Florida Department of Transportation

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June 17, 2010

Monica Gourdine
Program Operations Engineer
Federal Highway Administration
545 John Knox Road, Suite 200
Tallahassee, Florida 32303

Re: Office of Design, Specifications
Section 786
Proposed Specification: 7860203 Intelligent Transportation Systems – Vehicle Detection and Data Collection.

Dear Ms. Gourdine:

We are submitting, for your approval, two copies of the above referenced Supplemental Specification.

This change was proposed by Gene Glotzbach to clarify Design Approval Test Requirements as part of the device evaluations by the Traffic Engineering Research Laboratory (TERL) and to update SunGuide with a registered trademark symbol.

Please review and transmit your comments, if any, within two weeks. Comments should be sent via Email to ST986RP or rudy.powell@dot.state.fl.us.

If you have any questions relating to this specification change, please call Rudy Powell, State Specifications Engineer at 414-4280.

Sincerely,

Signature on File

Rudy Powell, Jr., P.E.
State Specifications Engineer

RP/ft
Attachment
cc: Gregory Jones, Chief Civil Litigation
Florida Transportation Builders' Assoc.
State Construction Engineer

INTELLIGENT TRANSPORTATION SYSTEMS – VEHICLE DETECTION AND DATA COLLECTION.

(REV ~~13-28~~29-09*10~~4-26~~13-10*) ~~(FA 2-4-09) (7-09)~~**

SUBARTICLE 786-2.3 (of the Supplemental Specifications) is deleted and the following substituted:

786-2.3 Configuration and Management: Ensure that the vehicle detection system is provided with computer software that allows an operator to program, operate, and read current status of all system features and functions using a laptop computer or remote TMC workstation. Furnish software that is compatible with the Department's SunGuide~~SM~~® Software System. Ensure that any software-based applications do not interfere with SunGuide®~~SM~~ software when the two are installed and used together on a shared hardware platform. Ensure that the software application provides PC desktop display of the detection zones and control of any vehicle detector connected to the network.

Provide software licenses as required in the plans. Ensure that the detection system software offers an open API and software development kit available to the Department at no cost for integration with third party software and systems.

Ensure that an operator using a locally connected laptop computer can conduct system setup, calibration, diagnosis, and data retrieval operations. Ensure that the detection system is capable of having its configuration data saved to a laptop computer or TMC operator workstation, which can later transfer the data back to the detection system for reloading.

Ensure that the detection system operator can use a laptop computer or TMC workstation to edit previously defined detection configurations to permit adjustments to the detection zone's size, placement and sensitivity, and to reprogram the detector's parameters.

Ensure that the laptop computer and the detection system can communicate when connected directly by an EIA-232 cable. Ensure that the laptop computer and detection system can communicate across the ITS system's communication network using the NTCIP standards described in this document. Ensure that the software allows communication between multiple users and multiple field devices concurrently across the same communication network.

Once programmed, ensure that no periodic adjustments are required to the detection zones unless physical roadway conditions change, such as lane shifts or closures.

ARTICLE 786-5 (of the Supplemental Specifications) is deleted and the following substituted:

786-5 Testing.

~~**786-5.1 General:** Subject the equipment covered by these specifications to design approval tests (DATs) and field acceptance tests (FATs). *Design approval tests shall be conducted by the FDOT Traffic Engineering Research Laboratory (TERL). An APL*~~

~~*approval and certification number is evidence of successful design approval testing by TERL.* Develop and submit a test plan for DATs and FATs to the Engineer for consideration and approval. Ensure that the test plans demonstrates *compliance to FDOT requirements.*each and every functional requirement specified for the device or system under test.~~

786-5.*1*~~2~~ Design Approval Test *(DAT)* Specifications: ~~Prior to site installation, conduct DATs on one or more sample detectors as detailed below. Perform the DATs at the Contractor's facility or, with the Engineer's approval, at a site in the project area. The Engineer~~ *DATs will be conducted by the Traffic Engineering Research Laboratory (TERL). An APL approval and certification number is evidence of successful testing by TERL. The Department~~*FDOT* may accept ~~certification by~~*test results from* an independent testing laboratory ~~in lieu of the DATs~~ to satisfy the requirement that certain features and functions have been witnessed and documented as performing satisfactorily.

Arrange and conduct the tests and satisfy all inspection requirements prior to submission for the Engineer's inspection and acceptance. Furnish all necessary test equipment. Use a radar gun to calibrate speed detection, following the manufacturer's recommended calibration procedures.

At a minimum, demonstrate the following:

1. Use a laptop computer provided as part of the support equipment to configure the installation.
2. Verify that configuration data is stored in nonvolatile memory.
3. Download previously stored configuration data.
4. Verify that vehicles traveling at the test site can be detected across multiple travel lanes to the accuracy specified herein.
5. Drive a test car of known length and speed through the detection zone. Compare the output from the vehicle detector to this known value to verify the accuracy of detection. Repeat this measurement at least 10 times.
6. Install the detection system sensor at the site for test setup. Place a video camera at the same point along the roadway, above the **s**ensor location, as determined appropriate by the Engineer. Produce a video recording of the test to obtain a manual count, then compare those results with those from the detection system to determine the accuracy of the sensor. Alternative verification methods may be considered by the Engineer.
7. Verify the volume counts and speed measurements for each installed assembly using the test software running on the laptop computer connected locally to the detector's EIA-232/485 communication port. Repeat this test remotely from the TMC's operator workstation. Verify the accuracy of traffic parameters specified herein by using permanent or temporary traffic detection devices of known accuracy.

786-5.*2*~~3~~ Field Acceptance Test *(FAT)* Specifications: *Develop and submit a test plan for FATs to the Engineer for consideration and approval. Ensure that the FAT test plan demonstrates compliance to all requirements.*

Inspect all vehicle detection system field components to ensure proper installation and cable termination.

