Appendix F – WIM Program Operation and Management Checklists

Contents

WIM Technology Selection Table

Sensor / APPLICATIONS	Load Cell	Bending Plate	Quartz Piezo	Strain Gauge Strip Sensor	Polymer Piezo	Portable Polymer Piezo	Bridge WIM
Highway Monitoring	√	√	√	√	√		
Highway Design	√	√	√	√			
Transportation Planning	√	√	√	√	√	√	
Bridge Monitoring							√
Pre-screening for Enforcement	√	√	√	√			
ASTM Type	I, II, III	I, II, III	I, II, III	I, II, III	II	II	II
Pavement	PCC	PCC	PCC or AC	PCC or AC	PCC or AC	PCC or AC	PCC or AC
Lifecycle Cost	High	Moderate	Moderate	Moderate	Low	Low	Moderate
Accuracy (array dependent)	High	High	High	High	Low	Low	Medium
Installation	Long	Moderate	Moderate	Moderate	Short	Short	Short
Maintenance	High	High	Low	Low	Low	N/A	N/A
Calibration Frequency (months)	18 to 24	18 to 24	12 to 18	12 to 18	6 to 12 or Initial + Auto-cal	7 to 12 or Initial + Auto-cal	Initial
Temperature Dependency	None	None	Low	Low	High	High	Low

WIM Site Selection Checklist

Preliminary Site Analysis (Off site, using office documentation)

Horizontal Curvature and Grade

- ☐ The horizontal curvature of the roadway lane, as stated in roadway design documentation, for 200 feet prior to and 100 feet beyond the WIM sensors has a radius not less than 5,700 feet measured along the centerline of the roadway.
- ☐ The vertical grade, as stated in roadway design documentation, is no more than 2% for *ASTM E1318-09 WIM* types I, II and II and 1% for type IV.

Pavement Age and Construction Plans (one must apply)

- ☐ The roadway segment is 3 years old or less or has been re-surfaced within the past 1-2 years.
- ☐ The proposed WIM site is part of a new roadway construction or pavement rehabilitation plan.
- ☐ Future repaving should not be anticipated or planned for the next 5 years.

Pavement Condition

- ☐ Pavement condition data identifies no surface distresses, such as: cracks, raveling, faulting, potholes, etc.

Pavement Smoothness (if pavement profile data not available, see on-site analysis)

- ☐ The WIM sensor installation roadway section(s) meets the smoothness requirements of AASHTO M331, Standard Specification for Smoothness of Pavement in Weigh-In-Motion (WIM) Systems. The value of WIM roughness index for 131 feet upstream of the scale should be below 1.34 84.8 in/mi for Type I WIM systems and below 1117.9 in/mi for Type II WIM systems WIM roughness Index is computed using the Optimal WIM Locator function of the Pro-Val software.

Test Truck Turnarounds

- ☐ The test truck turnarounds are reasonably close to enable testing to be completed in one or two days (5-20 minutes travel time to WIM site).

On-Site Analysis

Longitudinal Alignment (Roadway Grade – perform if site documentation was not available to establish these values)

- ☐ The longitudinal gradient (roadway grade) of the road surface for 200 feet in advance and 100 feet beyond the WIM sensors does not exceed 2% (ASTM Lateral Alignment (Transverse Slope of Roadway or Cross Slope)
- ☐ The cross-slope (lateral slope) of the road surface for 200 feet in advance and 100 feet beyond the WIM sensors does not exceed 3% for Type I and Type II WIM systems and 1% for Type III systems.

Lane Width and Markings

- ☐ The lane width for the WIM Sensor location is between 10 and 14 feet
- ☐ The lanes are clearly marked with painted lines, 4 inches to 6 inches in width, throughout the WIM section.

Traffic Composition and Traffic Flow Characteristics

- ☐ The WIM systems is in area of free traffic flow at highway speeds with good sight distances.

Pavement Condition

- ☐ Pavement condition should have no surface distresses, such as: cracks, raveling, faulting, potholes, etc.

