

Special Specification 6407

Full Color LED Variable Message Sign System



1. DESCRIPTION

Furnish and install full color matrix Light Emitting Diode (LED) Variable Message Signs (VMS) with nominal 18 in. tall characters. With each color VMS, furnish and install equipment cabinet with VMS controller at the base of the sign's support structure. Provide manufacturer approved end user training.

In the case of conflicts between standards and specifications, the latest State of Texas and Department standards and specifications will govern.

2. MATERIALS

2.1. **General Requirements.** All materials furnished, assembled, fabricated, or installed under this Item must be new, corrosion resistant, and in strict accordance with this item and the pertinent requirements of the following:

- NEMA TS 4, latest edition,
- Tx DOT Special Specification "Intelligent Transportation System (ITS) Ground Mounted Cabinet,"
- Tx DOT Special Specification, "Installation of Dynamic Message Sign System," for installation,
- Tx DOT Special Specification "Testing, Training, Documentation, Final Acceptance, and Warranty," and
- vendor must be ISO 9001 registered.

Furnish at least 4 licensed copies of vendor software on Department laptops for each VMS, ensuring at least one CD, DVD, or electronic copy is delivered, should the licensed copy need to be reinstalled. Any auxiliary software needed for execution or diagnostics will be supplied by the vendor.

Ensure that all materials and construction methods, necessary to complete the installation, conform to the requirements of the Item, the plans, and the pertinent requirements of the following items.

- Item 432, "Riprap"
- Item 441, "Steel Structures"
- Item 445, "Galvanizing"
- Item 449, "Anchor Bolts"
- Item 618, "Conduit"
- Item 620, "Electrical Conductors"
- Item 656, "Foundations for Traffic Control Devices"

Ensure that the sign displays symbols, graphics, and character fonts approved for VMS use by the TMUTCD and its accompanying reference documents.

Furnish the following equipment at each VMS field site shown on the plans.

- Full Color LED VMS, capable of rear mounting onto sign supports specified on TxDOT Standard Details MDM, OSB, COSS, and DMS latest versions.
- Sign Controller with software, NTCIP compliant.
- VMS mounting brackets and hardware.
- Electrical power connectors at VMS and controller, as specified by the VMS manufacturer.
- Telecommunications cabling and connectors between VMS and controller as specified by the VMS manufacturer when required.

- Power and communication cabling and connectors from controller to VMS must follow NEMA TS4, Section 4, "Controller to Sign Interface."
- Communications as shown on the plans.
- VMS cabinet (ground mount) and electronics.
- Documentation.
- All incidentals required for installing a VMS sign.

2.2.

Dynamic Message Sign. Ensure that the full color matrix LED VMS meets the following requirements:

- The color LED VMS should enable the display of text consisting of a string of alphanumeric and other characters.
- Each character must be formed by a matrix of luminous pixels.
- All display elements and modules should be solid state.
- No mechanical or electromechanical elements or shutters should be used.
- The configuration details of signs described by this specification can be seen in Table 1 below.

Table 1

Sign Type	Front Access
Matrix Type	Full
LED - Type	All InGaP Red LEDs InGaN Blue LEDs InGaN Green LEDs
LED Color – Wavelength	Red – 618-630 nm Blue – 440-480nm Green – 519-539nm
LED Viewing Angle	30°
LED Pixel Brightness	12,400cd/m ² minimum white brightness
Pixel Pitch	20 mm

2.2.1.

Physical Characteristics.

2.2.1.1.

General Construction. Equipment design and construction must use the latest available techniques with a minimum number of different parts, subassemblies, circuits, cards, and modules to maximize standardization and commonality. The equipment should be designed for ease of maintenance. All component parts must be readily accessible for inspection and maintenance. Test points must be provided for checking essential voltages.

Securely clamp cables in sign housings with cable attachments. Do not use adhesive attachments.

Ensure performance of the signs will not be impaired due to continuous vibration caused by wind, traffic, or other factors. This includes the visibility and legibility of the display.

Ensure the presence of power transients or electromagnetic fields, including those created by any components of the system, will have no deleterious effect on the performance of the system. Ensure the system does not conduct or radiate signals, which will adversely affect other electrical or electronic equipment including, but not limited to, other control systems, data processing equipment, audio, radio, and industrial equipment.

2.2.1.2.

Lift-Face Housing. The lift-face housing dimensions and total sign weight not to exceed 1,500 lb. will be as shown in the VMS Manufacturer's specification or on the plans.

The sign housing skin will be constructed of aluminum alloy 5052-H32 which must not be less than 1/8" thick, unless otherwise specified in this document. Framing structural members must be made of a aluminum alloy 6061-T6.