Adjust and verify the detector settings by comparing each sensor's recorded traffic volumes and speed with those actually observed. Remotely repeat this

test from the TMC. Verify the accuracy of traffic parameters using permanent or temporary traffic detection methods or devices of known accuracy.

~~Conduct the acceptance tests detailed below in conjunction with the detector support structure testing.~~ Notify the Engineer at least 14 calendar days prior to the proposed test date. The Contractor shall *at a minimum*:

1. Furnish all equipment, appliances, and labor necessary to test the installed vehicle detection system and the network communication device, and to perform the following tests before any connections are made:

a. Perform a continuity test on the detector cables to ensure that anomalies, such as openings, shorts, crimps or defects, are not present.

b. Perform continuity tests on the detector's stranded conductors element using a meter having a minimum input resistance of 20,000 Ω per volt and show that each conductor has a resistance of not more than that specified by the wire/cable manufacturer.

c. Measure the insulation resistance between isolated conductors and between each conductor, ground, and shield using a meter designed for measuring insulation resistance. The resistance must be greater than 100 MΩ. Perform all resistance testing after final termination and cable installation, but prior to the connection of any electronic or field devices.

d. Replace any cable that fails to meet these parameters, or if any testing reveals defects in the cable, and retest new cable as specified in this section.

2. Furnish and calibrate all test equipment.

3. Demonstrate the following after installation of the vehicle detection system, other hardware, power supplies, and connecting cables:

a. Verify that physical construction has been completed as specified in the plans.

b. Inspect the quality and tightness of ground and surge protector connections.

c. Check power supply voltages and outputs.

d. Verify that device connections to power sources are as specified in the plans.

e. Verify that the installation of specified cables and connections between all detectors and the field cabinet are as specified in the plans.

f. Demonstrate that the remote system is fully operational and performing all specified types of detection, including data storage functions, with a laptop computer.

g. Verify that the network interface device is receiving and transmitting data from the remote site to the ITS network.

ARTICLE 786-6 (of the Supplemental Specifications) is deleted and the following substituted:

786-6 System Acceptance Criteria.

Upon request, furnish independent laboratory testing documentation certifying adherence to the standards and specifications required herein, along with adherence to the

stated wind force criteria using a minimum effective projected area (EPA), the actual EPA, or an EPA greater than that of the detection assembly to be attached.

Within three calendar days of successful test completion, deliver to the Engineer a written completion notice and a copy of all test results. Include in this completion notice the documentation of any discrepancies found during testing. Also include assembly installation locations and successful test completion dates. If any component fails to pass required testing, replace the part and retest according to the requirements above, then resubmit the test results to the Engineer.

~~Within 10 calendar days of receipt of the completion notice and all test results, the Engineer shall either accept or reject the work. If rejected, t~~*T*he Engineer shall specify the defect or failure in the work *for any work rejected*. Notification of acceptance or rejection of the work shall be by delivery of written notice to the Contractor.

SUBARTICLE 786-7.3 (of the Supplemental Specifications) is deleted and the following substituted:

786-7.3 Installation of MVDS: Mount the MVDS' detector as detailed in the plans. In either configuration, mount the detector level from side to side. Ensure that the vertical and horizontal clearance of the installed detection device complies with Vol. I, Chapter 2 of the PPM.

Ensure that the MVDS sensor has a 200-foot range, and that the viewing angle is a minimum of 40 degrees vertical and a maximum of 15 degrees horizontal. Verify that all detection zones are contained within the specified elevation angle according to the manufacturer's recommendations and that the MVDS is capable of fully detecting all vehicles in a maximum of eight lanes. Ensure that the configuration also provides accurate collection of all data types as detailed in this specification.

Mount the detector in a NEMA 4X polycarbonate box, and verify that the electrical connection is located on the bottom of the box.

Provide a housing that can be pole- or wall-mounted, as indicated in the plans. Supply a universal mounting bracket that is adjustable on two axes for optimum alignment.

Attach the mounting bracket with approved stainless steel bands that are 0.75 inch wide and 0.025 inch thick, or mount to a concrete structure using two stainless steel expansion bolts of sufficient length and diameter to support 100 pounds.

When installing a detector near metal structures, such as buildings, bridges or sign supports, mount the sensor and aim it so that the detection zone is not under and does not pass through any structure to avoid distortion and reflection. In forward-looking configurations, the detector shall be mounted over the center of each lane.

Ensure that the detector is factory calibrated to comply with all applicable standards, specifications, and requirements. Ensure that the detector does not require further adjustment after initial setup, and that no periodic calibration is required.

Provide an interface to external equipment with a single connector. Ensure that the connector provides power to the unit and allows generation of contact closure output pairs for interface with traffic controller inputs. Ensure that the connector includes serial communication lines for programming, testing, and interfacing with the modem at a minimum 9,600-baud rate and that it has at least 26 pins. Ensure that the serial port's data

format is standard binary non-return to zero (NRZ) modulation with 8-bit data, 1-stop bit, and no parity.

Ensure that the home run cable is a polyurethane-jacketed cable approved by the Engineer, with polyvinyl chloride (PVC) insulated conductors. The home run cable shall have a 300-volt rating and a temperature rating of 200° F. Ensure that the cable is equipped with #20 or #22 American Wire Gauge (AWG) conductors.

Supply a test cable and converter to connect the detector to a laptop computer for testing and configuration. Verify that the test cable and converter are compliant with current EIA-232 and Universal Serial Bus specification standards for protocol converters. The male DB-9 and USB connectors for laptop computers equipped with only a USB port shall support the automatic handshake mode, transmission rates of 230 kilobits per second (kbps), and remote wakeup and power management features. Verify that the test cable and converter are compatible with the operating systems recommended for SunGuide~~SM~~® software, and are USB powered.

