781 INTELLIGENT TRANSPORTATION SYSTEMS – MOTORIST INFORMATION SYSTEMS.

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PAGE 813. The following new Section is added after Section 715:

SECTION 781
INTELLIGENT TRANSPORTATION SYSTEMS
MOTORIST INFORMATION SYSTEMS

781-1 Description.

Provide Motorist Information Systems meeting the general requirements of 781-2, the specific requirements for each system as defined in 781-3 through 781-6 of this specification, and in accordance with the details specified in the Contract Documents.

781-2 Materials.

Ensure that all materials furnished, assembled, fabricated, or installed are new products and approved by the Engineer.

781-3 Dynamic Message Signs.

781-3.1 Sign Types: Dynamic Message Signs must meet the requirements of NEMA TS4-2005. Dynamic Message Signs (DMS) are classified by the type of sign display and the type of mechanical construction. Provide monochrome, tri-color, or full-color signs as shown in the Contract Documents. Use only equipment and components that meet the requirements of these minimum specifications and are listed on the Department's Approved Product List (APL).

781-3.1.1 Front Access DMS: Ensure that front access signs meet the requirements of NEMA TS4 2005, section 3.2.5.

781-3.1.2 Walk-in DMS: Ensure that walk-in signs meet the requirements of NEMA TS4 2005, section 3.2.7.

781-3.1.3 Embedded DMS: Embedded DMSs are DMSs that are typically mounted to Ground Traffic Signs, Overhead Traffic Signs, or Overhead Cantilever Traffic Signs.

781-3.2 Sign Housing Requirements for all DMS: Ensure that the external skin of the sign housing is constructed of aluminum alloy 5052 H32 that is a minimum of 0.125 inch thick for walk-in DMS and 0.090 inch thick for front and embedded DMS. Ensure the interior structure is constructed of aluminum. Ensure that the sign housing design and appearance is approved by the Engineer. Ensure that no internal frame connections or external skin attachments rely upon adhesive bonding or rivets.

Ensure the sign enclosure meets the requirements of NEMA TS4 2005, section 3.1.1. Ensure that all drain holes and other openings in the sign housing are screened to prevent the entrance of insects and small animals.

Ensure that the sign housing complies with the fatigue resistance requirements of the fifth edition (2001) American Association of State Highway and Transportation Officials (AASHTO) Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals with current addendums. Design and construct the DMS unit for continuous usage of at least 20 years and the sign structure for a 50-year design life. Ensure that equipment

and structures are designed to withstand loads, including a wind load of 150 miles per hour, as defined in the FDOT Structures Manual without deformation or damage.

Ensure that the top of the housing includes multiple steel lifting eyebolts or equivalent hoisting points. Ensure hoist points are positioned such that the sign remains level when lifted. Ensure that the hoist points and sign frame allow the sign to be shipped, handled, and installed without damage.

Ensure all assembly hardware, including nuts, bolts, screws, and locking washers less than 5/8 inch in diameter, are type 304 or 316 passivated stainless steel and meet the requirements of American Society for Testing and Materials (ASTM) F 593 and ASTM F 594. All assembly hardware greater than or equal to 5/8 inch in diameter must be galvanized and meet the requirements of ASTM A 307.

Ensure all exterior, excluding the sign face, and all interior housing surfaces are a natural aluminum mill finish. Ensure signs are fabricated, welded, and inspected in accordance with the requirements of the current American National Standard Institute/American Welding Society (ANSI/AWS) Structural Welding Code-Aluminum.

Ensure the sign housing meets the requirements of NEMA TS4 2005, section 3.2.8 for convenience outlets.

781-3.2.1 Sign Housing for Walk-in DMS: Ensure that exterior seams and joints, except the finish coated face pieces, are continuously welded using an inert gas welding method. Limit the number of seams on the top of the housing to a maximum of three. Stitch weld the exterior housing panel material to the internal structural members to form a unitized structure.

Ensure that exterior mounting assemblies are fabricated from aluminum alloy 6061-T6 extrusions a minimum of 0.1875 inch thick. Include a minimum of three 6061-T6 structural aluminum Z members on the rear of the sign housing in accordance with the Design Standards, Index No. 18300. Ensure these structural members run parallel to the top and bottom of the sign housing and are each a single piece of material that spans the full length of the sign. Ensure these structural members are attached to the internal framework of the sign.

Ensure hoist points are attached directly to structural frame members by the sign manufacturer.

Ensure housing access is provided through an access door that meets the requirements of NEMA TS4 2005, section 3.2.7.1. Ensure the access door includes a keyed tumbler lock and a door handle with a hasp for a padlock. Ensure the door includes a closed-cell neoprene gasket and stainless steel hinges.

Ensure the sign housing meets the requirements of NEMA TS4 2005, section 3.2.7.3 for service lighting. If incandescent lamps are provided, ensure they are fully enclosed in heavy-duty shatterproof, protective fixtures. Ensure that incandescent fixtures include aluminum housing and base, a porcelain socket, and clear glass inner cover. Ensure that all removable components are secured with set screws. If fluorescent lamps are provided, ensure they are fitted with protective guards.

Ensure that the sign housing includes emergency lighting that automatically illuminates the interior in the event of a power outage. Emergency lighting must be capable of operation without power for a minimum of 90 minutes.

781-3.2.1.1 Walk-in DMS Work Area: Ensure the walk-in DMS has a work area that meets the requirements of NEMA TS4 2005, section 3.2.7.2. Finish all edges of the walkway to eliminate sharp edges or protrusions.

781-3.2.2 Sign Housing for Front Access and Embedded DMS: Ensure front access and embedded signs meet the requirements of NEMA TS4 2005, section 3.2.4. Ensure access does not require specialized tools or excessive force.

781-3.2.3 Housing Face requirements for all DMS: Ensure the sign face meets the requirements of NEMA TS4 2005, section 3.1.3. Ensure that all sign face surfaces are finished with a matte black coating system that meets or exceeds American Architectural Manufacturers Association (AAMA) Specification No. 2605. Provide certification that the sign face parts are coated with the prescribed thickness. Except for Embedded DMS, ensure the sign face includes a contrast border that meets the requirements of NEMA TS4 2005, section 3.1.6.