The equipment within the sign housing should be protected from moisture, dust, dirt, and corrosion. The lift-face housing must meet NEMA 3R enclosure criteria as defined in NEMA Standards Publication 250, "Enclosures for Electrical Equipment (1000 Volts Maximum.)"

To prevent open doors from blowing in wind, they must have a retaining latch mechanism to hold the door open at a 90° angle.

Design the sign and attached support elements to withstand design wind loads without permanent deformation. All sign types and attached support elements will be designed to withstand a 3-sec. gust Basic Wind Speed of 140 mph, a gust factor of 1.14, and the AASHTO specified wind importance factor for the 50-yr. mean recurrence interval for non-hurricane regions of 1.0 (in accordance with the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, 6th Edition (2013.)) Front face will have black finish with an outdoor service life of 20 yr. Sign face will provide a high-contrast appearance for the display. Mask (if used) will contain an opening for each pixel.

There will be no exposed fasteners or welds on the housing face.

The bottom panel of the housing must have a minimum of four drain holes, with snap-in, drain filter plug inserts, in each section formed by internal structural members. Water drain filter plug inserts will be replaceable. Weep holes and ventilation or exhaust hoods must be screened to prevent the entrance of insects and small animals.

The housing must be designed to accommodate mounting on the rear vertical plane.

- 2.2.1.3. **Surface Finish.** The face (lens panel aluminum mask) will be finished with a matte-black, licensed-factory-applied, KYNAR 500 Resin, fluoropolymer-based coating system or coated with semi-gloss black polyvinylidene fluoride (PVDF) applied in accordance to American Architectural Manufacturers Association (AAMA 2605.) The face should be uniform in appearance and completely free from distortion, gouges, and any other flaws or defects. A certification must be required from the licensed-factory KYNAR 500 coater for all aluminum face materials.

All other exterior surfaces will be a natural aluminum mill finish. No painted surfaces will be allowed.

All interior surfaces will be a natural aluminum mill finish.

- 2.2.1.4. **Exterior Skin.** The exterior skin of the housing will be 5052-H32 aluminum alloy sheet 0.125 in. minimum thickness.

The number of seams should be kept to a minimum. All exterior seams and joints must be sealed to form a rain and weather tight enclosure.

The skin material must be stitch welded to the internal structural members to form a unitized structure.

- 2.2.1.5. **Mounting.** The exterior mounting assemblies must be 6061-T6 aluminum alloy extrusions, 3/16-in. minimum thickness.

- 2.2.1.6. **Lens Panel Assembly.** The Lens Panel Assembly must consist of a KYNAR 500 coated aluminum mask over a clear glazing. The aluminum mask must be laminated and sealed to the surface of the glazing using the 3M Scotch VHB joining system or pre-approved equivalent.

- 2.2.1.7. **Lens Panel Aluminum Mask.** The Lens Panel Aluminum Mask will be:

- 0.063 in. minimum thickness;
- finished with a matte-black, licensed-factory-applied, KYNAR 500 Resin, fluoropolymer-based coating system; and
- perforated to provide an aperture for each pixel on the display modules. Each aperture should be as small as possible without blocking the LED light output at the required viewing angle.

- 2.2.1.8. **Sign Display.** The face panel clear glazing (if used) should be 90% UV opaque, non-breakable, polycarbonate, or equivalent, minimum 1/8 in. thick, and clear in color. Laminate and seal the glazing to the inside surface of the lens panel.

The sign face must not be subject to fogging, frost, and condensation. If an automatically controlled system is used to keep the front face panel free of fog, frost, and condensation, provide ability for monitoring and control by the sign controller. Heat generated by the system should not damage any part of the VMS.

2.2.2. **Environmental Control.**

- 2.2.2.1. **Ventilation.** The ventilation system must be a positive-pressure, filtered, forced-air system which cools both the display modules and the sign housing interior. Signs with negative pressure systems that use exhaust fans are not acceptable.

The ventilation system must provide a minimum of 2 sign housing volume air changes per minute at the pressure drop developed throughout the entire ventilation system.

The inlet and exhaust filters must be electrostatic and must be sized to properly accommodate the air flow and pressure drop requirements of the ventilation system. Filters should be easily removable from within the sign housing without the use of tools. Both inlet and exhaust must use environment-friendly, washable, and reusable electrostatic filters.

The VMS will contain an electronically controlled ventilation system and a failsafe thermostat to keep the internal VMS air temperature lower than +60°C, when the ambient outdoor temperature is +46°C. There must be a minimum of one sensor located near the middle of the sign housing interior. There must be an additional temperature sensor located to accurately measure the ambient temperature outside the sign housing. The temperature sensors should have an accuracy of +/- 1.5°C and a range from -40° to +74°C.