Crimp or solder the detector connector pins to the cable conductors. Assemble and test the cable prior to onsite installation and pulling. Cut all wires to their proper length before installation. Do not doubled back wire to take up slack. Neatly lace wires into cable with nylon lacing or plastic straps, and secure cables with clamps. Provide service loops at all connections.

Perform continuity tests on the detector's stranded conductors using a meter having a minimum input resistance of 20,000 Ω per volt and show that each conductor has a resistance of not more than 16 Ω per 984.25 feet of conductor.

Measure the insulation resistance between isolated conductors and between each conductor, ground, and shield using a meter designed for measuring insulation resistance. The resistance must be infinity. Perform all resistance testing after final termination and cable installation, but prior to the connection of any electronic or field devices.

SUBARTICLE 786-8.2.3 (of the Supplemental Specifications) is deleted and the following substituted:

786-8.2.3 Video Vehicle Detection Camera: Ensure that the camera is compatible with the current version of the Department's SunGuide~~SM~~® Software System.

Use a camera that produces National Television System Committee (NTSC) composite video output of 1 volt peak-to-peak (Vp-p) at 75 Ω. Use either a dome-type or external positioner-type camera assembly. Ensure that the VVDS camera can transmit images directly to the MVP.

Ensure that VVDS cameras, as well as any MVPs integrated in camera housings, meet the environmental requirements as detailed in Section 782-1.2.8.

Ensure that the VVDS camera conforms to one of the two options described below, as shown in the plans.

786-8.2.3.1 Dual-use Camera: Provide a VVDS camera that also functions as a closed-circuit television (CCTV) roadway surveillance system through the use of pan-tilt-zoom (PTZ) control by the operator. If utilized in this dual manner, ensure that the VVDS meets the following requirements:

1. Perform video vehicle detection and collect traffic data as its primary function, with surveillance as the secondary function.

2. Allow the VVDS operator to move the camera using PTZ control to view traffic conditions.

3. Return the VVDS camera to its preconfigured detection state when switched back from surveillance mode. Ensure that the positioner has a preset position return accuracy of ±0.36 degree, or less than 0.10% or better, as required in 782-1.2.3.

Ensure that dual-use cameras are either dome-type or external positioner-type cameras as shown in the plans, and that they meet the requirements detailed in Section 782-1.2.1.

Ensure that the lens meets the requirements of 782-1.2.2.

Use camera housings that meet the requirements of 782-1.2.7. Provide mounting hardware as required in 782-1.3.

Use PTZ mechanisms that meet the requirements of 782-1.2.3 for dome type cameras and 782-1.2.4 for external positioner type cameras.

Ensure that the camera meets the mechanical specifications in 782-1.2.7 and the electrical specifications in 782-1.2.6.

786-8.2.3.2 Detection-only Camera: Provide a fixed-mount camera that is either black-and-white or, alternately, color with automatic switchover from monochrome to color and vice versa, as shown in the plans.

Ensure that any detection-only camera provides the following features and capabilities:

1. Minimum resolution of 470 horizontal and 350 vertical TV lines.

2. User-selectable automatic gain control (AGC) that is peak-average adjustable to 30 decibels (dB).

3. A minimum signal-to-noise ratio of 50 dB.

4. User-selectable gamma settings of 0.45 and 1.0.

5. Automatic electronic shutter that is user selectable from 1/60 to 1/10,000 of a second.

Ensure that the detection-only camera has a minimum 10x motorized optical zoom lens with automatic iris. Ensure that the lens is capable of automatic and manual focus and iris control and has a minimum focal length of 0.14 to 3.2 inches. Ensure that the lens depth of field provides a clear image of roadside areas under all lighting conditions and has a maximum aperture of at least f/1.6.

Use camera housings that meet the requirements of 782-1.2.7. Provide mounting hardware as required in 782-1.3.

Ensure that the camera meets the mechanical specifications in 782-1.2.7 and the electrical specifications in 782-1.2.6.

SUBARTICLE 786-9.2 (of the Supplemental Specifications) is deleted and the following substituted:

786-9.2 Materials: Provide a magnetic detector that is able to resolve closely spaced vehicles and reject adjacent lane vehicles. Ensure that the operator is able

to select whether data is output as contact closures, mimicking standard loop detector outputs, or as accumulated statistical data using the detector's serial port.

At a 9,600-baud rate, the MTDS should meet the stated accuracy requirements applicable to data collected from each of four travel lanes in a given direction of travel in all prevalent traffic, weather, and lighting conditions. In addition, ensure that the MTDS also meets the following performance specifications:

1. The MTDS shall have a magnetic field of 0.2 to 0.8 oersted (Oe).

2. The unit's inductance (i.e., red to green wires) shall be 50 to 63 microHenries (μH) per probe, plus a nominal inductance of 16.5 μH per 100 feet of lead-in cable and 23 μH per 100 feet of home run cable.

3. The DC resistance between sensor leads (i.e., red to green wires) shall be 1.2 to 1.8 Ω per probe, plus a nominal resistance of 3 Ω per 100 feet of lead-in cable and 1.7 Ω per 100 feet of home run cable.

4. The DC resistance of each sensor lead to the earth at 500 V_{DC} shall be greater than 100 megohms (MΩ).

5. The transducer's gain (i.e., sensitivity) shall be 5 nanoHenries (nH) per millioersted (mOe) per probe at 0.4 Oe ambient field intensity.

6. The system's peak-to-peak drive current shall be 14 and 80 milliamperes (mA).

Ensure that the detector system is equipped with channel detect outputs and status output, plus fault and status light emitting diode (LED) indicators for each input channel.

Equip the detector system with a front panel that conforms to the EIA-232 communication port and 44 contact rear-edge connectors (i.e., 22 double-sided contacts). Ensure that the front of the detector is equipped with the appropriate switches, including a frequency selector switch, a reset switch, and mode/sensitivity switches.

Provide detector units that match the selected probes as part of the manufacturer's recommended detection assembly and that are compatible with the SunGuide℠® software. Ensure that each detector has four detector inputs and has the ability to accommodate up to four probes per channel.