Pavement Surface Smoothness

- ☐ For a distance of 300 feet before and 75 feet after the WIM sensor location, the roadway surface is maintained in a condition such that a 6 inch diameter circular plate 0.125 inches thick cannot be passed beneath a 16-foot long straightedge per ASTM E1318-09.

Pavement-Truck Interaction

- ☐ There are no visible truck dynamics (up and down bouncing, side-to side rocking, swiveling, acceleration, or deceleration) that may indicate that the pavement condition may affect the performance of the WIM scales.

WIM Cabinet Location and Safety Setbacks

- ☐ The proposed cabinet is in a safe location out of the clear zone or located behind a guardrail, so that it cannot be hit by a vehicle leaving the roadway
- ☐ The cabinet location has a clear line of sight to the sensors and an unobstructed view of passing traffic.

Maintenance of Traffic

- ☐ The proposed WIM site provides the opportunity to use basic MOT designs for WIM installation and ongoing maintenance actions and not be too complex.

Power and Communication Services

- ☐ If A/C power or, for communications, a cellular, fiber optic, or landline telephone service is to be used, the services are located nearby, or the costs to bring power and phone supply line to the site are not cost-prohibitive.

Drainage

- ☐ The cabinet is located at a level that is higher than the pavement surface.
- ☐ Pull boxes should not be installed in gullies or ditches.

Calibration Test Truck Turnarounds

- ☐ The WIM system should be no closer than 1 mile from the nearest turnaround in each direction.
- ☐ The total distance between two turnarounds should not exceed 10 miles.

Proximity to Certified Truck Scale

- ☐ If a certified truck scale is used to determine static weight of a test truck, the scale should be located within an acceptable distance that will not cause a significant amount of fuel to be burned traveling to or from the WIM site.

WIM Site Design Checklist

This checklist identifies items to be included on WIM Site construction plan.

- ☐ Road segment, lanes, lane markings
- ☐ Sensor Type
  - ☐ *Bending Plate*
  - ☐ *Load Cell*
  - ☐ *Quartz Piezo Sensor*
  - ☐ *Strain Gauge Strip Sensors*
  - ☐ *Polymer Piezo Sensor*
- ☐ Sensor Arrays (W= WIM Sensor, L = Loop Sensor)
  - ☐ *WLW*
  - ☐ *WLWW*
  - ☐ *WLWWW*
  - ☐ *LWL*
  - ☐ *WLWL*
  - ☐ *LWLW*
  - ☐ *WWLWW*
  - ☐ *Other:_______________*
- ☐ WIM Sensor Configuration
  - ☐ *Single Threshold (1 sensor per wheel path – in line)*
  - ☐ *Staggered (1 sensor per wheel path – separated by 10 to 16 feet.*
  - ☐ *Dual-Threshold (2 sensors per wheel path – leading and trailing sets of sensors in-line)*
  - ☐ *Dual-Staggered (2 sensor per wheel path – leading and trailing set of sensors separated by 1-2 feet and each set of left and right wheel path sensors separated by 10 to 16 feet. in line)*
- ☐ Cabinet Location
  - ☐ *Guardrail*
  - ☐ *Distance from roadway, GPS coordinates*
  - ☐ *Water runoff and drainage features*
  - ☐ *Concrete pad, post, cabinet, solar panel (if applicable) plan and side view*
- ☐ Directional Boring Location
- ☐ Pull Boxes and Conduit/Trenching Locations

- ☐ Data Acquisition (Communications) Devices and Locations
    - ☐ *Modem*
    - ☐ *Telephone Service*
    - ☐ *Fiber Optics*
    - ☐ *Cellular Service*
    - ☐ *On-Site Data Storage*
- ☐ System Power Service and Locations
    - ☐ *Solar Power Devices*
        - ☐ *Solar Panels*
        - ☐ *Solar Regulator*
        - ☐ *Battery*
    - ☐ *A/C Service Devices*
- ☐ Fans and Environmental Controls
- ☐ Drainage Locations
- ☐ Lightning Protection and Grounding Devices
    - ☐ *Surge Suppression Devices*
    - ☐ *Grounding Devices*
    - ☐ *Ground Rod Location*

WIM Site Installation QA Checklist

Preparation

- ☐ A pre-construction meeting of all personnel involved in the WIM system installation should be held prior to the beginning of work. Topics should include safety, lane closure time limits, work schedule and a detailed discussion of the work to be performed.
- ☐ Verify that the location of utilities within the work area has been performed within the past two weeks.
- ☐ All equipment shall be inspected by the QA Inspector and electronically tested by the Installation supervisor.
- ☐ Review and understand the contractor's Traffic Control Plan. Bring any deviation from the specifications and standards to the attention of the contractor's on-site supervisor for immediate remediation.

