1. **DESCRIPTION**

Furnish and install full color matrix, font-access, high-intensity Light Emitting Diode (LED) Lane Management System (LMS) which supports both text and graphical display. Furnish and install LMS sign controller, equipment cabinet, control software, and NTCIP communication protocol for each system. A system may include a minimum of 1 or a maximum of 8 displays mounted on a 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;
- TxDOT Special Specification “Intelligent Transportation System (ITS) Ground Mounted Cabinet”;
- TxDOT Special Specification “Intelligent Transportation System (ITS) Pole with Cabinet”, applicable to cabinet only; and
- Vendor will be ISO 9001 registered.

Furnish no less than 4 licensed copies of vendor software on Department laptops for each LMS, 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”; and
- Item 656, “Foundations for Traffic Control Devices”.

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

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

- Full color high-intensity LED LMS displays, capable of rear mounting onto sign supports specified on TxDOT Standard Details MDM, OSB and COSS, latest versions;
- Sign Controller with software, NTCIP Version 1203 complaint;
- LMS display mounting brackets and hardware;
2. Cabling and connectors from power source to LMS connection point as specified by the LMS manufacturer;

2. Cabling and connectors from telecommunications source to LMS connection point as specified by the LMS manufacturer when required;

2. Power and communication cabling and connectors from controller to LMS must follow NEMA TS4, Section 4, “Controller to Sign Interface”;

2. Communications as shown on the plans;

2. LMS equipment cabinet (pole or ground mount) and electronics;

2. Documentation; and

2. All incidentals required for installing a LMS.

2.2. Lane Management System Display. Ensure that the full color matrix LED LMS meets the following requirements:

2.2.1. General Construction. Utilize the latest available techniques with a minimum number of different parts, subassemblies, circuits, cards, and modules to maximize standardization and commonality. Design for ease of maintenance. Ensure all component parts are readily accessible for inspection and maintenance. Provide test points for checking essential voltages.

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

2.2.1.2. 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.

2.2.1.3. 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.

2.2.1.4. Provide a front-access display housing with a maximum total weight of 500 pounds and maximum dimensions of 5 ft. x 6 ft.

2.2.1.5. Construct the display housing skin of aluminum alloy 5052-H32 not less than 1/8 in. thick, unless otherwise specified in this document. Provide framing structural members of aluminum alloy 6061-T6.

Table 1

<table>
<thead>
<tr>
<th>Sign Type</th>
<th>Front-access lift face</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matrix Type</td>
<td>Full</td>
</tr>
<tr>
<td>LED - Type</td>
<td>AllInGaP Red LEDs</td>
</tr>
<tr>
<td></td>
<td>InGaN Blue LEDs</td>
</tr>
<tr>
<td></td>
<td>InGaN Green LEDs</td>
</tr>
<tr>
<td>LED Color – Wavelength</td>
<td>Red – 618-630 nm</td>
</tr>
<tr>
<td>LED Viewing Angle</td>
<td>30°</td>
</tr>
<tr>
<td>LED Pixel Brightness</td>
<td>12,400 cd/m^2 minimum white brightness</td>
</tr>
<tr>
<td>Pixel Pitch</td>
<td>20 mm</td>
</tr>
</tbody>
</table>
Protect equipment within the sign housing from moisture, dust, dirt, and corrosion. Ensure the front-access housing meets NEMA 3R enclosure criteria as defined in NEMA Standards Publication 250-2008, “Enclosures for Electrical Equipment (1000 Volts Maximum).”

The sign housings are designed in accordance with AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals – 6th Edition; for wind speeds of up to 140mph. AASHTO group load combinations include total sign weight dead load, ice, and wind loads; and the design meets the fatigue requirements for truck-induced gusts.

The housing face will be a two piece construction, consisting of internal structural members and display modules. The border from the display area to the edges of the sign will be a minimum of 4 in.

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

Provide a minimum of four drain holes in the bottom panel of the housing with snap-in, drain filter plug inserts, in each section formed by internal structural members. Ensure water drain filter plug inserts are replaceable.

Provide a housing designed to accommodate mounting on the rear vertical plane.