Ensure that the detector can self-tune to its detection zone with no external adjustments other than physical alignment. There shall be no external tuning controls of any kind.

Ensure that the system operator is able to view real-time traffic activity data from the TMC and is able to set the parameters for count periods, probe sensitivities, communication addresses, bit rates, modes of operation (i.e., pulse, presence, long loop, delay, or directional detection), output pulses, and enable power line filtering through use of the MTDS software.

Ensure that the detector system has a transceiver monitoring circuit that will change the output relay to the fail-safe position in the event of a component failure.

Ensure that the detector system can be rack-mounted and is compatible with requirements in the NEMA TS 1 and TS 2 standards for card racks, and with Model 170 and 2070 input files. Ensure that the MTDS has 44 contact edge connectors. Provide a detector with a separate rack-mounted card rack from the detector's manufacturer.

786-9.2.1 Detector Probe and Carrier: Ensure that the magnetic detector probe is a transducer that detects vehicles by converting changes in the vertical component of the earth's magnetic field to changes in inductance. One probe centered under each monitored lane shall be sufficient to provide the accuracy specified herein, except in projects where motorcycles must be detected. In these cases, determine the number of required probes according to the manufacturer's recommendations.

Ensure that the carriers hold the magnetic probes firmly under a lane in a fixed, vertical alignment and lateral position as they are inserted into conduits installed beneath the pavement. Ensure that the carrier's interlocking mechanism maintains the probe's alignment within ±20 degrees from vertical alignment. Install the probes within 3 inches of the desired carrier position.

Verify that probes may be easily repositioned or readjusted to improve vehicle-sensing accuracy or to reflect changing traffic characteristics in permanent installations or work zones. Determine the proper configuration for the probe sets based on the number of probes used, their depth, and the traffic or roadway characteristics.

786-9.2.2 Carrier, Conduit and Pull Box: Install the magnetic probes and carriers in a 3-inch nonferrous conduit. Provide the conduits under a separate pay item. Ensure that the conduit is polyvinyl chloride (PVC) Schedule 80 conduit, or its structural and dimensional equivalent in high density polyethylene (HDPE) pipe. Mechanical joints are allowed only if the carrier sections can slide freely over the joints.

Ensure that the pull box, provided for under a separate pay item, conforms to Section 635. Ensure that the pull box is a minimum of 2 feet in diameter, or a minimum of 2 feet square. The nominal depth for either square or round pull boxes shall be 3 feet.

Provide the home run and lead-in cables according to the MTDS manufacturer's recommendations. Equip the probes with a lead-in cable assembled by the manufacturer. Ensure that the lead-in cable's length is adequate to connect the probe to a splice at the pull box.

Ensure that up to four probes can be connected to the same lead. The lead-in cable shall be a maximum of 1,000 feet in length.

Connect the lead-in cables to the field cabinet with a four-conductor home run cable. Provide the kits to splice the probe's lead-in cables to the home run cables according to the MTDS manufacturer's recommendations. Ensure that each sensor's lead-in cable length allows sufficient, but not excessive, slack for splicing connections to the shielded home run cable at the pull box. Solder, insulate, and waterproof the splices using underground-rated splice kits with an encapsulation compound. Ensure that a combined home run and lead-in cable can have a length of up to 2,500 feet.

786-9.2.3 MTDS Cabling: Ensure that the lead-in cable is a polyurethane-jacketed cable with two PVC-insulated conductors and includes #22 AWG conductors.

786-9.3 Installation of MTDS: Install the magnetic traffic detector below the road's surface, employing horizontal directional drilling or other methods approved by the Engineer. Prior to drilling, furnish a sufficient number of bore logs at 5-foot intervals across the installation site to characterize the soils, sediments, clays, groundwater, and related subsurface conditions.

Install and maintain the MTDS probes as detailed in the plans without the need to close traffic lanes. Do not damage the road's surface or disturb the pavement in any way. Trenching may be utilized during installation in non-paved areas.

Prepare shop drawings that detail the complete MTDS, and all other components to be supplied and constructed. Provide detailed drawings with the exact location and placement of system components, and include the installation details for required cables. Install all cabling according to the manufacturer's recommendations.

Adjust and program the system components so that all lanes generate data meeting the required accuracy specifications. Follow the manufacturer's recommendations for setting the sensitivity, depending on the expected vehicle mix. Install all electrical and communication conduits as specified in the plans. Install the 3-inch conduit at a depth of 21 inches, ±3 inches, extending from under the road's surface to the roadside pull box as described herein. Provide the conduit separately, according to the manufacturer's recommendations. Extend the installed conduit 2 to 3.5 inches into the terminating roadside pull box to facilitate installation of the probes in their carriers.

Ensure that the conduit's vertical alignment does not vary more than 0.25 inch per 1 foot of the horizontal length. Ensure that the conduit slopes downward slightly to drain any accumulated water from the conduit. Install a removable cap on the conduit at the far end of the pull box. Drill a weep hole measuring 0.1875 inch in the cap's bottom, facing downward. After all connections are completed, enclose the conduit's end in the pull box with a filter material that will let water enter and escape while preventing soil sediment intrusion. Provide details of the spacing of the probes in the plans and adapted to any local conditions.

Ensure that the field cabinet's wiring is in accordance with the functions assigned to the vehicle detector module pins. Ensure that all conductor pairs in the field cabinet between the home run cable conductor pair terminations and the traffic detector card sensor input are twisted at six or more turns per 1 foot.

Neatly bundle, tie-wrap and label all cables. Label each lead-in cable, as well as its detector, with the lane number.