The temperatures from the sensors must be continuously measured and monitored by the sign controller. A temperature reading greater than a user selectable critical temperature should cause the sign to go to blank and the sign controller must report this action to the central controller. This user selectable critical temperature must be capable of being changed by the central controller or laptop computer. The central controller and laptop computers should have the ability to read temperature measurements from the sign controller.

The LED modules and electronic equipment must be protected by a fail-safe, back-up fan control system in the event of an electronic fan control failure or shutdown of the sign controller. The housing must be equipped with a thermally-controlled back-up system that will activate the ventilation system automatically if the temperature inside the housing exceeds a pre-set limit.

- 2.2.2.2. **Temperature and Humidity.** Provide signs and associated field electronics that satisfy at a minimum Section 2.1.5 "TEMPERATURE AND HUMIDITY" of the NEMA TS 4, latest revision.

The enclosed housing with fans must meet the following requirements:

- provide positive air ventilation system with intake fans;
- fans with permanently lubricated ball or roller bearings;
- fans must allow user configured on- and off-temperature settings; and
- adequate air flow should be automatically tested once per day from Lonestar™. Inadequate air flow will cause an error message to be sent to the central control software.

2.3. **Optical and Electrical Requirements.**

- 2.3.1. **LED and Pixel Characteristics.** The LEDs should be AlInGaP or InGaN, Precision Optical Performance T 1-3/4 diodes. The LEDs must be rated for 100,000 hr. continuous operation while maintaining a minimum of 50% of the original brightness or less than 30% lumen depreciation. The LEDs will have standoff heights that hold the base of the LEDs off the printed circuit board to promote cooling of the LEDs. Through-hole LEDs

mounted flush to the printed circuit board are not acceptable. Surface-mount LEDs are not acceptable. The LED brightness and color bins that are used in each pixel will be provided to the engineer for approval. Certification must be provided, with the submittals, from the LED manufacturer that demonstrates that the LEDs were tested.

The LEDs in each pixel must be clustered to maximize long range visibility. All pixels will have equal color and on-axis intensity. All pixels in all signs in this project, including the spare parts, will have equal color and on-axis intensity. The method used to provide the equal color and intensity, as stated above, must be included in the submittals and approved.

The pixel strings should be powered from a regulated DC power source and the LED current must be maintained at a current level to maximize life of the pixel. The failure of an LED in one string within a pixel should not affect the operation of any other string or pixel.

The LEDs must be individually mounted directly to a printed circuit board and should be easily replaceable and individually removable using conventional, electronic repair methods.

2.3.2. **Display Module and Driver Boards.** Each display module consists of a display board with a matrix of LED pixels. The pixels are mounted on the front side of the display module.

The driver board connects to the sign interface circuits and passes information to the associated display modules, which control the character pixels. The driver board must receive control signals and display data from the sign controller. The display module must contain the control and memory elements and provide the signals to switch and read the LED pixels.

The driver boards must connect to a single control cable common to each line of display modules.

The LED display board must contain all LEDs required to form a matrix of pixels. Pixels should be arranged uniformly to display a dot-matrix character of the desired height and width. The height of a standard character will be defined as the distance from the lowest point of the lowermost pixel of the character to the highest point of the uppermost pixel of the character. Smaller characters are not acceptable.

The display modules should be rectangular and have an identical horizontal and vertical pitch between pixels.

The separation between the last column of one module and the first column of the next should be equal to the horizontal distance between the columns of a single display module.

The separation between the last row of one module and the first row of the next must be equal to the horizontal distance between the rows of a single display module.

All LEDs must be individually and directly mounted to the LED circuit board to form the LED display board. The LED display board should support the driver board.

All LEDs must be mounted so that their mechanical axis is normal $\pm 1.00^\circ$ to the face of the sign to ensure brightness uniformity over the face of the sign.

Design modules, such that failure of one or more pixels, does not affect the operation of other pixels. Ensure failure of any module does not affect the operation of other modules.

Conformal coat Printed Circuit Boards (PCB) with a minimum 0.005 in. (5 mil) thick silicone resin or a cylic resin conformal coat. Use coating material that complies with military specification MIL-I-46058C Type SR and IPC-CC-830.

Each LED driver board will be microprocessor-controlled and will communicate with the sign controller on a wire or fiber optic communication network using an addressable network protocol. The microprocessor will

process commands from the sign controller to display data, perform diagnostic tests, and report pixel and diagnostic status.

- 2.3.3. **Display Assembly.** Each display module must include an LED display circuit board. A single data exchange and addressing cable must connect the driver board to the LED boards it controls that are not directly attached to the driver board. The driver board must contain the solid-state electronics necessary to control pixel data and read pixel status.