WIM Installation

Excavation and Conduit

- ☐ All excavation and installation of conduit used for the WIM installation is of the proper depth, type and dimension, as stated in the design standards.
- ☐ The cabinet and junction boxes are staked, conduit runs marked, and the outer limits of the array area marked on the edge of pavement.
- ☐ Only material necessary for the installation is removed.
- ☐ Excessive pavement damage is repaired with like material or epoxy.
- ☐ Homerun conduits are installed at the proper depth.
- ☐ Locator tape is installed on all PVC conduit runs (not required for metal conduits).
- ☐ Sensor exit conduits should be driven deep enough into the pavement (3 to 4 inch depth) so that the home run wires are not be susceptible to being ground off with a mill and overlay.
- ☐ All conduit end points have smooth edges.
- ☐ All conduit used within the travel lane is galvanized rigid metal conduit (RMC).
- ☐ Conduit openings are sealed with duct seal.
- ☐ Drain conduits used for the bending plate or load cell sensors are lower than the electrical conduit openings.
- ☐ Proper size of PVC conduit is used from the pull box to the cabinet and base.

Pole/Cabinet

- ☐ The pole and cabinet equipment meet contract specifications.
- ☐ The pole and cabinet are placed where they are not in the clear zone (50' is recommended):
  - ☐ They are not subject to rain runoff, standing or moving water.
  - ☐ They will not be hit by moving vehicle, preferably behind a guard rail.
  - ☐ The grounding rod and/or 4-6 gauge grounding wire and bonding joint can be installed.
  - ☐ They are accessible with clear line of sight to the sensors.
  - ☐ They are serviceable without technician endangerment.
  - ☐ The cabinet door can be fully opened.

- ☐ The cabinet attributes meet contract specifications:
  - ☐ Proper height and level.
  - ☐ Cabinet/pole system is made to be break-away.
  - ☐ Conduit is securely and properly attached to the cabinet.
  - ☐ Hinged door with lock and two set of keys.
  - ☐ Louvered vent with standard filter.
  - ☐ Air exhaust through roof overhang with temperature activated forced air fan system.
  - ☐ Wiring and equipment layout.
  - ☐ Switched light.
  - ☐ Ground-Fault Circuit Interrupter (GFCI) duplex outlet and a circuit breaker for A/C input.
  - ☐ Surge suppression.
- ☐ The pole attributes meet contract specifications, including:
  - ☐ The pole is installed vertically.
  - ☐ The pole foundation is installed properly.

Solar Panels

- ☐ The solar panels and mounting equipment are properly installed.
  - ☐ The panels are facing the proper direction (8° west of magnetic south).
  - ☐ The panels are installed at the proper angle (latitude +15°). This pitch may vary by the state this is installed in.
  - ☐ All vegetation that may block exposure to the sun has been removed from in front of the solar panel.
  - ☐ Panel height is high enough (16' - 18') to thwart vandalism or theft.
  - ☐ Fastening hardware may include bolts and hardware that is torx, safety torx, or other theft-proof type heads to prevent vandalism or theft.

Solar Panel Charge Circuit Devices

- ☐ The solar panel charge circuit devices have been verified and tested.
  - ☐ Batteries are the correct type and have the specified rating for amp hours.
  - ☐ Proper solar controller has been provided.
  - ☐ Wiring of solar panels, solar controller and batteries.
  - ☐ Settings on the solar controller.
  - ☐ Solar charging device/controller that begins charging when voltage from the solar panel is present (even if battery voltage may be very low).