Use the installation kits required for inserting and removing the probes, labeling probe cables, and closing off conduit ends according to the manufacturer's recommendations. At the splice box, splice the home run cables to the detector probe lead-in cables, as specified in Subsection 786-9.2.2 herein and according to the probe manufacturer's recommended practices. Mechanically connect the spliced wires together by soldering. Seal the soldered cable assemblies with an encapsulating compound from the splice kit. Permanently label the lead-in and home run cables at both the splice and in the field cabinet. Splice the lead-in cable to the home run cable according to the manufacturer's recommendations to ensure a reliable connection in the environmental conditions encountered by the MTDS.

Mount and install the detector assembly so that movement and vibration of the assembly does not degrade detection quality. Ensure that the detectors are well calibrated to ensure that they perform as required. Ensure that no further adjustments or calibration will be required after the initial setup. During installation, measure the MTDS loop resistance, loop inductance, crosstalk, and inductance change for each probe array. Record these results for each set of sensors. Verify that the resistance between sensor leads does not exceed the following limits: leads shall have resistance of less than

2 Ω per probe; lead-ins shall have resistance of less than 3 Ω per 100 feet; and home run cables shall have resistance of less than 1.7 Ω per 100 feet. After verifying that each detector probe's loop resistance is within these acceptable limits, seal and encapsulate the splices using the manufacturer's recommended splicing kit and procedures. Check each probe set for continuity using an ohmmeter according to the probe manufacturer's recommendations.

INTELLIGENT TRANSPORTATION SYSTEMS – VEHICLE DETECTION AND DATA COLLECTION.
(REV 4-26-10)

SUBARTICLE 786-2.3 (of the Supplemental Specifications) is deleted and the following substituted:

786-2.3 Configuration and Management: Ensure that the vehicle detection system is provided with computer software that allows an operator to program, operate, and read current status of all system features and functions using a laptop computer or remote TMC workstation. Furnish software that is compatible with the Department's SunGuide® Software System. Ensure that any software-based applications do not interfere with SunGuide® software when the two are installed and used together on a shared hardware platform. Ensure that the software application provides PC desktop display of the detection zones and control of any vehicle detector connected to the network.

Provide software licenses as required in the plans. Ensure that the detection system software offers an open API and software development kit available to the Department at no cost for integration with third party software and systems.

Ensure that an operator using a locally connected laptop computer can conduct system setup, calibration, diagnosis, and data retrieval operations. Ensure that the detection system is capable of having its configuration data saved to a laptop computer or TMC operator workstation, which can later transfer the data back to the detection system for reloading.

Ensure that the detection system operator can use a laptop computer or TMC workstation to edit previously defined detection configurations to permit adjustments to the detection zone's size, placement and sensitivity, and to reprogram the detector's parameters.

Ensure that the laptop computer and the detection system can communicate when connected directly by an EIA-232 cable. Ensure that the laptop computer and detection system can communicate across the ITS system's communication network using the NTCIP standards described in this document. Ensure that the software allows communication between multiple users and multiple field devices concurrently across the same communication network.

Once programmed, ensure that no periodic adjustments are required to the detection zones unless physical roadway conditions change, such as lane shifts or closures.

ARTICLE 786-5 (of the Supplemental Specifications) is deleted and the following substituted:

786-5 Testing.

786-5.1 Design Approval Test (DAT) Specifications: DATs will be conducted by the Traffic Engineering Research Laboratory (TERL). An APL approval and certification number is evidence of successful testing by TERL. The Department may

accept test results from an independent testing laboratory to satisfy the requirement that certain features and functions have been witnessed and documented as performing satisfactorily.

Arrange and conduct the tests and satisfy all inspection requirements prior to submission for the Engineer's inspection and acceptance. Furnish all necessary test equipment. Use a radar gun to calibrate speed detection, following the manufacturer's recommended calibration procedures.

At a minimum, demonstrate the following:

1. Use a laptop computer provided as part of the support equipment to configure the installation.

2. Verify that configuration data is stored in nonvolatile memory.

3. Download previously stored configuration data.

4. Verify that vehicles traveling at the test site can be detected across multiple travel lanes to the accuracy specified herein.

5. Drive a test car of known length and speed through the detection zone. Compare the output from the vehicle detector to this known value to verify the accuracy of detection. Repeat this measurement at least 10 times.

6. Install the detection system sensor at the site for test setup. Place a video camera at the same point along the roadway, above the **s**ensor location, as determined appropriate by the Engineer. Produce a video recording of the test to obtain a manual count, then compare those results with those from the detection system to determine the accuracy of the sensor. Alternative verification methods may be considered by the Engineer.

7. Verify the volume counts and speed measurements for each installed assembly using the test software running on the laptop computer connected locally to the detector's EIA-232/485 communication port. Repeat this test remotely from the TMC's operator workstation. Verify the accuracy of traffic parameters specified herein by using permanent or temporary traffic detection devices of known accuracy.

786-5.2 Field Acceptance Test (FAT) Specifications: Develop and submit a test plan for FATs to the Engineer for consideration and approval. Ensure that the FAT test plan demonstrates compliance to all requirements.

Inspect all vehicle detection system field components to ensure proper installation and cable termination.

Adjust and verify the detector settings by comparing each sensor's recorded traffic volumes and speed with those actually observed. Remotely repeat this test from the TMC. Verify the accuracy of traffic parameters using permanent or temporary traffic detection methods or devices of known accuracy.

Notify the Engineer at least 14 calendar days prior to the proposed test date. The Contractor shall at a minimum:

1. Furnish all equipment, appliances, and labor necessary to test the installed vehicle detection system and the network communication device, and to perform the following tests before any connections are made:

a. Perform a continuity test on the detector cables to ensure that anomalies, such as openings, shorts, crimps or defects, are not present.

b. Perform continuity tests on the detector's stranded conductors element using a meter having a minimum input resistance of 20,000 Ω per

volt and show that each conductor has a resistance of not more than that specified by the wire/cable manufacturer.

c. Measure the insulation resistance between isolated conductors and between each conductor, ground, and shield using a meter designed for measuring insulation resistance. The resistance must be greater than 100 MΩ. Perform all resistance testing after final termination and cable installation, but prior to the connection of any electronic or field devices.

d. Replace any cable that fails to meet these parameters, or if any testing reveals defects in the cable, and retest new cable as specified in this section.