781-3.2.3.1 Housing Face for Walk-in DMS: No exposed fasteners shall be allowed on the housing face. Ensure that display modules can be easily and rapidly removed from within the sign without disturbing adjacent display modules.

781-3.2.3.2 Housing Face for Front Access and Embedded DMS: Any exposed fasteners on the housing face shall be the same color and finish as the housing face. Only captive fasteners shall be used on the housing face.

781-3.2.3.3 External Fascia Panels: If the sign includes external fascia panels, ensure that they are constructed using aluminum. Finish each fascia panel with a matte black coating system that meets or exceeds AAMA Specification No. 2605.

781-3.2.3.4 Lens Panel Assembly: If sign includes lens panel assemblies, ensure they are modular in design, removable, and interchangeable without misalignment of the lens panel and the light-emitting diode (LED) pixels. The lens panel assembly must consist of an environmental shielding layer coating to protect and seal the LEDs and internal electronics. The coating shall be a minimum 90% ultraviolet (UV) opaque. Lens panels must have a matte black coating that meets or exceeds AAMA Specification No. 2605. Lens panels must include a mask constructed of 0.080 inch minimum thickness aluminum. Ensure that the mask is perforated to provide an aperture for each pixel on the display module. Ensure that the apertures do not block the LED output at the required viewing angle.

781-3.2.4 Sign Housing Ventilation System: The ventilation systems for walk-in, front-access, and embedded DMS must meet the requirements of NEMA TS4 2005, section 3.1.2.

Ensure that air drawn into the sign is filtered upon entry. Ensure the ventilation system is automatically tested once each day and that it may be tested on command from remote and local control access locations. Ensure the sign includes a sensor or a sensor assembly to monitor airflow volume to predict the need for a filter change. Ensure the ventilation system fans possess a 100,000-hour, L10 life rating.

781-3.2.4.1 Ventilation System for Walk-in DMS: Ensure the sign includes a fail-safe ventilation subsystem that includes a snap disk thermostat that is independent of the sign controller. Preset the thermostat at 130°F. If the sign housing's interior reaches 130°F, the thermostat must override the normal ventilation system, bypassing the sign controller and turning on all fans. The fans must remain on until the internal sign housing temperature falls to 115°F.

781-3.2.5 Sign Housing Temperature Sensor: Ensure that the sign controller continuously measures and monitors the temperature sensors. Ensure that the sign blanks when a critical temperature is exceeded and that the sign will report this event when polled. Ensure that remote and local computers can read all temperature measurements from the sign controller.

781-3.2.6 Sign Housing Humidity Sensor: Humidity sensors must detect from 0 to 100% relative humidity in 1% or smaller increments. Sensors must operate and survive in 0 to 100% relative humidity, and have an accuracy that is better than plus or minus 5% relative humidity. A humidistat is not acceptable.

781-3.2.7 Sign Housing Photosensors: Ensure the sign meets the requirements of NEMA TS4 2005, section 8.8. Ensure that the sensors provide accurate ambient light condition information to the sign controller for automatic light intensity adjustment. Ensure that the automatic adjustment of the LED driving waveform duty cycle occurs in small enough increments that the sign's brightness changes smoothly, with no perceivable brightness change between adjacent levels. Ensure that stray headlights shining on the photoelectric sensor at night do not cause LED brightness changes.

Ensure that the brightness and color of each pixel is uniform over the sign's entire face within a 30-degree viewing angle in all lighting conditions.

781-3.3: Display Modules: Provide display modules manufactured by one source and fully interchangeable throughout the manufacturer's sign system(s). Ensure that removal or replacement of a complete display module or LED board can be accomplished without the use of special tools.

Ensure display modules contain solid-state electronics needed to control pixel data and read pixel status.

Ensure that the sign has a full matrix display area as defined in the glossary of NEMA TS4 2005.

781-3.3.1 LED and Pixel Specifications: Ensure that LED lamps have a minimum viewing angle of 30 degrees.

Ensure that all pixels in all signs in a project, including operational support supplies, have equal color and on-axis intensity. Ensure that the sign display meets the luminance requirements of NEMA TS4 2005, section 5.4, for light emitting signs connected at full power. Ensure that amber displays produce an overall luminous intensity of at least 9200 candelas per square meter when operating at 100% intensity. Provide the LED brightness and color bins that are used in each pixel to the Engineer for approval. Ensure that the LED manufacturer demonstrates testing and binning according to the International Commission on Illumination (CIE) 127 (1997) standard.

Ensure that all LEDs operate within the LED manufacturer's recommendations for typical forward voltage, peak pulsed forward current, and other ratings. Component ratings shall not be exceeded under any operating condition.

Provide a pixel test as a form of status feedback to the transportation management center (TMC) from the local sign controller. Ensure that the operational status of each pixel in the sign can be automatically tested once a day. Ensure that the pixel status test determines the functional status of the pixel as defined by the pixel Failure Status object in National Transportation Communications for ITS Protocol (NTCIP) 1203v0239 and does not affect the displayed message for more than half a second.

Ensure that LEDs are individually mounted directly on a printed circuit board (PCB).

781-3.3.2 Optical, Electrical, and Mechanical Specifications for Display Modules: Ensure the display modules are rectangular and have an identical vertical and horizontal pitch between adjacent pixels. Ensure that the separation between the last column of one display module and the first column of the next module is equal to the horizontal distance

between the columns of a single display module. Full-color signs must have a pitch equal to or less than 35mm.

Ensure that the LED circuit board is a NEMA FR4-rated, single 0.062 inch, black PCB. Ensure that no PCB has more than two PCB jumper wires present. Finish all PCBs with a solder mask and a component-identifying silk screen.

Provide the LED motherboards with a complete conformal coating of silicone resin with a minimum thickness of 0.01 inch, except for the pixels on the front of the PCB. All other PCBs must be provided with a complete conformal coating of silicone resin with a minimum thickness of 0.01 inch. Meet the material requirements of MIL-I-46058C Military Standard, United States Department of Defense (USDOD).