Pull Boxes

- ☐ The pull boxes are properly sized and are installed at the locations shown on the WIM design plan and away from water collection areas.
- ☐ The lid is flush with adjacent grade or surfaces.
- ☐ Adequate drainage was installed.
- ☐ If required from WIM vendor, grounding rod installed. Earth ground test with megger should be performed to insure proper grounding to the cabinet, power drop and communication drop.

Loop and Sensor Layout Marking and Cutting

- ☐ Square lines and markings are correct and match construction plan to within ¼ inch.
- ☐ Proper spacing between array elements (WIM sensors, inductance loops, axle sensors).
- ☐ The WIM sensor array layout is squared in lane per the 6-8-10 triangle method or by using a pre-made template.
- ☐ All saw cuts are neat and straight.
- ☐ Saw cuts are at the proper width and depth:
- ☐ Loop slot depths measured every two feet and at corners.
- ☐ WIM sensor channels measured at both ends and in the middle of each perimeter cut.
- ☐ If corners of the loop are present they are drilled to the depth of the slots using a 1" to 1 ½" rock drill bit.
- ☐ The saw cuts have been cleaned and dried with water and/or clean high pressure air, and all residue and moisture is removed for proper epoxy adhesion.

Loop and Sensor Installation and Sealing (General)

- ☐ Loop homerun cuts are wide enough to allow for complete encapsulation by the loop sealant for a minimum cover of 3".
- ☐ Loop wires are installed without the use of sharp implements and then secured with backer rod.
- ☐ Loop wires are in bottom of the slot, with 3 to 5 loops, depending on the operational requirements of the WIM controller's loop detection circuit.
- ☐ Loop wires run to the pull box without any splicing and are twisted around each other 3 to 4 times per foot.
- ☐ Each loop wire pair is clearly labeled prior to pulling through the conduit.
- ☐ Loop wires are completely covered with sealant and the sealant surface is flush with pavement with no voids or dips.
- ☐ An earth ground/insulation test is performed before pulling the lane closure to insure the loops are not compromised in any way.

WIM Sensor Installation

Load Cell Sensor Installation

- ☐ Load cell sensor insulation resistance is pre-checked prior to installation.
- ☐ LC pit is properly installed.
- ☐ Only vendor-specified installation grout is used.
- ☐ Load cell sensors are installed to be as flush with the pavement surface as possible (within 1/8 inch).
- ☐ All voids in pavement around sensors are filled in with epoxy and/or caulk. All high spots in epoxy are ground flush.
- ☐ All sensor lead-in wires exit the pavement through conduit and run all of the way to the pull box without splices.

Bending Plate Sensor Installation

- ☐ Frame excavation should be deep enough to allow enough clearance below the frame and around conduits for epoxy.
- ☐ Bending plate sensor shield and Wheatstone bridge resistances are pre-checked prior to installation.
- ☐ Only vendor-specified installation grout is used.
- ☐ Bending plate sensors are installed (shimmed) to be as flush with pavement surface as possible (within 1/8 inch).
- ☐ All voids in around the frame are filled in with epoxy and/or caulk. All high spots in epoxy are ground flush.
- ☐ All sensor lead-in wires exit pavement through frame conduit all of the way to the pull box without severe bends.

Quartz Piezo and Strain Gauge Strip Sensor Installation

- ☐ Axle sensor channels are cut to the proper depth and width, based on the type of sensor.
- ☐ Sensor insulation resistance is pre-checked in the cabinet prior to installation.
- ☐ Only vendor-specified installation grout is used.
- ☐ WIM Sensors are installed in accordance with manufacturer specifications.
- ☐ Each sensor is properly connected to the ground lead.
- ☐ Sensors are ground flush with pavement.
- ☐ All voids in pavement around sensors are filled in with epoxy and/or caulk. All epoxy high spots are ground flush to the surface and there are no bumps or dips in the surface greater than 1/8 inch.
- ☐ All sensor lead-in wires exit the pavement through the conduit and run all of the way to the pull box without splices.