All LED boards and driver boards should be fully interchangeable and must not require any manual addressing switches or a adjustment when interchanged or placed in service.

The display modules must be mounted to the display face in a manner that facilitates easy and rapid removal of each display module without disturbing adjacent display modules. Replacement of a complete display module should be possible without the use of any tools.

- 2.3.4. **Legibility.** The characters should be legible under all light conditions at a distance of 350 ft. within the degree cone of vision centered around the optical axis of the pixel. The cone perimeter will be defined by its 50% intensity points.

The sign must be the proper brightness in all lighting conditions for optimum legibility.

It must be bright enough to have a good target value, but not to the point where the pixels bloom, especially in low ambient light level conditions.

The brightness and color of each pixel should be uniform over the entire face of the sign within the cone of vision from 350 ft. to 50 ft. in all lighting conditions. Non-uniformity of brightness or color over the face of the sign under these conditions will be cause for rejection of the sign.

The sign and its controller must meet a minimum Section 8.8 "BRIGHTNESS CONTROLS" of the NEMA TS 4, latest revision. The controller should monitor and self-adjust the brightness of the display. Ensure brightness is manually and automatically adjustable from the local sign controller. Enable brightness control to be set to specific levels from the sign controller (local,) laptop (remote,) and Lonestar™ (central) software.

- 2.3.5. **Characters Displayed.** The signs must be capable of displaying ASCII characters 32 through 126 (including all upper and lower-case letters and digits from 0 to 9) at any location in a message line. If shown on the plans, a special graphics character should be substituted for any of these characters.

The sign should normally display double stroke (11 X 7) characters with triple-column spacing between characters. The spacing options should be one, two, or three pixel columns. Each font may be edited and downloaded to the sign controller from the central controller or laptop computer at any time without any software or hardware modifications.

The sign must have the capability to display automatically-scaled character fonts applied to a given message to maximize the font size of the displayed text, up to the full height of the display for a single line of text.

Full matrix VMS capable of displaying 3 rows of 18 in. tall characters, displaying 8 characters on each row. Color sign with a minimum of 224 pixel columns and 96 pixel rows. Pixel pitch must be 20 mm.

- 2.3.6. **LED DC Power.** The voltage to the LED modules and associated electronics must not exceed 25 VDC. The power supplies should have a minimum efficiency of 85% with a minimum power factor rating of 0.95.

The power supplies will be wired in a redundant configuration, that uses multiple supplies for the display matrix or paralleled in a diode OR configuration and supply enough power to run 100% of all pixels at 100% duty cycle. Functioning supplies must current-share to within 10%.

The power supplies used to power the LED pixel modules must be identical and interchangeable throughout the VMS.

Power supplies will be UL listed and have an application of coating to protect from the environmental elements.

- 2.3.7. **Photoelectric Sensor Devices.** Three photocells must be installed in the sign. These devices should permit automatic light intensity measurement of light conditions at each sign location. These photocells must be mounted in a manner to measure front, rear, and ambient light conditions.

Automatic adjustment of the LED brightness should occur in small enough increments so that the brightness of the sign changes smoothly, with no perceivable brightness change between adjacent levels. Provision must be made to prevent perceivable brightening of the sign due to stray headlights shining upon the photo sensors at night.

There should be a means to adjust how rapidly the sign responds to changes in ambient light as measured by the photocells. This can be used, for example, to prevent the sign from changing its brightness due to a vehicle's headlight momentarily shining on the sign. The adjustment must be made from the central controller or laptop computer and should have two different settings, one for daytime control and one for nighttime control, with the day or night ambient light threshold also being an adjustable value. In addition, there should be a means to specify different weighting factors for each photocell, to specify how prominently each photocell figures in the calculation of nighttime ambient light.

- 2.3.8. **Power.** The sign and its sign controller must be capable of operating with 120/240 VAC, 20 A per leg maximum, 60 Hz, single-phase power. The sign controller cabinet must be capable of distributing power to 2 separate VMS's.

Inside the sign housing, all 120 VAC service lines must be independently protected by a thermo magnetic circuit breaker at the sign housing entry point. All 120 VAC wiring must be located in conduit, pull boxes, raceways, or control cabinets as required by the latest version of the National Electric Code (NEC). No 120 VAC wiring must be exposed to the inside or outside of the sign housing. The sign housing should not be considered as a raceway or control cabinet.

The presence of power transients or electromagnetic fields, including those created by any components of the system, will have no deleterious effect on the performance of the system. The system must not conduct or radiate signals which will adversely affect other electrical or electronic equipment including, but not limited to, other control systems, data processing equipment, audio, radio, and industrial equipment.

The system power and communication lines should be protected by transient voltage suppression devices including MOVs and spark gap arrestor.