**Surface Finish.** The front face panel and front face border pieces will be finished with a semi-gloss black, polyvinylidene fluoride (PVDF) applied in accordance with the American Architectural Manufacturers Association (AAMA 2605). Ensure the face is uniform in appearance and completely free from distortion, gouges and any other flaws or defects.

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

All interior surfaces will be a natural aluminum mill finish.

2.2.1.3. **Exterior Skin.** Provide an exterior skin for the housing of 5052-H32 aluminum alloy sheet at 1/8 in. thick, minimum.

Ensure all exterior seams and joints are sealed from rain and environmental containments with a weather tight enclosure, minimizing the number of seams.

Stitch weld the skin material to the internal structural members to form a unitized structure.

2.2.1.4. **Mounting.** Provide exterior mounting assemblies of 6061-T6 aluminum alloy extrusions, 3/16-inch minimum thickness.

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

2.2.1.6. **Lens Panel Aluminum Mask.** Provide a high-contrast aluminum mask meeting the following:

- Black in color containing an opening for each pixel;
- Polycarbonate sheet securely attached to the inside of the aluminum panel; and
- Perforated to provide an aperture for each pixel on the display modules and be as small as possible, without blocking the LED light output at the required viewing angle.

2.2.1.7. **Sign Display.** The face panel clear glazing (if used) must be 90% UV opaque, non-breakable, polycarbonate, or equivalent, minimum 1/8 inch 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 DMS.

2.2.2. **Environmental Control.**

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

Ensure the inlet and exhaust filters are electrostatic and are sized to properly accommodate the air flow and pressure drop requirements of the ventilation system. Ensure filters are easily removable from within the sign housing without the use of tools. Provide both inlet and exhaust filters that are environment-friendly, washable, and reusable.

Provide an electronically controlled ventilation system activated by a failsafe thermostat designed to keep the internal LMS air temperature lower than +140°F (+60°C), when the outdoor ambient temperature is +115°F (+46°C) or less.

Provide a ventilation system where the temperature from the thermostat are continuously measured and monitored by the sign controller. A temperature reading greater than a user selectable critical temperature will cause the sign to go to blank and the sign controller will 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.

Provide LMS displays and electronic equipment that are 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 will be equipped with a thermally-controlled back-up system that will activate the ventilation system automatically in the event that 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.

2.3. **Optical and Electrical Requirements.**

2.3.1. **LED and Pixel Characteristics.** Provide AlInGaP or INGaN, Precision Optical Performance T 1-3/4 LED diodes. Provide LEDs rated for 100,000 hr. continuous operation at 30mA drive current, with less than 30% lumen depreciation. The cone perimeter is defined by its 50% intensity points. Provide LEDs with standoffs that hold the base of the LEDs 3.5mm + 1.0mm 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. Measure the brightness of each LED in accordance with the CIE Test Method A, as described in CIE 127-1997, Technical Report: Measurement of LEDs. The LED brightness and color bins that are used in each pixel must be provided to the engineer for approval. Provide certification with the submittals from the LED manufacturer that demonstrates that the LEDs were tested and binned in accordance with the CIE Test Method A.

The pixel strings will be powered from a regulated DC power source and the LED current must be maintained at 28 milliamperes or less per string 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. Pixel power drawn from the DC supplies must not exceed 1.5 watts per pixel, including the driving circuitry.

The LEDs must be individually mounted directly to a printed circuit board and should be easily replaceable and individually removable using conventional electronics repair methods.
2.3.2. Display Module and Driver Boards. Provide LMS with LED display modules consisting of one circuit board per LED display module 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 will receive control signals and display data from the sign controller. The display module will 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 will be arranged uniformly to display a dot-matrix character of the desired height and width. The height of a standard character must 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 will 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 must 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 will 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 circuit board must be a single, 0.062 inch, FR4, flat black printed circuit board. The LED display board should support the driver board.

All LEDs must be mounted so that their mechanical axis is normal +/- 1.00 degree 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 acrylic resin conformal coat. Use coating material that complies with military specification MIL-I-46058C Type SR and IPC-CC-830.

2.3.3. Display Assembly. Provide an LED display module with a LED display circuit board. Ensure a single data exchange and addressing cable connects the driver board to the LED boards it controls that are not directly attached to the driver board. The driver board contains the solid state electronics necessary to control pixel data and read pixel status.