Polymer Piezo Sensor Installation

- ☐ The sensor are not dented, twisted or bent.
- ☐ The sensors are pretested for proper capacitance and resistance using a multi-meter and/or capacitance meter.
- ☐ Sensors are placed in accordance with the site layout plan.
- ☐ Sensor channels are cut ¾ inches wide and at least 2 inches deep. Saw cuts made in a single pass with a ¾” blade or two 3/8” blades ganged together are recommended.
- ☐ Pavement removal from the slots was done with care to ensure proper slot width and depth.
- ☐ Slots were cleaned and dried before sensor placement.
- ☐ Installation W-chairs are properly attached to the sensor, a minimum of 6 inches apart.
- ☐ Completely clean the sensor (removing any dirt or oxidized material) no more than 20 minutes from installation to allow for proper bonding of the sensor to the epoxy.
- ☐ The sensor must be checked along its entire length to verify it is being installed at the proper depth. The W-chairs must be adjusted within the slot to get the proper depth.
- ☐ The sensor is post-tested to ensure proper capacitance and resistance readings.
- ☐ The sensor output signal is tested for proper voltage output.

Cabling

- ☐ All cabling is clearly labeled in each pull box and in the cabinet.
- ☐ Service loops such that at least 5 extra feet of wire is left in each pull box and in the cabinet for repairs.
- ☐ Splices are industrial quality, watertight, hermetically sealed, and made with bifurcated terminals to prevent shorting.
- ☐ Check each loop for proper inductance range is met before putting the splice kit on it.
- ☐ Splices, if used, are used in the closest pull box to the sensor.
- ☐ Each sensor is tested before final terminations are made.

Grounding

- ☐ The ground was tested using an approved method.
- ☐ Verify the meter reads a resistance that is within specification.

Operational Testing

- ☐ The system is properly collecting, storing, and transmitting data to the host computer.
- ☐ Tested system outputs are documented for future reference

Initial Calibration and Acceptance

- ☐ Sufficient number of calibration test truck runs have been performed (at least 10 runs of heavily loaded class 9 trucks or other dominant heavy truck type for the site is recommended).
- ☐ The WIM System bias (mean error for each type of measurements) computed based on the data from the available test runs is as close to zero as possible, (less than 2 percent error for the mean error).
- ☐ None of the individual runs are outside of the ASTM E1318-09 tolerances for 95 percent compliance.
- ☐ The WIM system is classifying vehicles properly as compared to the agency’s classification scheme or class tree.

Initial WIM Calibration Checklist

Data Accuracy Requirements

Function	Tolerance for 95% Compliance		
	Type I	Type II	Type III
Wheel Load**	±25%		±20%
Axle Load	±20%	±30%	±15%
Axle-Group Load	±15%	±20%	±10%
Gross Vehicle Weight	±10%	±15%	±6%
Speed	±1 mph (2 km/h)		
Axle-Spacing and Wheelbase	±0.5 ft (0.15 m)		

* Does not include Type IV since it is not approved for use in the U.S.
** includes single or dual tires

- ☐ Overall vehicle length should be accurate to ½ foot, or 3% of the overall length of the vehicle, whichever is longer.

Test Trucks

- ☐ Select test trucks. One should be a loaded Class 9, unless Class 9s are not allowed at the site.
- ☐ Obtain all static axle weights, axle spacings, and overall length of test trucks.
- ☐ Inspect truck tires and suspension for defects.

Pre-Calibration Test Runs

- ☐ Conduct test truck runs at the prevalent truck speeds and at the widest possible ranges of temperatures observed at the site.
- ☐ Perform a sufficient number of pre-calibration runs to quantify WIM measurement error percent (at least ten test runs per WIM lane).

Test Truck Run Data Analysis to Evaluate WIM Performance before Calibration

- ☐ Determine the number of calculated differences that exceeded the tolerance for each data item in the table above, expressed as a percent of the total number of observed values of this item.
- ☐ If more than 5% of the calculated differences for any applicable data item exceed the specified tolerance for that item, the system requires calibration.
- ☐ If any specified WIM system function failed and can't be easily fixed in the field, declare the WIM system as failed. Otherwise, restore the failed function and perform system calibration.

System Calibration

- ☐ Adjust current WIM system weight and distance error compensation factors to minimize errors observed in test data.