The efficiency of the power supply must be 80% or greater when operated at 50% to 100% of maximum load. The power supply should have a power factor of 0.95 or greater at operating voltage from 50% to 100% of maximum load.

A minimum of 2 power supplies must be provided for redundancy. Power supplies should be designed such that if one supply fails, the remaining supply must be able to operate 100% of the pixels at full brightness. Supply 50%, 80%, and 100% full-load calculations for Volt-Amps-Reactive (VARs) and Volt-Amps (VA) loads consumed by VMS sign, operating at 120 VAC.

The sign controller must monitor and report to Lonestar™ the output voltage and functional status of regulated Direct-Current (DC) power supplies located in the VMS by monitoring diagnostic outputs located on these power supplies.

Ensure GFCI devices protect all service outlets. At a minimum, there should be one duplex outlet inside the cabinet.

Ensure AC cables are type Cross-Linked High Heat Water (XHHW) and sized as required by the NEC.

The sign housing must have one earth ground lug that is electrically bonded and located near the power entrance location on the sign housing.

All earth grounding will conform to the National Electric Code.

2.3.9. **Transients.** The equipment will meet the performance requirements specified in Section 2.1.4 of the NEMA standard TS4.

2.4. **Field Equipment Cabinet.** With each VMS, furnish one ground mount cabinet configuration as specified on the plans. Furnish cabinet meeting minimum materials and construction requirements of Special Specifications Item, "Intelligent Transportation Systems (ITS) Ground Mounted Cabinet" (applicable to cabinet only) with additional features described herein.

Provide the following items in the field equipment cabinet:

- power-on indicator;
- room for communication devices (shelf mounted and rack-mounted switches, modems, terminal servers;)
- local or remote switch and LED indicator;
- alarm switch when the cabinet has been opened and capable of communicating with Lonestar™;
- provide a full-height standard EIA 19-inch rack. The rack must be secured within the cabinet by mounts at the top and bottom;
- provide a minimum of one empty pull out drawer. Ensure drawer is capable of supporting a 20 lb. load; and
- provide outdoor rated markings and identification on the power protection panel.

2.5. **Sign Controller.** Provide a sign controller with resident software and the capability of operating up to 2 VMS's. Ensure controller has a what-you-see-is-what-you-get (WYSIWYG) LCD display, representing the message being displayed. Perform all communication, control, and feedback functions for the VMS through the local sign controller. Ensure sign controller supports all Lonestar™ software functionality.

Include a front panel user interface with graphical LCD or keypad for direct operation and diagnostics as described herein (keypad not needed for touchscreen interface.)

Send and receive messages from the sign controller through the communication demarcation point in cabinet via the communications port housed in the field equipment cabinet. Furnishing and installation of communications and power cables from the cabinet to the utility service or the communications demark is described in Special Specification "Installation of Dynamic Message Sign System."

The controller will have power-up and auto-restart capabilities with a programmable default message (including a blank message) when recovering from a power off condition. A hardware watch dog circuit will be used to provide automatic reset to the controller and the modem. The central computer must be capable of remotely commanding a controller and modem reset.

The sign controller must be capable of being controlled from the central controller or the laptop computer.

2.5.1. **Modes of Operation.** Ensure the modes of operation are consistent with those defined in NTCIP, specifically Local, Central, and Central Override.

Ensure the sign controller can monitor individual sensors status. Controller must be able to pass sensor information to Lonestar™ such as Power Status Data, Temperature Sensor Data, and Light Sensor Data as defined in NTCIP 1203. The controller must have cabinet door-open sensor and report back door-open status to Lonestar™.

In the event of a communications failure with the VMS central control software, the local sign controller sets the sign to blank, all pixels off, after a user-defined number of minutes unless communications are restored within this period.

The local sign controller must be remotely resettable from the central control software.

During any time the controller is in reset or bootup condition, the message should be in neutral state (default, blank, all pixels off.)

VMS sign controller should support the storage and use of a minimum of 255 TMUTCD graphics which can be formatted and displayed.

2.6. Communication

2.6.1. **Ports for Remote Communication.** Controller must provide a minimum of 1 Ethernet port with RJ45 connector.

2.6.2. **Ports for Local Communication.** Controller must provide a minimum of 2 Ethernet ports with RJ45 connector to operate up to 2 VMS's.

2.6.3. **Protocols.** The communications ports, for the sign, will act in accordance with all commands defined in Section 8-10-7 "NTCIP PROTOCOL AND COMMAND SETS" of the NEMA TS 4, latest version. Ensure the communications ports, for the sign, act in accordance with all TxDOT NTCIP user defined commands.

2.6.4. **Communication Interface.** The sign controller must include separate serial interfaces for communication with the central controller and the laptop computer.