Provide LED boards and driver boards that are fully interchangeable and should not require any manual addressing switches or adjustment when interchanged or placed in service.

Provide display modules that can be mounted to the display face in a manner that facilitates easy and rapid removal of each display module without disturbing adjacent display modules. Ensure replacement of a complete display module is possible without the use of any tools.

2.3.4. Legibility. Provide LMS displays legible under all light conditions at a distance of 350 feet, when displaying 6 inch characters, within the degree cone of vision centered around the optical axis of the pixel.
Ensure proper brightness in all lighting conditions for optimum legibility. LMS display should 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.

Provide uniform brightness and color of each pixel over the entire face of the sign within the cone of vision from 300 feet to 50 feet 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.

Meet the minimum Section 8.8 "BRIGHTNESS CONTROLS" of the NEMA TS 4, latest revision. Provide a controller with the capability of monitoring and self-adjusting 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. Character Display. Provide LMS displays capable of displaying ASCII characters 32 through 126 (including all upper and lower case letters and digits from 0 to 9). If shown in the plans, a special graphics character should be substituted for any of these characters.

Provide an LMS display that supports a minimum of 6 inch (5 X 7) up to a maximum 18 in. (15 x 23) character fonts. Provide spacing options for one, two, three, or four 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.

Provide LMS display with 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.

2.3.6. Graphical Display. Provide LMS displays capable of displaying graphical messaging that conform to NTCIP 1203 Version 2 standard.

2.3.7. LED DC Power. Ensure the voltage to the LMS displays and associated electronics does not exceed 25 VDC. Functioning supplies must current-share to within 10%. Ensure the combined effect of line (97 to 135 VAC) and load (10% to 100%) on the power supplies does not exceed 1.0%. The power supplies must have an efficiency of 75%.

Provide paralleled power supplies in a diode OR configuration and supply enough power to run 100% of all pixels at 100% duty cycle at 65 degrees C (149 degrees F). Functioning supplies must current-share to within 10%.

Provide a power distribution system that connects each LMS display to all power supplies and minimizes the voltage drop over the face of the sign. The voltage measured at the display modules should not vary more than 50 millivolts over all the display modules in the sign with 17 pixels on at 100% intensity in each and every display module.

2.4. Field Equipment Cabinet. For each LMS location, furnish one ground mount or pole mount cabinet configuration as specified in the plans. Furnish cabinet meeting minimum materials and construction requirements of Special Specifications Item, "Intelligent Transportation Systems (ITS) Ground Mounted Cabinet" and "Intelligent Transportation System (ITS) Pole with 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, Ethernet switches, fiber distribution equipment);
- 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 LMS display controller with resident software. 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 LMS through the local sign controller. Ensure sign controller supports all Lonestar™ software functionality and is NTCIP compliant.

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

Provide a controller that will control up to 8 LMS displays on a single structure.

Send and receive messages from the LMS display 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 other specifications.

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

Provide a controller with the ability to provide a fiber optic redundant signal path if the project plans require the use of multi-sign control. The failure of one LMS display will not affect other displays.

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 sensor(s) status. Provide a controller with the ability to pass sensor information to Lonestar™ such as Power Status Data, Temperature Sensor Data, and Light Sensor Data as defined in NTCIP 1203. Provide a controller that will integrate with a cabinet door-open sensor and report back door-open status to Lonestar™.

In the event of a communications failure with the DMS 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. Provide communication loss message as defined by NTCIP to Lonestar™.

Provide a controller that can be remotely resettable from the central control software.

Provide a controller that will support 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.** Provide a minimum of one (1) Ethernet port with RJ45 connector and a minimum of one (1) EIA232 (RS232) configurable to EIA485 (RS485) with DB9 connector.

2.6.2. **Ports for Local Communication.** Provide a minimum of one (1) Ethernet port with RJ45 connector, a minimum of one (1) EIA232 (RS232) configurable to EIA (RS485) with DB9 connector.
2.6.3. **Protocols.** Support communication protocols 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.** Provide separate serial interfaces for communication with the central controller and the laptop computer.