Ensure that any devices used to secure LEDs do not block air flow to the LED leads or block the LED light output at the required viewing angle. Ensure that all components on the LED side of PCBs are black.

Ensure that there are a minimum of two power supplies that are wired in a parallel configuration for redundancy. Ensure that if one or 25% of the supplies in a group, whichever is greater, completely fails, the sign shall still be supplied with enough power to run 40% of all pixels at a 100% duty cycle with an ambient operating temperature of 165°F.

Ensure that the sign controller continuously measures and monitors all LED module power supply voltages and provides the voltage readings to the TMC or a laptop computer on command.

Ensure that LEDs are protected from external environmental conditions, including moisture, snow, ice, wind, dust, dirt, and UV rays. Do not use epoxy to encapsulate the LEDs.

781-3.3.3 Display Area for Walk-in DMS: Ensure that the display area is capable of displaying three lines of 15 characters using an 18 inch font that meets the height to width ratio and character spacing in the Manual on Uniform Traffic Control Devices for Streets and Highways 2009 Edition (MUTCD), section 2L.04, paragraphs 05, 06, and 08.

781-3.4 Characters, Fonts, and Color: Ensure that the signs are capable of displaying American Standard Code for Information Interchange (ASCII) characters 32 through 126, including all uppercase and lowercase letters and digits 0 through 9, at any location in the message line. Submit a list of the character fonts to the Engineer for approval.

All signs must be loaded (as a factory default) with a font in accordance with or that resembles the standard font set described in NEMA TS4 2005, section 5.6. For signs with a pixel pitch of 35mm or less, ensure the sign is loaded (as a factory default) with a font set that resembles the Federal Highway Administration (FHWA) Series E2000 standard font.

Ensure DMS fonts have character dimensions that meet the MUTCD, section 2L.04, paragraph 08.

Ensure that full-color signs can display the colors prescribed in the MUTCD, section 1A.12.

781-3.5 Main Power Supply and Energy Distribution Specifications:

Provide a nominal single-phase power line voltage of 120/240 $V_{AC.}$ Ensure the DMS meets the requirements of NEMA TS4 2005, section 10.2.

Locate all 120 V_{AC} wiring in conduit, pull boxes, raceways, or control cabinets as required by the National Electrical Code (NEC). Ensure that no 120 V_{AC} wiring is exposed inside or outside of the sign housing. Do not use the sign housing as a wiring raceway or control cabinet.

Provide Type XHHW power cables sized as required by the NEC for acceptable voltage drops while supplying alternating current to the sign.

Provide surge protective devices (SPD) installed or incorporated in the sign system by the manufacturer to guard against lightning, transient voltage surges, and induced current. Ensure that SPDs meet or exceed the requirements of Section 785-2. Ensure SPDs protect all electric power and data communication connections.

781-3.6 Uninterruptible Power Supply (UPS): If a UPS is required in the Contract Documents for walk-in DMS, ensure the UPS is installed within the sign housing or as shown in the Plans. If a UPS is required in the Contract Documents for front access and embedded signs, ensure the UPS is installed within the control cabinet or as shown in the Plans. The UPS system must be capable of displaying the current message on a sign when a power outage occurs. Signs with UPS must be able to operate on battery power and display text messages for a minimum of two hours. Ensure the system uses sealed absorbed glass mat (AGM) batteries.

781-3.7 Operational Support Supplies: Furnish the operational support supplies listed in the table below. Promptly replace any of the supplies used to perform a warranty repair.

For every group of 10 or fewer DMS provided or required, provide one set of supplies as follows:

1 each	Sign controller and I/O board(s)
10 each	LED display modules
1 each	Display power supply
1 each	Uninterruptible power supply
1 each	Cable for connecting interface circuits to daughter boards
1 each	Display module cables
2 each	Surge suppression sets
1 each	Fan assembly
1 each	Time relay for fan control
10 each	Each type of small fuse ($\leq$ 10 amp)
2 each	Each type of large fuse (> 10 amp)
1 each	Each type of sensor

781-3.8 Components: All components must meet the requirements of NEMA TS4 2005, section 8.

781-3.8.1 Mechanical Components: Ensure that all fasteners, including bolts, nuts, and washers less than 5/8 inch in diameter, are passivated stainless steel, Type 316 or Type 304 and meet the requirements of ASTM F 593 and ASTM F 594 for corrosion resistance. Ensure that all bolts and nuts 5/8 inch and over in diameter are galvanized and meet the requirements of ASTM A 307. Do not use self-tapping screws. Ensure that all parts are fabricated from corrosion resistant materials, such as plastic, stainless steel, aluminum, or brass. Ensure that construction materials are resistant to fungus growth and moisture deterioration. Ensure that all dissimilar metals are separated with an inert, dielectric material.

781-3.8.2 Sign Controller: Ensure that the sign controller monitors the sign in accordance with NEMA TS4 2005, section 9. Ensure the sign monitors the status of any photocells, LED power supplies, humidity, and airflow sensors. Ensure sign controllers use fiber optic cables for data connections between the sign housing and ground-level cabinet.

Ensure that the sign controller meets the requirements of NEMA TS4 2005, sections 8.9, 8.10. Ensure that the sign controller is capable of displaying a self-updating time and date message on the sign. Ensure that sign controllers within ground cabinets are rack-mountable, designed for a standard EIA-310 19 inch rack, and include a keypad and display.

781-3.8.3 Display System Hardware: Ensure the sign utilizes a system data interface circuit for communications between the sign controller and display modules. Except for embedded DMS, ensure that the following components reside inside the sign housing: sign controller (master or slave), display system interface circuits, display modules, power supplies, local and remote control switches, LED indicators, Electronic Industries Alliance (EIA)-232 null modem cables (minimum of 4 feet long for connecting laptop computer to sign controller), and surge protective devices.

781-3.8.4 Control Cabinet: Provide a control cabinet that meets the requirements of Section 785-4. Ensure that the minimum height of the cabinet is 46 inches.

Provide a ground control cabinet that includes the following assemblies and components: power indicator, surge suppression on both sides of all electronics, communication interface devices, connection for a laptop computer for local control and programming, a 4 foot long cable to connect laptop computers, a workspace for a laptop computer, and duplex outlets.