The communications between the sign controller and the central controller or laptop computer should comply with the National Transportation Communications for ITS Protocol (NTCIP). Unless otherwise stated, the software will comply with the versions of the relevant NTCIP standards that are current at the date of this document.

In addition to the standard MIB objects, the sign should include any additional manufacturer-specific MIB objects required to support all of the sign and central software functionality defined elsewhere in this specification.

2.7. Clock and Timer

2.7.1. **Internal Clock.** Internal Clock will be backed up with a non-battery device such as a large capacitor (super capacitor) for a minimum of 168 hours and ensure the correct messages are displayed at the correct time, even in the event of a communications loss.

2.7.2. **Watchdog.** When polled by Lonestar™ the local sign controller will submit a status report to the central control software when a watchdog event has occurred, including the current sign status and must wait in a Neutral state until further instructions are sent from the statewide central control software, or until manually reset by local control.

2.8. **Initial Documentation.** Before sign manufacturing, provide VMS manufacturer's documentation for each sign type. Document should include each applicable equipment item or component in a searchable PDF manual and submit it for approval. Provide electronic copies of the manual and a minimum of one paper copy of the manual for each sign delivered. Ensure that VMS manufacturer's manual includes the following.

- Independent laboratory test reports explaining testing process and verification worksheet displaying NEMA TS 4 compliance.
- Verification of NTCIP Compliance. The Department will verify, through use of the Department's NTCIP Tester, that the equipment complies with the requirements of NTCIP 1101 Simple Transportation Management Framework; NTCIP 2101, Subnet Profile for PMPP.

- The vendor must submit documentation of successful software compliance testing with TxDOT's Lonestar™ VMS subsystem, latest version. Maintenance software will be provided by the vendor to the Department at no cost to the Department. This software should allow fonts to be added or changed by the Department.
- Documented testing procedures (see section 3.5.)
- VMS shop drawings.
- Power load requirements (for Sign and for the Controller Cabinet) and communications cabling pinouts for cables run between the Cabinet and VMS sign (as per Special Specification "Installation of Dynamic Message Sign System.")
- Complete and accurate schematic diagrams including circuit board schematics.
- Complete and accurate cabinet, enclosure, and building wiring diagrams.
- Complete installation procedures.
- Complete performance specifications (functional, electrical, mechanical, and environmental) on the unit.
- Complete parts list including names of vendors for parts not identified by universal part numbers such as JEDEC, RETMA, or EIA.
- Pictorial of component layout on circuit board.
- Complete stage-by-stage explanation of circuit theory and operation.
- Complete and detailed system operations manuals.
- Data necessary for isolation and repair of failures or malfunctions, assuming the maintenance technicians to be capable of analytical reasoning using the information provided in above subsection. Describe accuracy, limits, and tolerances for all electrical, physical, or other applicable measurements. Include general instructions for disassembly, overhaul, and reassemble, including shop specifications or performance requirements.
- Detailed instructions where failure to follow special procedures would result in damage to the equipment, improper operation, or danger to operating or maintenance personnel. Such instructions and specifications should be included only for such maintenance as may be accomplished by specialized technicians and engineers in a modern Electro mechanical shop. Describe special test setup, component fabrication, and the use of special tools, jigs, and test equipment.
- A detailed physical description of size, weight, special mounting requirements, electrical connections, power requirements, and all other pertinent information necessary for proper installation and use of the equipment. Ensure the vendor works with contractor to submit sign supports and support brackets, and shop drawings compliant with Special Specification "Dynamic Message Sign System."
- Periodic maintenance schedule.
- A list of certified maintenance personnel, including qualifications, experience, and applicable certifications of individuals who may be performing maintenance on products as required by this specification.

3. CONSTRUCTION

- 3.1. **General.** Install contractor-furnished color VMS according to the manufacturer's recommendations and in accordance to Special Specification "Installation of Dynamic Message Sign System." Ensure installation and configuration of software on Department computers is included with the color VMS.
- 3.2. **Requirements for Shop Drawings.** Submit shop drawings in Microstation DGN and PDF format for approval before fabrication; include the sign structural members and attachment supports in accordance with Standard Specification Item 5 Article 5.2 "Plans and Working Drawings." Shop drawings must be sealed by a licensed professional engineer (Licensed in the U.S.)
- 3.3. **Delivery.** Deliver sign and cabinet to location determined by the Department, including removing sign from delivery truck onto ground. The Department will not provide any crane equipment to lift sign off of truck. Must provide equipment to lift. The Department will not be held liable for any damages incurred during shipment,

including lifting the sign from delivery truck onto ground. Delivery will not be complete until sign has been unloaded onto ground, secured to prevent tipping, and passed the demonstration test.