Post-Calibration Test Runs and Evaluation

- ☐ Repeat steps above to evaluate if WIM system met or failed tolerance requirements.

Classification Accuracy Validation

- ☐ Test if the WIM system is classifying vehicles properly as compared to the agency's classification scheme or class tree using a manual sample of 100 vehicles in classes 4-13 combined or at least 3 hours of vehicle class observations.

WIM Site Acceptance Checklist

Site acceptance and acceptance testing should be done by the contracting agency or contracting agency agent that is independent of the installation contractor. Similarly, WIM system performance verification should be done independent of the WIM maintenance contractor.

The acceptance of the site includes a review of the installation and a determination if the installation has met the contract specifications and is installed in accordance with manufacturer’s specifications. Site acceptance should be based on the following criteria:

- ☐ All equipment is installed as per manufacturer’s specifications.
- ☐ All equipment is installed as per contract specifications.
- ☐ All sensors have been successfully tested.
- ☐ All support equipment (solar, A/C, telephone) has been successfully tested.
- ☐ System has been calibrated per manufacturer procedures and validated to be performing per contract specifications.
- ☐ System collects data with accuracy that satisfies contract specifications, based on the data from heavily loaded test trucks.
- ☐ System has successfully passed vehicle classification test.
- ☐ System has operated for 30 consecutive days without failure and produces data of consistent acceptable quality.
- ☐ All site documentation, operational test data, initial calibration results, and as-built drawings have been submitted and accepted.

Test Truck Selection for WIM Calibration

Use the following guidance to select calibration truck(s):

Truck Type

- ☐ Calibration test truck(s) represents the dominant heavy trucks (i.e. trucks in vehicle classes 6-10) for the WIM site.
  - ☐ ASTM and LTPP recommend using two calibration test trucks, at least one is a FHWA Class 9.
  - ☐ For load-restricted or commercial truck-restricted roads, use the heaviest truck class that routinely uses the road.

Truck Loading

- ☐ If two calibration trucks are used, one truck should be at or near full load capacity
- ☐ Select a different loading for the second truck to better represent the most frequently observed loadings conditions at the site.
- ☐ Loads are non-shifting.
- ☐ If loads that allow the collection of rainwater are used, the trailer and load are completely covered to avoid the collection of water.

Truck Axle Configuration and Suspension

- ☐ At least one single axle (steering) and one tandem axle. In addition, tridem axle could be used but is not a preferred configuration.
- ☐ Tandem or tridem axle spacing is between 4.0 feet to 4.5 feet.
- ☐ Air suspension on truck and trailer.
- ☐ Suspension systems free of mechanical deficiencies, including cracks, punctures, air leaks, or loose fittings.

Other Truck Characteristics

- ☐ Working speedometer.
- ☐ Capable of meeting the test truck speed requirements.

Routine WIM Calibration Checklist

Data Accuracy Requirements

Function	Tolerance for 95% Compliance		
	Type I	Type II	Type III
Wheel Load**	±25%		±20%
Axle Load	±20%	±30%	±15%
Axle-Group Load	±15%	±20%	±10%
Gross Vehicle Weight	±10%	±15%	±6%
Speed	±1 mph (2 km/h)		
Axle-Spacing and Wheelbase	±0.5 ft (0.15 m)		

* Does not include Type IV since it is not approved for use in the U.S.

** includes single or dual tires

- ☐ Overall vehicle length should be accurate to ½ foot, or 3% of the overall length of the vehicle, whichever is longer.

Pre-Visit

Perform Pre-Visit WIM Data Analysis

Obtain recent sample of WIM data for vehicles in FHWA class 9

Compare current data with the data from the last comparison Data Set (CDS)

Draw conclusions about any changes in WIM measurements for class 9 vehicles

Perform Pavement Profile Data Analysis

Select Test Trucks and Determine Test Speeds

On Site

Test Trucks

- ☐ Select test trucks. One should be loaded Class 9, unless Class 9s are not allowed at the site.
- ☐ Obtain static weights, axle spacing, and overall length of test trucks.
- ☐ Inspect truck tires and suspension for defects.