2. Furnish and calibrate all test equipment.

3. Demonstrate the following after installation of the vehicle detection system, other hardware, power supplies, and connecting cables:

a. Verify that physical construction has been completed as specified in the plans.

b. Inspect the quality and tightness of ground and surge protector connections.

c. Check power supply voltages and outputs.

d. Verify that device connections to power sources are as specified in the plans.

e. Verify that the installation of specified cables and connections between all detectors and the field cabinet are as specified in the plans.

f. Demonstrate that the remote system is fully operational and performing all specified types of detection, including data storage functions, with a laptop computer.

g. Verify that the network interface device is receiving and transmitting data from the remote site to the ITS network.

ARTICLE 786-6 (of the Supplemental Specifications) is deleted and the following substituted:

786-6 System Acceptance Criteria.

Upon request, furnish independent laboratory testing documentation certifying adherence to the standards and specifications required herein, along with adherence to the stated wind force criteria using a minimum effective projected area (EPA), the actual EPA, or an EPA greater than that of the detection assembly to be attached.

Within three calendar days of successful test completion, deliver to the Engineer a written completion notice and a copy of all test results. Include in this completion notice the documentation of any discrepancies found during testing. Also include assembly installation locations and successful test completion dates. If any component fails to pass required testing, replace the part and retest according to the requirements above, then resubmit the test results to the Engineer.

The Engineer shall specify the defect or failure in the work for any work rejected. Notification of acceptance or rejection of the work shall be by delivery of written notice to the Contractor.

SUBARTICLE 786-7.3 (of the Supplemental Specifications) is deleted and the following substituted:

786-7.3 Installation of MVDS: Mount the MVDS' detector as detailed in the plans. In either configuration, mount the detector level from side to side. Ensure that the vertical and horizontal clearance of the installed detection device complies with Vol. I, Chapter 2 of the PPM.

Ensure that the MVDS sensor has a 200-foot range, and that the viewing angle is a minimum of 40 degrees vertical and a maximum of 15 degrees horizontal. Verify that all detection zones are contained within the specified elevation angle according to the manufacturer's recommendations and that the MVDS is capable of fully detecting all vehicles in a maximum of eight lanes. Ensure that the configuration also provides accurate collection of all data types as detailed in this specification.

Mount the detector in a NEMA 4X polycarbonate box, and verify that the electrical connection is located on the bottom of the box.

Provide a housing that can be pole- or wall-mounted, as indicated in the plans. Supply a universal mounting bracket that is adjustable on two axes for optimum alignment.

Attach the mounting bracket with approved stainless steel bands that are 0.75 inch wide and 0.025 inch thick, or mount to a concrete structure using two stainless steel expansion bolts of sufficient length and diameter to support 100 pounds.

When installing a detector near metal structures, such as buildings, bridges or sign supports, mount the sensor and aim it so that the detection zone is not under and does not pass through any structure to avoid distortion and reflection. In forward-looking configurations, the detector shall be mounted over the center of each lane.

Ensure that the detector is factory calibrated to comply with all applicable standards, specifications, and requirements. Ensure that the detector does not require further adjustment after initial setup, and that no periodic calibration is required.

Provide an interface to external equipment with a single connector. Ensure that the connector provides power to the unit and allows generation of contact closure output pairs for interface with traffic controller inputs. Ensure that the connector includes serial communication lines for programming, testing, and interfacing with the modem at a minimum 9,600-baud rate and that it has at least 26 pins. Ensure that the serial port's data format is standard binary non-return to zero (NRZ) modulation with 8-bit data, 1-stop bit, and no parity.

Ensure that the home run cable is a polyurethane-jacketed cable approved by the Engineer, with polyvinyl chloride (PVC) insulated conductors. The home run cable shall have a 300-volt rating and a temperature rating of 200° F. Ensure that the cable is equipped with #20 or #22 American Wire Gauge (AWG) conductors.

Supply a test cable and converter to connect the detector to a laptop computer for testing and configuration. Verify that the test cable and converter are compliant with current EIA-232 and Universal Serial Bus specification standards for protocol converters. The male DB-9 and USB connectors for laptop computers equipped with only a USB port shall support the automatic handshake mode, transmission rates of 230 kilobits per second (kbps), and remote wakeup and power management features. Verify that the test cable and converter are compatible with the operating systems recommended for SunGuide® software, and are USB powered.

Crimp or solder the detector connector pins to the cable conductors. Assemble and test the cable prior to onsite installation and pulling. Cut all wires to their proper length before installation. Do not doubled back wire to take up slack. Neatly lace wires into cable with nylon lacing or plastic straps, and secure cables with clamps. Provide service loops at all connections.

Perform continuity tests on the detector's stranded conductors using a meter having a minimum input resistance of 20,000 Ω per volt and show that each conductor has a resistance of not more than 16 Ω per 984.25 feet of conductor.

Measure the insulation resistance between isolated conductors and between each conductor, ground, and shield using a meter designed for measuring insulation resistance. The resistance must be infinity. Perform all resistance testing after final termination and cable installation, but prior to the connection of any electronic or field devices.

SUBARTICLE 786-8.2.3 (of the Supplemental Specifications) is deleted and the following substituted:

786-8.2.3 Video Vehicle Detection Camera: Ensure that the camera is compatible with the current version of the Department's SunGuide® Software System.

Use a camera that produces National Television System Committee (NTSC) composite video output of 1 volt peak-to-peak (Vp-p) at 75 Ω. Use either a dome-type or external positioner-type camera assembly. Ensure that the VVDS camera can transmit images directly to the MVP.

Ensure that VVDS cameras, as well as any MVPs integrated in camera housings, meet the environmental requirements as detailed in Section 782-1.2.8.