- 3.3.1. **Final Documentation.** Provide as-built final documentation for approval reflecting all field changes and software modifications. Include detailed drawings of conduit layouts, cable diagrams, wiring lists, cabinet layouts, wiring diagrams, and schematics for all elements of the communications system. Include the cable type, color code, and function, the routing of all conductors' pairs in the cable diagrams and wiring lists.
- Provide manufacturer's software, documentation, and intellectual property rights for the computer software system and components. These must include, but are not limited to, the following.
- **Deliver.** One copy of all documentation supplied by the manufacturers for all plug-in circuit cards used in the microcomputer chassis.
 - **License.** Grant the department a non-exclusive unrestricted license that will allow the Department to use, modify, or distribute any or all of the stated communication protocols and documentation.
 - **Technical Assistance.** Include instructions for troubleshooting and warranty replacements.
- 3.4. **Testing.** Ensure that the Department receives a sign capable of complying with the following test procedures which will be performed upon delivery of the Color VMS to the contractor's yard and again at installation of the Color VMS on the support structure as located on the plans.
- 3.4.1. **Examination of Product.** Contractor will examine each unit carefully to verify that the materials, design, construction, markings, and workmanship comply with the requirements of the parent specification. Department may also verify that the Color VMS furnished by the Contractor meets specification.
- 3.4.2. **Continuity Tests.** Department may check the wiring to determine conformance with the requirements.
- 3.4.3. **Operational Test.** Contractor will operate each unit for 2 hr. to permit equipment temperature stabilization and an adequate number of performance characteristics to ensure compliance with the requirements.
- 3.4.4. **Pixel Status Tests.** Contractor will conduct pixel status tests to ensure the pixels are fully functional. Ensure that Vendor must provide detection for out-of-service LED pixels through testing procedures conducted through the sign controller. When polled, controller must be required to report results to Lonestar™ VMS central software.
- **Pixel Test.** Sign must be capable of a full operational status of each pixel and report of the status to the local sign controller. Upon request from Lonestar™ software, sign should identify a list of modules with defective pixels. The pixel test may briefly disturb the displayed message for no more than 0.5 sec.
 - **Pixel Read.** Sign must be capable of reporting back to the local controller which pixels are on or off. Upon request from Lonestar™ software, sign should provide a list of which pixels are on or off. Pixel read should not interfere the displayed message.
- 3.4.5. **VMS Testing Procedures.** Contractor must coordinate with the Vendor to be present during all testing. Contractor will submit Manufacturer-approved test procedures and worksheets detailing the following tests to ensure VMS meets all specifications defined:
- initial demonstration, and
 - stand-alone.
- Contractor will ensure that Vendor representative will perform both tests at location determined by the Department.
- 3.5. **Maintenance.** Ensure that the installed color VMS has a manufacturer's maintenance plan covering: Vendor must perform periodic maintenance during the warranty period as follows.
- 3.5.1. Vendor must submit a recommended periodic maintenance schedule for the review by the Department.

- 3.5.2. Vendor should have a maintenance representative located within the state of Texas. Visits by the representative to various locations identified by the Department will be required. Representative will be notified by telephone at the location and telephone number designated by the vendor as the point of contact for any repair work. Vendor must notify the Department immediately of any changes in this location and telephone number. Maintenance representative must possess and maintain an inventory of common replacement parts.
- 3.5.3. Vendor must perform periodic maintenance tests 4 times per year during the warranty period at no additional cost to the Department. This periodic maintenance may be performed remotely. Provide documentation to TxDOT.
- 3.5.4. Vendor must perform periodic VMS equipment maintenance on-site at intervals not exceeding 12 months. The vendor will be responsible for all costs related to this requirement, including but not limited to the following: travel, per diem, labor, material, equipment, on-site labor, on-site material, on-site equipment, and access to the signs. The vendor must satisfy TMUTCD for temporary traffic control requirements and must obtain approval from the Department.
- 3.5.5. Vendor will provide to the Department a quarterly report of activities performed, in an electronic spreadsheet format. This report must include all activities performed, equipment serviced, dates, and names of technicians who performed the maintenance. The report must include both periodic maintenance activities as well as warranty repair work, independently categorized. Include a list of all trouble calls, with time and date received, and time and date responded, including technician.

Minor items such as pixel outages which do not significantly affect sign operation can be scheduled for future repair not subject to the 72 hr. requirement.

- 3.6. **Training.** Provide manufacturer approved end user training to the Department and their representatives. Provide a minimum of 2 days of instruction in the operation and maintenance procedures. Train a maximum of 10 Department designated personnel.

Training will cover a minimum but is not limited to:

- hands-on operation of the sign;
- explanation of any system commands, their function, and usage;
- required preventative maintenance procedures;
- equipment servicing procedures;
- sign troubleshooting and problem identification procedures; and
- use of Diagnostic software.