Pre-Calibration Test Runs

- ☐ Conduct test truck runs at the prevalent truck speeds and at the widest possible ranges of temperatures observed at the site.
- ☐ Perform a sufficient number of pre-calibration runs to quantify WIM measurement error percent (at least ten test runs per WIM lane).

Test Truck Run Data Analysis to Evaluate WIM Performance before Calibration

- ☐ Determine the number of calculated differences that exceeded the tolerance value for each data item listed in the table above, expressed as a percent of the total number of observed values of this item.
- ☐ If more than 5% of the calculated differences for any applicable data item exceed the specified tolerance for that item, the system requires calibration.
- ☐ If any WIM system function failed and it cannot be easily fixed in the field, declare the WIM system as failed. Otherwise, restore the failed function and perform system calibration.

System Calibration

- ☐ Adjust current WIM system weight and distance error compensation factors to minimize errors observed in test data.

Post-Calibration Test Runs and Evaluation

- ☐ Repeat steps above to evaluate if WIM system met or failed tolerance requirements.

Classification Accuracy Validation

Test if the WIM system is classifying vehicles properly as compared to the agency's classification scheme or class tree using a manual sample of 100 vehicles in classes 4-13 combined or at least 3 hours of vehicle class observations.

Post-Visit

Conduct Post-Visit Data Analysis
Develop and Submit Calibration Report

WIM Maintenance Tools, Materials, and Supporting Documentation

Manufacturers' maintenance guides typically contain a list of required spare service parts, tools, and equipment necessary to properly maintain the vendors' WIM systems.

Materials

- ☐ Clipboard
- ☐ Shop rags or clothes
- ☐ Cleaning solvent
- ☐ Pens
- ☐ Electrical tape
- ☐ Splice kits
- ☐ First Aid kit
- ☐ Spray silicone
- ☐ Silicone caulking

Hand tools

- ☐ Digital camera or smart phone
- ☐ Screwdriver sets – slotted and Philips.
- ☐ Small socket driver set
- ☐ Pliers – long nose, round nose, curved. Both smooth and serrated types are useful.
- ☐ Adjustable wrench, small.
- ☐ Cutters – diagonal and flush.
- ☐ Linesman's pliers.
- ☐ Wire strippers – fixed and adjustable.
- ☐ Wet/Dry Shop Vacuum
- ☐ Crimping tool
- ☐ Global Positioning System (GPS) receiver
- ☐ Power inverter
- ☐ Tape measure
- ☐ Measuring wheel
- ☐ Small shovel
- ☐ Pry bar
- ☐ Putty knife

Test Equipment

- ☐ Digital multi-meter with well insulated test probes (capability for resistance, inductance and capacitance).
- ☐ Megger (loop and ground tester).
- ☐ Oscilloscope – dual trace, 10 to 20 MHz minimum vertical bandwidth and 10x probes (optional, to check the sensor output waveforms).
- ☐ Logic probe - for quick checks of digital circuitry for activity.
- ☐ Laser speed detection gun.

Computer Software

- ☐ WIM System connectivity and data download software.
- ☐ Modem setup script files and/or setup guide.

Supporting Forms and Documentation

- ☐ Manufacturers' maintenance guides or service manual.
- ☐ WIM Site As-built Plans showing locations of WIM components
- ☐ WIM Site Maintenance and Inspection Form
- ☐ WIM System Troubleshooting Form
- ☐ WIM Site Maintenance Log (to be kept in the WIM cabinet)

WIM Preventive Maintenance Checklist

Inspection and Cleaning

- ☐ Conduct a visual inspection of the pavement in the WIM scale approach will provide an indication of whether the pavement condition may be contributing to any inaccuracies of the WIM system.
- ☐ Inspect each WIM system component and annotate any deficiencies on the WIM Site Preventive Maintenance and Inspection Form.

Electronic and Electrical Checks

- ☐ Perform electronic checks of all WIM system components.
- ☐ Perform electrical checks on power and communication devices.

Firmware Upgrades

- ☐ Perform any scheduled software upgrades.