Provide for all telephone, data, control, power, and confirmation connections between the sign and ground control box, and for any required wiring harnesses and connectors.

781-3.8.5 Sign Controller Communication Interfaces: Ensure the sign controller has communication interfaces in accordance with NEMA TS4 2005, section 8.7.1. Ensure that EIA-232 serial interfaces support the following:

Data Bits	7 or 8 bits
Parity	Even, Odd, or None
Number Stop Bits	1 or 2 bit

Ensure the sign controller has a 10/100 Base TX 8P8C port or a 100 Base FX port Ethernet interface.

For dial-up operations, acquire and bear the charges of installing and connecting the dial-up telephone line. Provide modems to be retained by the Department at each location. Provide a user-selectable data transmission rate of up to 19.2 kbps for dial-up operations. Ensure that switching between dial-up, Ethernet, and multidrop operation does not require sign controller software or hardware modifications.

Ensure that the TMC or a laptop computer can be used to remotely reset the sign controller.

781-3.9 Message and Status Monitoring: Ensure the DMS provides two modes of operation: (1) remote operation, where the TMC commands and controls the sign and determines the appropriate message or test pattern; and (2) local operation, where the sign controller or a laptop computer commands and controls the sign and determines the appropriate message or test pattern.

Ensure that the sign can perform the following functions:

1. Control Selection – Ensure that local or remote sign control can be selected. Ensure that there is a visual indicator on the controller that identifies whether the sign is under local or remote control.

2. Message Selection – Ensure that the sign controller can select a blank message or any one of the messages stored in the sign controller's nonvolatile memory when the control mode is set to local.

3. Message Implementation – Ensure that the sign controller can activate the selected message.

Ensure that the sign can be programmed to display a user-defined message, including a blank page, in the event of power loss.

Ensure that message additions, deletions, and sign controller changes may be made from either the remote TMC or a local laptop computer. Ensure that each font may be customized, and modifications to a font may be downloaded to the sign controller from the TMC or a laptop computer at any time without any software or hardware modifications.

Ensure that there is no perceivable flicker or ghosting of the pixels during sign erasure and writing periods.

781-3.10 TMC Communication Specification for all DMS: Ensure that the sign controller is addressable by the TMC through the Ethernet communications network using software that complies with the NTCIP 1101 base standard (formerly the NEMA TS 3.2 -1996 standard), including all amendments as published at the time of contract letting, the NTCIP Simple Transportation Management Framework, and conforms to Compliance Level 1. Ensure that the software implements all mandatory objects in the supplemental requirement SR-781-3-1, FDOT Dynamic Message Sign NTCIP Requirements, as published on the FDOT State Traffic Engineering and Operations Office web site at the time of contract letting. Ensure that the sign complies with the NTCIP 1102v01.15, 2101 v01.19, 2103v02.07, 2201v01.15, 2202 v01.05, and 2301v02.19 standards. Ensure that the sign complies with NTCIP 1103v02.17, section 3.

Ensure that the controller's internal time clock can be configured to synchronize to a time server using the network time protocol (NTP). NTP synchronization frequency must be user-configurable and permit polling intervals from once per minute to once per week in one-minute increments. The controller must allow the user to define the NTP server by internet protocol (IP) address.

Provide communications line circuits that are point-to-point or multipoint, and that provide full duplex asynchronous data transmissions at the rate shown in the contract documents or directed by the Engineer.

Assign each sign controller a unique address.

781-3.11 Sign Control Software: Ensure that the sign is provided with computer software from its manufacturer that allows an operator to program, operate, exercise, diagnose, and read current status of all sign features and functions using a laptop computer. Ensure that sign control software provides a graphical representation that visibly depicts the sign face and the current ON/OFF state of all pixels as well as allows messages to be created and displayed on the sign. Ensure that the laptop computer and sign can communicate when connected directly by an EIA-232 cable and via Ethernet. Ensure that the software will allow communication between multiple users and multiple signs across the same communication network.

781-3.12 Sign Support Structure: Meet the requirements of 700-2.4.

781-3.13 Installation Requirements: Provide walk-in DMS for locations over interstate travel lanes. Do not install the sign prior to the availability of electric power. Verify that any

ventilation system incorporated within the sign is operational within 72 hours after sign installation.

Ensure that the location of the lifting eyebolts, left in place or removed, is sealed to prevent water entry after installation.

Load the initial message libraries on both the sign control software and the sign controller. The Engineer will furnish the messages to be placed in these libraries.

781-3.14 Documentation: Provide documentation for electronic equipment in accordance with 603-8.

781-3.15 Licensing: Ensure that the manufacturer grants the Department a license that allows the Department to use and internally distribute any and all sign communications protocols, operating systems, drivers, and documentation.

781-3.16 Technical Assistance: Ensure that a manufacturer's representative is available to assist the Contractor's technical personnel during pre-installation testing and installation.

Do not provide initial power to the sign(s) without the permission of the manufacturer's representative.

781-3.17 Environmental Requirements: The DMS must meet the requirements of NEMA TS4 2005, section 2.

781-3.18 Pre-installation Field Testing: Conduct pre-installation tests on all units at a Contractor-provided facility within the appropriate District. Perform the tests on each unit supplied to verify that no damage was done to any sign during the shipment and delivery process. Notify the Engineer a minimum of 10 calendar days before the start of any tests. Conduct all tests according to the approved test procedures detailed in this section. Each DMS must pass the individual tests detailed below prior to installation.

781-3.18.1 Material Inspection: Examine each DMS carefully to verify that the materials, design, construction, markings, and workmanship comply with all applicable standards, specifications, and requirements.

781-3.18.2 Operational Test: Operate each DMS long enough to permit equipment temperature stabilization, and to check and record an adequate number of performance characteristics to ensure compliance with applicable standards, specifications, and requirements.

781-3.18.3 Pre-installation Test Failure Consequence: If any unit fails, the unit shall be corrected or another unit substituted in its place and the test repeated.

If a unit has been modified as a result of a failure, a report shall be prepared and delivered to the Engineer. The report shall describe the nature of the failure and the corrective action taken.