Furnish a manufacturer approved training session agenda, a complete set of manufacturer approved training materials. Provide one copy of the course material for each person. The training room will be provided by the Department.

- 3.7. **Warranty.** Ensure that the installed color VMS has a manufacturer's warranty covering: Materials will be warranted for 5 years from a accepted installation date. The accepted installation date is defined as the date the Department determines the sign has passed installed testing requirements. The warranty will cover all defects in material, design, and workmanship, and will cover 100% parts and labor for repair work, including diagnostics. If the vendor standard warranty period exceeds 72 months, with a minimum of 60 months from a accepted installation date, then the standard warranty period will be in effect. The vendor will submit in writing the terms of warranty.

During the warranty period the vendor will be responsible for labor, materials, shipping, traffic control, and other costs as outlined below for required warranty repair. It is the intent of this warranty that the vendor performs warranty repair work. At the Department's option, the Department may perform minor warranty repairs at the vendor's expense without voiding the warranty.

All diagnostics, testing, and replacements necessary to resolve any problems will be assumed by the vendor at no cost to the Department.

- 3.7.1. **Repairs.** The maintenance representative must respond within next business day and be available for warranty repairs and performance of services within 72 hr. of notification by the Department throughout the duration of the Warranty. Failure to meet this requirement may result in the Department billing the vendor for repair work performed by the Department or through a 3rd party without voiding the Warranty. Document all repairs within the quarterly report of activities.
- 3.7.2. **Exclusions.** The Department will assume the expense for replacement of knocked down cabinets, support structures, and other minor items resulting from day to day operations. The Department will assume responsibility for cost of repairs resulting from collision, theft, vandalism, or acts of God.
- If vendor arrives at location for diagnostics or repair and TxDOT subsequently determines an exclusion, then TxDOT will assume responsibility for vendor's time and travel costs.
- 3.7.3. **Warranty Repairs by the Department.** The vendor performs all warranty repairs; however, at the Department's option, warranty repairs deemed by the Department to be minor in nature or due to vendor's failure to respond within 72 hr. of notification may be performed by the Department at the vendor's expense. Parts required for repairs made by the Department will be obtained from the vendor at no cost to the Department. The Department may request reimbursement for additional time incurred such as technician's travel time or diagnostic time. Reimbursement by the vendor to the Department for the cost of warranty repairs must be computed as follows.
- 3.7.3.1. **Labor:** Labor for warranty repairs will be calculated including travel to field locations, configuring devices, and running diagnostics on field device and communications equipment.
- 3.7.3.2. **Warranty Repair Claims:** Warranty repairs will be accumulated on Department Repair Orders and will be billed from same, unless the vendor prefers to have claims processed on the vendor's standard forms.
- 3.7.3.3. **Parts:** Replaced parts will be held 30 calendar days and will be available for inspection by the vendor or authorized representative. Copies of invoices for all parts will be provided to the vendor. The cost of parts other than those furnished to the Department at no cost by the vendor will be billed at actual cost.
- 3.7.3.4. **Billing and Payment for Warranty Repair Expenses:** Costs for minor warranty repairs will be accumulated, including labor, diagnosis time, and replacement parts (if not provided.) Reimbursement payment should be made within 30 calendar days of the billing date. The warranty must be in accordance with the Special Specification, "Testing, Training, Documentation, Final Acceptance, and Warranty."

4. MEASUREMENT

This Item will be measured as each unit furnished, installed, made fully operational, and tested in accordance with this Special Specification.

5. PAYMENT

The work performed and materials furnished, in accordance with this Item and measured as provided under "Measurement," will be paid for at the unit price bid for "Variable Message System (VMS) with Foundation Mounted Cabinet" or "Variable Message System (VMS) without Cabinet." This price is full compensation for furnishing, transportation, and installation of VMS and its equipment cabinet; furnishing and installing any new mounting hardware and VMS controller cabinet foundation when required; storing the VMS when required; cleaning and testing the VMS; replacement or repair of damaged components; disposal of unsalvageable material and for all manipulations, labor, tools, working drawings, equipment, and incidentals. This price is full compensation for furnishing, placing, and testing all materials and equipment, and for all tools, labor, equipment, hardware, operational software packages, communication cable and media

converters (if required,) supplies, support, personnel training, shop drawings, documentation, and incidentals.

New overhead sign supports or relocation of existing overhead sign supports will be paid for under Item 650, "Overhead Sign Supports." New drilled shaft foundations will be paid for under Item 416, "Drilled Shaft Foundations." New electrical conductors for power distribution will be paid for under Item 620 "Electrical Conductors."