				
All lengths	"0.5 feet	0.4 " 1.7	0.1 " 1.2	0.4 " 1.8
Tandem axles	"0.5 feet	0.1 " 0.8	--	0.2 " 0.6

Table 3 Computations for LTPP SPS WIM tolerances by temperature range

Characteristic	95% Confidence Limit of Error	Low Temperature 70-90	Medium Temp. 90-110	High Temperature 110-130
Axle Weights				
All single axles	"20 percent	--	-3.9% " 33.7%	-4.5% " 33.6%
Steering axles	"20 percent	--	-12.4% " 24.0%	-15.9% " 26.5%
Other single axles	"20 percent	--	7.2% " 21.1%	-8.3% " 23.5%
Tandem axles	"15 percent	-1.2% " 34.8%	-2.6% " 28.4%	--
Gross Vehicle Weights	"10 percent	--	1.6% " 14.5%	2.6% " 13.6%
Vehicle Speed	"1 mph	--	1.1 " 4.8	1.1 " 3.3
Axle spacing				
All lengths	"0.5 feet	0.7 " 1.7	0.3 " 1.5	0.2 " 1.7
Tandem axles	"0.5 feet	0.0 " 0.8	0.1 " 0.6	--

Short wave length profiling was done as a part of the site validation. The site passed/ failed. [The reason for failure is …]

OR

Short wave length profiling was not done as part of the site validation. The profiling requirement for the year was completed on… / is scheduled for ….

Long wave length analysis was not done / done as a part of the site validation. [The site value is … which meets/ does not meet LTPP requirements.]

The attached analysis report discusses the reasons contributing to the observed failures. The following options are suggested for corrective action -…..

Data collected since … from this site should be marked as being of unknown quality.