If a failure pattern develops, the Engineer may direct that design and construction modifications be made to all units without additional cost to the Department or an extension of the contract period.

781-3.19 Installed Site Tests: Conduct an approved, stand-alone equipment installation test at the field site. Test all stand-alone (i.e., non-network) functions of the field equipment using equipment installed as detailed in the Plans and as approved by the Engineer.

Complete approved data forms and turn them over to the Engineer for review and as a basis for rejection or acceptance. Provide a minimum notice of 30 calendar days prior to all tests to permit the Engineer or his representative to observe each test.

If any unit fails to pass its stand-alone test, correct the unit or substitute another unit in its place, then repeat the test.

If a unit has been modified as a result of a stand-alone test failure, prepare a report describing the nature of the failure and the corrective action taken and deliver it to the Engineer prior to re-testing the unit. If a failure pattern develops, the Engineer may direct that design and construction modifications be made to all units without additional cost to the Department or an extension of the contract period.

781-3.20 System Testing: Conduct approved DMS system tests on the field equipment with the master equipment including, at a minimum, all remote control functions. Display the return status codes from the sign controller for a minimum of 72 hours. Complete approved data forms and turn them over to the Engineer for review, and as a basis for rejection or acceptance.

Demonstrate the sign's ability to display the proper predefined message or remain blank when power is restored following an AC power interruption.

If the system test fails because of any subsystem component, repair that component or substitute another in its place, then repeat the test. If a component has been modified as a result of a system test failure, prepare a report and deliver it to the Engineer prior to retesting.

781-3.21 Operational Testing: After the system testing is successfully completed, conduct one continuous 72-hour, full-operating test prior to conducting the 60-day acceptance test. The Engineer will approve the type of tests to be conducted. Include in the tests all control, monitoring, and communications functions of the field equipment by the master equipment.

781-3.22 Acceptance Testing: Conduct a 60-day acceptance test after the successful completion of the approved 72-hour operational test. During the 60-day test period, limit downtime due to mechanical, electrical, or other malfunctions to a maximum total of five calendar days. If the equipment fails to operate for a total of five or more calendar days, testing will be restarted. The Engineer may select to pause and extend the 60-day test period by the number of days lost by failure and repair time in lieu of restarting the full 60-day test. The Engineer will furnish the Contractor with a letter of approval and completion stating the first and last day of the 60-day test period.

781-4 Highway Advisory Radio.

781-4.1 Description: Furnish and install a highway advisory radio (HAR) system having all equipment necessary to record verbal messages from onsite or remote locations, and to continually broadcast live, prerecorded, or synthesized messages.

781-4.2 Materials:

781-4.2.1 General: Provide a HAR system that includes static signage with flashing beacons to notify motorists of active HAR broadcasts. Ensure that all HAR transmitter components are modular and fit in a rack-mounted chassis. Use HAR subsystems and components that are programmable remotely or onsite.

Ensure that the HAR system includes software, hardware and any other component required to fully configure, operate and monitor the HAR field equipment locally and remotely using a personal computer. Use only equipment and components that meet the requirements of these minimum specifications, and are listed on the Department's Approved Product List (APL).

781-4.2.2 Transmitter: Ensure that the transmitter complies with the requirements of Code of Federal Regulations (CFR) Title 47, Section 90.242, "Travelers' Information Stations", and 47 CFR Section 2.901 et seqq. (Part 2, Subpart J), of the Federal Communications Commission (FCC) Rules and Regulations.

Use a transmitter with a power efficiency of 80% or greater. Ensure that the transmitter is adjustable from 0 to 10 watts. Ensure that the transmitter frequency is set at the factory. Ensure that the transmitter parameters can be monitored locally and remotely.

Ensure that the radio frequency (RF) output impedance is 50 ohms and unbalanced.

Ensure that the audio input impedance is 600 ohms and balanced. Ensure that the transmitter module has audio distortion of less than 1.5% for a audio frequency response of 200 Hz to 3.5 kHz.

Provide a transmitter module with indicators or displays for power status, RF power output, and audio modulation level.

781-4.2.3 Digital Recorder and Playback Unit: Ensure that the digital recorder and playback unit can locally and remotely record, store, transmit, and receive digital messages or audio files. Ensure that the digital recorder and playback unit allows operator control by dual tone multi-frequency (DTMF) tones over standard public switched telephone networks (PSTNs) and digital cellular telephone, and digital commands via serial modem. Ensure that the digital recorder and playback unit is FCC certified under Part 68 for dial-up operations.

Ensure that the digital recorder and playback unit can schedule broadcasts, which shall be programmable by the day of the week, month, date, and time. Ensure that the digital recorder and playback unit uses solid state electronics. Do not use floppy disks or magnetic tapes. Use a digital recorder and playback unit with the ability to record and store a minimum of 250 distinct, variable-length messages, and provide a minimum of 14 minutes of recorded message time.

Ensure that the digital recorder and playback unit has access to, and command and control of, the remote flashing beacon controller.

Ensure that the digital recorder and playback unit is password protected and has an input source indicator. Ensure that the digital recorder and playback unit can simultaneously record and playback messages. Ensure that the digital recorder and playback unit can retain messages indefinitely, in the event of a power loss, and not require a battery. Ensure that the digital recorder and playback unit has built-in voice prompts.

781-4.2.4 Transmitter Synchronizer: Ensure that multiple HAR transmitters broadcasting the same message are synchronized. Ensure that the synchronization eliminates interference and audio distortion within possible overlapping areas.

Provide a global positioning system (GPS) receiver for audio synchronization and frequency synchronization. Provide a minimum of eight channels in the transmitter synchronizer module. Ensure that the accuracy of the module is within 45 nanoseconds at 10 MHz reference.

781-4.2.5 Antenna Assembly: Provide an antenna assembly with hardware and cables to mount the antenna as shown in the plans. Use either a vertical monopole, which propagates omnidirectional radio waves in a circular pattern, or a directional array that propagates radio waves in a noncircular shape, according to the plans.

Use an antenna that can be tuned to the transmission frequency either mechanically or electronically. Tune the antenna to the same frequency as the transmitter.