Ensure that the VVDS camera conforms to one of the two options described below, as shown in the plans.

786-8.2.3.1 Dual-use Camera: Provide a VVDS camera that also functions as a closed-circuit television (CCTV) roadway surveillance system through the use of pan-tilt-zoom (PTZ) control by the operator. If utilized in this dual manner, ensure that the VVDS meets the following requirements:

1. Perform video vehicle detection and collect traffic data as its primary function, with surveillance as the secondary function.

2. Allow the VVDS operator to move the camera using PTZ control to view traffic conditions.

3. Return the VVDS camera to its preconfigured detection state when switched back from surveillance mode. Ensure that the positioner has a preset position return accuracy of ±0.36 degree, or less than 0.10% or better, as required in 782-1.2.3.

Ensure that dual-use cameras are either dome-type or external positioner-type cameras as shown in the plans, and that they meet the requirements detailed in Section 782-1.2.1.

Ensure that the lens meets the requirements of 782-1.2.2.

Use camera housings that meet the requirements of 782-1.2.7. Provide mounting hardware as required in 782-1.3.

Use PTZ mechanisms that meet the requirements of 782-1.2.3 for dome type cameras and 782-1.2.4 for external positioner type cameras.

Ensure that the camera meets the mechanical specifications in 782-1.2.7 and the electrical specifications in 782-1.2.6.

786-8.2.3.2 Detection-only Camera: Provide a fixed-mount camera that is either black-and-white or, alternately, color with automatic switchover from monochrome to color and vice versa, as shown in the plans.

Ensure that any detection-only camera provides the following features and capabilities:

1. Minimum resolution of 470 horizontal and 350 vertical TV lines.
2. User-selectable automatic gain control (AGC) that is peak-average adjustable to 30 decibels (dB).
3. A minimum signal-to-noise ratio of 50 dB.
4. User-selectable gamma settings of 0.45 and 1.0.
5. Automatic electronic shutter that is user selectable from 1/60 to 1/10,000 of a second.

Ensure that the detection-only camera has a minimum 10x motorized optical zoom lens with automatic iris. Ensure that the lens is capable of automatic and manual focus and iris control and has a minimum focal length of 0.14 to 3.2 inches. Ensure that the lens depth of field provides a clear image of roadside areas under all lighting conditions and has a maximum aperture of at least f/1.6.

Use camera housings that meet the requirements of 782-1.2.7. Provide mounting hardware as required in 782-1.3.

Ensure that the camera meets the mechanical specifications in 782-1.2.7 and the electrical specifications in 782-1.2.6.

SUBARTICLE 786-9.2 (of the Supplemental Specifications) is deleted and the following substituted:

786-9.2 Materials: Provide a magnetic detector that is able to resolve closely spaced vehicles and reject adjacent lane vehicles. Ensure that the operator is able to select whether data is output as contact closures, mimicking standard loop detector outputs, or as accumulated statistical data using the detector's serial port.

At a 9,600-baud rate, the MTDS should meet the stated accuracy requirements applicable to data collected from each of four travel lanes in a given direction of travel in all prevalent traffic, weather, and lighting conditions. In addition, ensure that the MTDS also meets the following performance specifications:

1. The MTDS shall have a magnetic field of 0.2 to 0.8 oersted (Oe).
2. The unit's inductance (i.e., red to green wires) shall be 50 to 63 microHenries (μH) per probe, plus a nominal inductance of 16.5 μH per 100 feet of lead-in cable and 23 μH per 100 feet of home run cable.
3. The DC resistance between sensor leads (i.e., red to green wires) shall be 1.2 to 1.8 Ω per probe, plus a nominal resistance of 3 Ω per 100 feet of lead-in cable and 1.7 Ω per 100 feet of home run cable.

4. The DC resistance of each sensor lead to the earth at 500 V_{DC} shall be greater than 100 megohms (MΩ).

5. The transducer's gain (i.e., sensitivity) shall be 5 nanoHenries (nH) per millioersted (mOe) per probe at 0.4 Oe ambient field intensity.

6. The system's peak-to-peak drive current shall be 14 and 80 milliamperes (mA).

Ensure that the detector system is equipped with channel detect outputs and status output, plus fault and status light emitting diode (LED) indicators for each input channel.

Equip the detector system with a front panel that conforms to the EIA-232 communication port and 44 contact rear-edge connectors (i.e., 22 double-sided contacts). Ensure that the front of the detector is equipped with the appropriate switches, including a frequency selector switch, a reset switch, and mode/sensitivity switches.

Provide detector units that match the selected probes as part of the manufacturer's recommended detection assembly and that are compatible with the SunGuide® software. Ensure that each detector has four detector inputs and has the ability to accommodate up to four probes per channel.

Ensure that the detector can self-tune to its detection zone with no external adjustments other than physical alignment. There shall be no external tuning controls of any kind.

Ensure that the system operator is able to view real-time traffic activity data from the TMC and is able to set the parameters for count periods, probe sensitivities, communication addresses, bit rates, modes of operation (i.e., pulse, presence, long loop, delay, or directional detection), output pulses, and enable power line filtering through use of the MTDS software.

Ensure that the detector system has a transceiver monitoring circuit that will change the output relay to the fail-safe position in the event of a component failure.

Ensure that the detector system can be rack-mounted and is compatible with requirements in the NEMA TS 1 and TS 2 standards for card racks, and with Model 170 and 2070 input files. Ensure that the MTDS has 44 contact edge connectors. Provide a detector with a separate rack-mounted card rack from the detector's manufacturer.

786-9.2.1 Detector Probe and Carrier: Ensure that the magnetic detector probe is a transducer that detects vehicles by converting changes in the vertical component of the earth's magnetic field to changes in inductance. One probe centered under each monitored lane shall be sufficient to provide the accuracy specified herein, except in projects where motorcycles must be detected. In these cases, determine the number of required probes according to the manufacturer's recommendations.