Operational Testing and Verification

- ☐ Verify the proper operation of the WIM sensors and inductive loops by observing the individual vehicle characteristic values (PVF) provided by the WIM system after a vehicle passes over the WIM scale area.
- ☐ Prior to leaving the site, contact office personnel to verify that the WIM system can communicate remotely with the host computer.
- ☐ Update WIM Maintenance Log and leave it in the cabinet for future updates.

WIM Troubleshooting Checklist

Step 1 – Develop a Detailed Description of the Problem.

- ☐ Download data from the previous day or within the time frame in question.
- ☐ Compare data values with the Data Comparison Set values.
- ☐ Find out if the traffic characteristics of the site changed due to weather, construction, seasonal agriculture or some other reason.
- ☐ Conduct a thorough WIM data analysis. Drill down to the "by lane" data and even conduct "by sensor" readings if need be.
- ☐ Review "by vehicle" data. The individual by vehicle data will help see if the issue is related to heavy or light axles certain vehicle types or maybe some vehicle characteristic such as time of day when the error occurs.

Step 2 – Evaluate System Parameters and Data.

- ☐ Review the site operating parameters, site data, and sensor analog values and make any necessary corrections.
- ☐ Double-check all measurements that appear incorrect or out of tolerance.

Step 3 – Find the Source of the Problem.

- ☐ Use gathered data to determine the probable functional failure.
  - ☐ Power
  - ☐ Classification and Weight
  - ☐ Loop Settings or Function
  - ☐ Communications
  - ☐ Data Storage
  - ☐ Data Download and Processing
- ☐ Take electrical readings of system components to make a determination of the probable faulty function.
- ☐ Use troubleshooting flow charts and step-by-step guides are provided in the Manufacturer's Maintenance Manual to determine the faulty component.

Step 4 – Make the Necessary Repairs.

- ☐ Replace the faulty component.
- ☐ Mark faulty components "bad".

Step 5 – Documents Repairs

- ☐ Update site documentation.
- ☐ Prepare maintenance report(s).

WIM Data QA Checklist

1. Develop a Comparison Data Set (CDS) from the data sample collected immediately following the most recent successful calibration. Use Class 9 (or the most common heavy vehicle with GVW over 40 kips present at the site, if different from Class 9) to compute the following statistical parameters for CDS :
    - ☐ Class 9 average GVW and GVW distribution by load bins (tabular or plot).
    - ☐ Class 9 average front axle weight and front axle weight distribution by load bins (tabular or plot).
    - ☐ Class 9 tandem axle group axle load distribution by load bins(tabular or plot)
    - ☐ Load bins corresponding to the maximum percentage of GVW, steering axle loads, unloaded and loaded tandem axle loads (i.e. peak loads in the axle load and GVW distributions)
    - ☐ Percentage of Class 9 trucks over federal legal limit (80 kips)
    - ☐ Class 9 tractor average tandem axle spacing
    - ☐ Class 9 total length of vehicle
    - ☐ 85th percentile speed for heavy trucks
    - ☐ Vehicle class distribution (FHWA classes 4-13)
2. Sample WIM data every 1, 2, or 4 weeks, depending on site truck volumes. A minimum sample of 200 Class 9 trucks per lane is needed; a sample of 500 or more class 9 trucks is recommended to identify and analyze GVW and axle load distribution characteristics.
3. Use the data sample to develop the following the same statistics developed for the CDS.
4. Compute the differences between the statistics based on recent data with CDS statistics.
5. Flag and report data samples that show differences over ±5 percent (or other agency selected value) between the current data set and CDS. These data require close monitoring and trend analysis.
6. Subject data that deviates from CDS to monthly trend analysis. Compare data from the current month with the data for the same month from the previous year(s) or to the data from the previous month of the current or past year(s).
    a. In areas of harvest or other seasonal production, like timber, analysis of monthly or seasonal average for several values like GVW distribution, peak load values, and percentage of overweight of Class 9 trucks with standard configuration is recommended.
7. If deviation over 5% from CDS and seasonal trends persists or increases, an out-of-cycle calibration may be needed.
8. If calibration drift is frequently observed at the site, daily or weekly data quality monitoring and trend analysis is recommended. For the trend analysis, use time series plots to monitor the daily changes in the WIM statistics listed in step 1 above.