781-4.2.6 Ground Plane: Install system grounding components in accordance with 785-1 or as shown in the plans. Use a minimum of American Wire Gauge (AWG) #20 wire for any radial ground planes. Install these wires extending outward from the base of the antenna,

at a minimum of 6 inches below ground, forming a circular pattern with a radius of 30 to 100 feet.

781-4.2.7 Surge Protective Devices: Install surge protective devices between the transmitter and the antenna. Ensure surge protective devices meet the requirements of Section 785-2.

781-4.2.8 HAR Sign and Flashing Beacons: Provide roadside signs with flashing beacons that are activated when the associated HAR system is transmitting. Ensure that the HAR sign conforms to the FDOT Standard Index for Special Sign Details pertaining to highway advisory radio.

Provide 12-inch beacons that comply with Section 650, along with controller, communications, power and material needed to provide a fully functioning flashing beacon system. Ensure that the flashing beacons use a NEMA-rated flasher circuit. Ensure that the flashing beacons can be operated locally and remotely.

781-4.2.9 Power System: Provide a solar or AC power system as shown in the plans. Provide a power distribution system, for both solar and AC powered sites, that includes automatic battery charging circuitry. Ensure that battery chargers prevent overcharging and provide a means of battery disconnection and isolation.

Provide external AC power supply module with backup batteries as shown in the plans. Ensure that AC powered systems utilize 120 volts of alternating current (V_{AC}) nominal input voltage. Ensure that the HAR operates from 89-135VAC with a frequency of 60 +/-3 Hz. Provide batteries that can continuously operate the HAR system at full power for a minimum period of three days without an external power source. Ensure that loss of AC power to the system does not interrupt HAR transmissions.

Provide a solar power supply module, as shown in the plans, with photovoltaic array and battery storage system to operate the HAR system continuously at full power for a minimum period of three days without sunlight. Verify that the system's solar panels are compliant with the International Electrotechnical Commission (IEC) requirements detailed in the IEC 61215 standard. Verify that the DC output power specifications are a nominal 13.6 volts of direct current (V_{DC}) at 5 amps, with a maximum of 15 V_{DC} and a maximum of 10 amps.

Provide 12 volt batteries that are rated at a minimum of 180 Ah, are deep cycle, and maintenance-free.

Provide an accessible attachment point that allows connection of a portable generator for emergency power.

781-4.2.10 Control Cabinet: Provide a control cabinet for housing the transmitter, digital recorder and playback unit, transmitter synchronizer, power, surge suppressors, and flashing beacon controller, as shown in the plans. Ensure that cabinets meet NEMA 3R requirements for aluminum enclosures and conform to Section 676. Use a cabinet that is constructed of aluminum alloy 5052-H32 measuring 0.125 inch thick.

781-4.2.11 Performance Requirements: Furnish a HAR system that is compatible with the current version of the Department's SunGuide® Software System.

Ensure that the system has a text-to-speech capability for converting typed words to audio files. Ensure that the system logs the status of all devices. Ensure that the operator is able to record, edit, and delete messages, and to select desired messages for broadcast. Ensure that the system maintains event schedules, diagnostic information, and logs of messages that have been downloaded and played, along with the date and time that a message

was activated for each HAR. Ensure that the HAR system provides system failure remote alarms and indicates system status in the user interface.

781-4.2.12 Environmental Specifications: Ensure that the HAR system installed at the field site is able to withstand temperatures between -29° and 165°F as per the NEMA TS 2 standard at 95% noncondensing humidity. Ensure that the HAR system meets the requirements specified in the Plans Preparation Manual for wind loading.

781-4.3 Installation Requirements: Install all HAR equipment according to the manufacturer's recommendations or as directed by the Engineer.

Obtain all required licenses to operate the HAR as per FCC requirements using the services of the HAR manufacturer. Perform all necessary on-site testing to select the clearest and most appropriate operating frequency for all HAR transmitters at the proposed locations. Submit the results of the frequency search, testing, and the recommended frequency selection to the Engineer for approval prior to application for FCC licenses.

Provide all utility coordination, power design and power service installations to obtain power for the HAR and flashing beacon sites.

Ensure that any public network connections (PSTN, cellular, or other connections) used for system interconnect are approved by the Engineer.

781-4.4 Testing: Subject the equipment covered by these specifications to design approval tests (DATs) and field acceptance tests (FATs). Develop and submit a test plan for DATs and FATs to the Engineer for consideration and approval.

The Engineer may accept certification by 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.

The Engineer reserves the right to witness all DATs and FATs. Complete the tests within five calendar days.

Ensure that the test plans demonstrate each and every feature available in the device or system under test and includes the tests discussed below.

781-4.4.1 Stand-Alone Tests: Perform the following stand-alone tests on the HAR, after all equipment has been installed and initial adjustment is complete at the field site.

781-4.4.1.1 Ground Plane Resistivity: Conduct ground plane resistivity measurements as required in 785-1.

781-4.4.1.2 Transmitter: Perform field measurements to verify compliance with 47 CFR Part 90.242. Document the location and results of field measurements and submit them to the Engineer.

781-4.4.1.3 Digital Recorder and Playback Unit: Demonstrate the correct operation of each function of the digital recorder and playback unit at the field site using the display screen. Verify the test message is received on a vehicle radio set to the approved transmitter frequency and located within the coverage area of the HAR transmission.

781-4.4.1.4 Battery System: Verify that the charged batteries can run the HAR system for the number of days as advertised by the manufacturer.

781-4.4.2 System Tests: Conduct approved HAR system tests on at least one HAR system, including the operations center, one sign and flashing beacon, and one transmitter. Perform, at a minimum, all remote control functions. Complete approved data forms and turn them over to the Engineer for review, and as a basis for rejection or acceptance.

If the system test fails because of any subsystem component, correct that component or substitute another in its place, then repeat the test. If a component has been modified as a result of a system test failure, prepare a report and deliver it to the Engineer prior to retesting.