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

In addition to the standard MIB objects, provide 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.** Provide a computer readable clock that has a battery backup circuit that will keep the clock operating properly for a minimum of 2 years. Provide a clock that will automatically adjust for daylight savings time and leap year using software, hardware, or both.

2.7.2. **Watchdog Timer.** Meet at a minimum Section 8.9.5 "WATCHDOG TIMER" of the NEMA TS 4, latest version.

During watchdog timer reset the sign must be blank, all pixels off.

When polled by Lonestar™ submit a status report to the central control software when a watchdog event has occurred, including the current sign status and 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.** Prior to sign manufacturing, provide LMS manufacturer’s documentation for each system comprised of the LMS displays, controller, and equipment cabinet in searchable PDF manual and submit for approval. Provide electronic copies of the manual and a minimum of one paper copy of the manual for each system delivered. Ensure that LMS manufacturer’s manual includes:

- 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™ DMS subsystem, latest version. Vendor to provide maintenance software to the Department at no cost to the Department. Allow fonts to be added or changed by the Department within the software.
- Documented testing procedures (see section 3.5);
- LMS shop drawings;
- Power load requirements;
- 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;
3. CONSTRUCTION

3.1. General. Install contractor-furnished color LMS according to the manufacturer’s recommendations and in accordance to Section 3 Construction of SS6028 Dynamic Message Sign System. Ensure installation and configuration of software on Department computers is included with the LMS.

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 registered professional engineer (Licensed in the U.S.).

3.3. Delivery. Deliver LMS equipment to location determined by the Department, including removing from delivery truck onto ground. The Department will not provide any crane equipment to lift equipment off 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 equipment 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 LMS to the contractor’s yard and again at installation of the LMS on the support structure as located in 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 LMS 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 will 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™ DMS central software.

- **Pixel Test.** Sign should 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 will 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 should be capable of reporting back to the local controller which pixels are on/off. Upon request from Lonestar™ software, sign will provide a list of which pixels are on/off. Pixel read should not interfere the displayed message.

3.4.5. **DMS Testing Procedures.** Contractor to coordinate with the Vendor to be present during all testing. Submit Manufacturer-approved test procedures and worksheets detailing the following tests to ensure DMS meets all specifications defined:

- initial demonstration
- stand-alone

Contractor will ensure that Vendor representative performs both tests at location determined by the Department.

3.5. **Maintenance.** Perform periodic maintenance during the warranty period as follows:

Submit a recommended periodic maintenance schedule for the review by the Department.

Provide 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.

Perform periodic maintenance tests four 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.

Perform periodic LMS equipment maintenance on-site at intervals not exceeding 12 months. 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. Meet TMUTCD for temporary traffic control requirements and obtain approval from the Department during maintenance visits.

Provide to the Department a quarterly report of activities performed, in an electronic spreadsheet format. Include all activities performed, equipment serviced, dates, and names of technicians who performed the maintenance. 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 hour 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.

Cover, at a minimum, the following:
- 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.** Provide 5 year warranty on materials from accepted installation date. The accepted installation date is defined as the date the Department determines the sign has passed installed testing requirements. Warranty must cover all defects in material, design, and workmanship, and 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 accepted installation date, then the standard warranty period applies. Submit warranty terms in writing.

During the warranty period, all labor, materials, shipping, traffic control, and other costs as outlined below for required warranty repair are the responsibility of the Vendor. It is the intent of this warranty that the vendor performs warranty repair work.

All diagnostics, testing, and replacements necessary to resolve any problems is a Vendor responsibility, at no cost to the Department.

3.7.1. **Repairs.** The maintenance representative is required to respond within the 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 should 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 6005, “Testing, Training, Documentation, Final Acceptance and Warranty.”

### 4. MEASUREMENT

This Item will be measured as each LMS furnished, installed, made fully operational and tested in accordance with these Special Specifications.

### 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 “Lane Management System (LMS)” for the number of LMS displays and cabinet mounting type specified (pole mounted, ground mounted, or wall mounted). This price is full compensation for furnishing, transportation and installation of LMS and its equipment cabinet; furnishing and installing any new mounting hardware, and LMS controller cabinet foundation when required; storing the LMS when required; cleaning and testing the LMS; replacement/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 package(s), 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.”