Ensure that the carriers hold the magnetic probes firmly under a lane in a fixed, vertical alignment and lateral position as they are inserted into conduits installed beneath the pavement. Ensure that the carrier's interlocking mechanism maintains the probe's alignment within ±20 degrees from vertical alignment. Install the probes within 3 inches of the desired carrier position.

Verify that probes may be easily repositioned or readjusted to improve vehicle-sensing accuracy or to reflect changing traffic characteristics in permanent installations or work zones. Determine the proper configuration for the probe

sets based on the number of probes used, their depth, and the traffic or roadway characteristics.

786-9.2.2 Carrier, Conduit and Pull Box: Install the magnetic probes and carriers in a 3-inch nonferrous conduit. Provide the conduits under a separate pay item. Ensure that the conduit is polyvinyl chloride (PVC) Schedule 80 conduit, or its structural and dimensional equivalent in high density polyethylene (HDPE) pipe. Mechanical joints are allowed only if the carrier sections can slide freely over the joints.

Ensure that the pull box, provided for under a separate pay item, conforms to Section 635. Ensure that the pull box is a minimum of 2 feet in diameter, or a minimum of 2 feet square. The nominal depth for either square or round pull boxes shall be 3 feet.

Provide the home run and lead-in cables according to the MTDS manufacturer's recommendations. Equip the probes with a lead-in cable assembled by the manufacturer. Ensure that the lead-in cable's length is adequate to connect the probe to a splice at the pull box.

Ensure that up to four probes can be connected to the same lead. The lead-in cable shall be a maximum of 1,000 feet in length.

Connect the lead-in cables to the field cabinet with a four-conductor home run cable. Provide the kits to splice the probe's lead-in cables to the home run cables according to the MTDS manufacturer's recommendations. Ensure that each sensor's lead-in cable length allows sufficient, but not excessive, slack for splicing connections to the shielded home run cable at the pull box. Solder, insulate, and waterproof the splices using underground-rated splice kits with an encapsulation compound. Ensure that a combined home run and lead-in cable can have a length of up to 2,500 feet.

786-9.2.3 MTDS Cabling: Ensure that the lead-in cable is a polyurethane-jacketed cable with two PVC-insulated conductors and includes #22 AWG conductors.

786-9.3 Installation of MTDS: Install the magnetic traffic detector below the road's surface, employing horizontal directional drilling or other methods approved by the Engineer. Prior to drilling, furnish a sufficient number of bore logs at 5-foot intervals across the installation site to characterize the soils, sediments, clays, groundwater, and related subsurface conditions.

Install and maintain the MTDS probes as detailed in the plans without the need to close traffic lanes. Do not damage the road's surface or disturb the pavement in any way. Trenching may be utilized during installation in non-paved areas.

Prepare shop drawings that detail the complete MTDS, and all other components to be supplied and constructed. Provide detailed drawings with the exact location and placement of system components, and include the installation details for required cables. Install all cabling according to the manufacturer's recommendations.

Adjust and program the system components so that all lanes generate data meeting the required accuracy specifications. Follow the manufacturer's recommendations for setting the sensitivity, depending on the expected vehicle mix. Install all electrical and communication conduits as specified in the plans. Install the 3-inch conduit at a depth of 21 inches, ±3 inches, extending from under the road's surface to the roadside pull box as described herein. Provide the conduit separately, according to

the manufacturer's recommendations. Extend the installed conduit 2 to 3.5 inches into the terminating roadside pull box to facilitate installation of the probes in their carriers.

Ensure that the conduit's vertical alignment does not vary more than 0.25 inch per 1 foot of the horizontal length. Ensure that the conduit slopes downward slightly to drain any accumulated water from the conduit. Install a removable cap on the conduit at the far end of the pull box. Drill a weep hole measuring 0.1875 inch in the cap's bottom, facing downward. After all connections are completed, enclose the conduit's end in the pull box with a filter material that will let water enter and escape while preventing soil sediment intrusion. Provide details of the spacing of the probes in the plans and adapted to any local conditions.

Ensure that the field cabinet's wiring is in accordance with the functions assigned to the vehicle detector module pins. Ensure that all conductor pairs in the field cabinet between the home run cable conductor pair terminations and the traffic detector card sensor input are twisted at six or more turns per 1 foot.

Neatly bundle, tie-wrap and label all cables. Label each lead-in cable, as well as its detector, with the lane number.

Use the installation kits required for inserting and removing the probes, labeling probe cables, and closing off conduit ends according to the manufacturer's recommendations. At the splice box, splice the home run cables to the detector probe lead-in cables, as specified in Subsection 786-9.2.2 herein and according to the probe manufacturer's recommended practices. Mechanically connect the spliced wires together by soldering. Seal the soldered cable assemblies with an encapsulating compound from the splice kit. Permanently label the lead-in and home run cables at both the splice and in the field cabinet. Splice the lead-in cable to the home run cable according to the manufacturer's recommendations to ensure a reliable connection in the environmental conditions encountered by the MTDS.

Mount and install the detector assembly so that movement and vibration of the assembly does not degrade detection quality. Ensure that the detectors are well calibrated to ensure that they perform as required. Ensure that no further adjustments or calibration will be required after the initial setup. During installation, measure the MTDS loop resistance, loop inductance, crosstalk, and inductance change for each probe array. Record these results for each set of sensors. Verify that the resistance between sensor leads does not exceed the following limits: leads shall have resistance of less than 2 Ω per probe; lead-ins shall have resistance of less than 3 Ω per 100 feet; and home run cables shall have resistance of less than 1.7 Ω per 100 feet. After verifying that each detector probe's loop resistance is within these acceptable limits, seal and encapsulate the splices using the manufacturer's recommended splicing kit and procedures. Check each probe set for continuity using an ohmmeter according to the probe manufacturer's recommendations.