781-4.4.2.1 Digital Recorder and Playback Unit: Test the remote loading of the messages on digital recorder and playback unit and verify the quality of voice broadcasted. Load 14 minutes of messages and demonstrate different sequences of playback. Test the message loading from a remote location using cellular telephone, standard analog telephone line and digital commands via serial modem.

781-4.4.2.2 Transmitter Synchronization: If multiple HARs are deployed, test that a clear signal is obtained in the signal influence region that is free of interference caused by synchronization faults.

781-5 Road Weather Information System.

781-5.1 Description: Furnish and install a road weather information system (RWIS) as shown in the plans.

781-5.2 Materials: Provide an RWIS consisting of environmental sensor stations (ESS) installed at specified locations. Provide an ESS as shown in the plans that includes environmental sensors mounted on an approved structure (typically a concrete pole), other sensors mounted in the roadway, and a remote processing unit (RPU) at the base of the structure. Ensure that the RPU can collect, store, and process sensor data to describe current weather conditions.

Provide any ancillary equipment or incidental items required, including mounting hardware, power supplies, grounding, surge protection devices, and communication equipment, at each ESS location to make a complete and fully operational RWIS. Ensure that the system provides real-time, accurate, reliable data on all system parameters to the degree of precision defined in this specification.

Ensure all assembly hardware, including nuts, bolts, external screws and locking washers less than 5/8 inch in diameter, are Type 304 or 316 passivated stainless steel and meet the requirements of ASTM F 593 and ASTM F 594. All assembly hardware greater than or equal to 5/8 inch in diameter must be galvanized and meet the requirements of ASTM A 325.

781-5.2.1 Sensors: Provide an RWIS that can collect and store data from various sensors including, but not limited to:

1. Roadway sensors located in or under the pavement.
2. Atmospheric sensors.

Ensure that all RWIS sensors and other field equipment are made of UV, heat, and corrosion resistant materials

Provide ultrasonic anemometers and other sensors that are electronic devices which do not rely on moving parts to create electrical signals for processing.

781-5.2.2 Sensor Performance: Each environmental sensor and its associated transducers shall record the following attributes to the listed degree of accuracy:

Roadway Data		
Surface Temperature	±0.36° F between -40° and 176° F	
Precipitation	Type:	Dry, wet at >32° F; wet at <32° F; frozen, frost and dew

	Percent of Ice:	From 0 to 100%
	Depth/Amount:	From 0 to 0.5 inch
Atmospheric Data		
Temperature	±1° F between -40° and 176° F; resolution of 0.1 degree	
Relative Humidity at 70° F	±5% between 10 and 100%	
Barometric Pressure	Accurate to ±0.02 inch of mercury (in. Hg) between 27.2 and 31.9 in. Hg; resolution of 0.005 inches Hg	
Precipitation	Type:	Light rain, rain and ice
	Intensity:	±20% between 0.02 to 200 inches per hour
	Visibility:	±10% from 0.005 to 1 mile
Wind	Direction:	±3 degrees between 0 and 360 degrees
	Speed:	±3% between 0 and 120 mph

Ensure that pavement sensors function as specified above when installed at a maximum of 2,000 feet from the RPU.

781-5.2.3 ESS: Install an ESS having the sensors necessary to collect, store, and transmit the following data:

1. Roadway data, including:
    A) Temperature
    B) Surface data that includes ice and precipitation depth/amount.
2. Atmospheric data, including:
    A) Temperature
    B) Relative humidity
    C) Barometric pressure
    D) Precipitation data that includes type and intensity
    E) Visibility as affected by fog, smoke, or a combination thereof
    F) Wind data, including direction and average speed

781-5.2.4 Communications: Use an RPU capable of transmitting all collected data to the transportation management center (TMC) using the National Transportation Communications for ITS Protocol (NTCIP). Ensure that the RWIS field station supports EIA 232/485 serial communication, TCP/IP, and UDP/IP.

Ensure that all communications, including those between sensors and the RPU, are nonproprietary and compatible with the Department's SunGuide® Software System.

781-5.2.5 Remote Processing Unit:

The RPU shall store a minimum of 24 data records. Each data record will include sensor readings of a user-defined time interval of up to 5 minutes.

Ensure that the RPU operates using a nominal input voltage at the cabinet of 110 to 120 V_{AC}, and also be capable of operating on 12 V_{DC} of solar battery power. The RPU shall issue an alarm to the TMC if the AC power supply is low or if there has been a complete power loss. Ensure that the system sends a message when the unit returns to normal conditions.

781-5.2.6 RPU Enclosure: Use a cabinet listed on the APL to house and protect the RPU and all field electronics associated with the RWIS.

781-5.2.7 RWIS Software: Ensure that the RWIS software enables the system operator to derive environmental measurements, such as the dew point, wind chill, and heat

index, from sensor data received. Ensure that the RWIS software can be used to report minimums, maximums, averages, cumulative values, and standard deviations for all data over a prescribed time period.

Ensure that the RWIS software provides English-to-metric unit conversions, when applicable, and lets the operator choose which unit of measure to report if more than one unit is common for a particular measurement.

When the software supplied with the RWIS is installed on a laptop computer or a remote workstation, ensure that the operator is able to access, either remotely through the workstation or at the site with the laptop computer, all user-defined parameters and stored data within the RPU, including the ability to view, download, and delete stored data.

781-5.2.8 Electrical Specifications: Provide RWIS equipment and components installed at the ESS that operate at 110 to 120 V_{AC} from a commercial utility company or, alternatively, 12 V_{DC} from a solar-powered or battery-powered system. In cases where the ESS are mounted on the Department's MAS towers, ensure that the devices can utilize the 48 V_{DC} power supply available at the site.

Ensure that solar- and battery-powered units operate continuously for 14 days without requiring battery recharging. Provide an appropriate means of conversion for any device that requires a different power source.

Equip each ESS installation with provisions for emergency backup power in the event of primary power loss. Ensure that backup power is capable of continuing the ESS' operations for a minimum of 12 hours.

781-5.2.9 Foundation and Tower Specifications: Provide a supporting tower or pole as shown in the plans. Ensure the tower or pole provides a mounting platform for atmospheric sensors free of influences from topography, buildings, and vehicles. Ensure that the tower also supports any lightning protection devices (e.g., grounding rods) for the site. Provide a support structure that is self-supporting without guy wires, using a 50-year design life, and in accordance with the current Structures Manual.

If the field site is solar powered, ensure that the structure provides the mounting platform for the solar array and the control cabinet that houses the battery bank and charger.

Place a concrete work pad measuring 4 feet wide by 3 feet long by 4 inches deep in front of the RPU control cabinet if the cabinet is ground mounted. Construct the pad using concrete meeting the requirements of Section 347.

781-5.3 Applicable Standards: Ensure that the RWIS complies with all applicable standards from the National Weather Service.

Ensure that the RWIS complies with the latest revisions of all applicable NTCIP standards, including NTCIP-1201 and NTCIP-1204. Ensure that all RWIS field equipment complies with the environmental requirements of section A615 of the MSTCSD.

781-5.4 Installation Requirements: Ensure that all equipment and materials furnished, assembled, fabricated, or installed are commercial off-the-shelf products.

Unless detailed otherwise in the plans, mount all atmospheric sensors except anemometers at cabinet-top height, approximately 10 feet above grade. Mount anemometers at the top of the tower or as shown in the plans. Locate pavement sensors as shown in the plans.

Install all wiring so that it is either internal to a pole or in conduit.

Install all buried lead-in cable to pavement sensors in conduit.

Mount all roadway sensors flush with the roadway surface.

781-5.5 Testing: Utilize a testing procedure that includes a remote field sensor and RPU test, a remote-to-central communication test, and a systems operational test. Conduct the following tests and submit the results to the Engineer:

1. Perform and document laboratory tests verifying proper sensor calibration.
2. Calibrate instrument alignment with true north.
3. Furnish sensor calibration protocols and adjustment procedures.
4. Verify and ensure that sensors are reporting proper field data.
5. Detail regular site maintenance procedures and calibration training.
6. Provide block diagrams, schematics, catalogs, and line drawings.
7. Program source codes in both printed and digital form.
8. Verify proper orientation of wiring and cabling.
9. Ensure that above-ground conduit is straight, neat, and properly secured.
10. Verify that the grounding system is installed per the requirements of 785-2.

Subject the RWIS to a 30-day observation period, during which time the Contractor shall perform any and all maintenance, recalibration, and data verification required by the Engineer.

Certify anemometers by wind tunnel tests. Submit test results to the Engineer for review and approval. Upon request, furnish independent laboratory testing documentation certifying 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 device to be attached.

Perform local field operational testing at each RWIS field site according to the test plans detailed in this section. After the environmental sensor and RPUs, and other RWIS hardware, power supplies, and connecting cables have been installed, perform the following:

1. Verify that physical construction has been completed as specified in the plans.
2. Inspect the quality and tightness of ground and surge protector connections.
3. Check power supply voltages and outputs.
4. Connect devices to the power sources.
5. Verify installation of specified cables and connections between the environmental sensor and RPUs, and the control cabinet.
6. Test local operation of all environmental sensor and RPU components.

Deliver a summary test report and a copy of all test results to the Engineer for approval. Include documentation of any discrepancies found during testing, along with environmental sensor and RPU serial numbers. Include assembly installation locations and successful test completion dates.

781-6 Guaranty Provisions.

Ensure that the DMS and HAR systems and equipment furnished have a manufacturer's warranty covering defects in assembly, fabrication, and materials for a minimum of five years from the date of final acceptance by the Engineer in accordance with 5-11 of all the work to be performed under the Contract.

Ensure that the RWIS equipment and components furnished have a manufacturer's warranty covering defects in assembly, fabrication, and materials for three years from the date of final acceptance by the Engineer in accordance with 5-11 of all the work to be performed under the Contract.

If the manufacturer's warranties for these systems and components are for a longer period, those longer period warranties will apply.

Ensure that the manufacturers' warranties on DMS, RWIS, and HAR systems are fully transferable from the Contractor to the Department. Ensure that these warranties require the manufacturer to furnish replacements for any part or equipment found to be defective during the warranty period at no cost to the Department within 10 calendar days of notification by the Department.

781-7 Method of Measurement.

Measurement for payment will be in accordance with the following work tasks.

781-7.1 Furnish and Install: For DMS, the quantity to be paid for will be each sign furnished, installed, complete in accordance with the details shown in the plans, warranted, made fully operational, and tested in accordance with the specifications in this section.

For DMS Support Structure, the quantity to be paid for will be each structure furnished, installed, complete in accordance with the details shown in the plans; including posts and supports, catwalks, handrails, footings, excavation, site grounding, painting, and incidentals necessary to complete the work.

The Contract unit price for each HAR system, furnished and installed, will include furnishing, placement, and testing of all materials and equipment, and for all tools, labor, equipment, hardware, operational software package(s) and firmware(s), supplies, support, personnel training, shop drawings, documentation, and incidentals necessary to complete the work.

The Contract unit price for an RWIS at each field location, furnished and installed, will include furnishing, placement, and testing of all materials and equipment, and for all tools, labor, equipment, hardware, operational software package(s) and firmware(s), supplies, support, personnel training, shop drawings, warranty documentation, and incidentals necessary to complete the work.

781-7.2 Furnish: The Contract unit price per each DMS, HAR or RWIS system, furnished, will include all equipment specified in the Contract Documents, plus all shipping and handling costs involved in delivery as specified in the Contract Documents.

781-7.3 Install: The Contract unit price per each DMS, HAR or RWIS system, installed, will include placement, and testing of all materials and equipment, and for all tools, labor, equipment, hardware, operational software package(s) and firmware(s), supplies, support, personnel training, shop drawings, documentation, and incidentals necessary to complete the work. The Engineer will supply the equipment specified in the Contract Documents.

781-8 Basis of Payment.

Price and payment will be full compensation for furnishing all materials and completing all work as specified in this section or shown in the plans.

Payment will be made under:

Item No. 781-2	Highway Advisory Radio System – each.
Item No. 781-3	Road Weather Information System – each.
Item No. 781-4	Dynamic Message Sign – each.
Item No. 781-5	Dynamic Message Sign Support Structure – each.