MICHIGAN
DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION
FOR
DYNAMIC MESSAGE SIGN, LARGE

a. Description. This work consists of the furnishing, installation and integration of a complete dynamic message sign (DMS) system at site designated within the plans. Work includes a full-matrix light-emitting diode (LED), walk-in housing type DMS, an auxiliary control panel (ACP) and a ground mounted ITS Cabinet with required foundation placed the opposite side of traffic flow (paid under different pay item). The DMS display matrix will be 125 pixels wide by 27 pixels tall and capable of displaying up to 21 18-inch characters in each of three distinct rows of characters. The electrical work will include the furnishing and installing of all required conduit and cable in the DMS foundations and attached to the DMS structure and the termination of all power supply cables in the ITS cabinet and the DMS sign with the wire sized as required for each DMS site.

It is the responsibility of the Contractor to furnish and install any and all appurtenances necessary for a fully operational and functional DMS. This work must be done in accordance with the current Standard Specifications for Construction, except as modified herein.

1. General.

A. Furnish, install, integrate and test all equipment and components necessary to provide full and complete ITS functionality in all respects, without additional expense to the Department.

B. Furnish one auxiliary control panel (ACP) as an integral part of each DMS.

C. Install the ACP within the DMS housing, the DMS controller within the ITS cabinet; the interconnecting of the power and communications cables and any other required appurtenance for a fully functional ACP/DMS as directed by the Engineer.

D. Furnish, test and deliver the DMS as stipulated by the Engineer.

E. Demonstrate the DMS functions and meets the requirements in these specifications.

F. Position DMS with message facing oncoming traffic and align in such a manner as to maximize message visibility.

G. Provide temporary blocking to keep the DMS off the ground, sign power and assure the DMS is secure while in storage.

H. Provide all equipment required for testing of the DMS and DMS components contained within this procurement as an appurtenance to the electronic equipment included within the project at no additional cost to the Department.

2. Requirements of Regulatory Agencies.
The compliance with the latest edition of the following codes or standards is required:

A. Institute of Electrical and Electronic Engineers (IEEE).
B. American Association of State Highway and Transportation Officials (AASHTO) including, but not limited to:

(1) Standard Specifications for Highway Bridges, 17th Edition with interim updates.

(2) Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, 4th Edition with interim updates.

C. National Transportation Communications for ITS Protocol (NTCIP).
D. American Society for Testing and Materials.
E. American National Standards Institute Standard C2 (ANSI).
F. American Society of Testing and Materials' (ASTM).
G. National Electric Code (NEC).
H. American Society of Civil Engineers (ASCE).
I. American Institute of Steel Construction (AISC).
J. Institute of Electrical and Electronic Engineers (IEEE) 802.3.
K. National Electrical Manufacturers Association (NEMA).
L. National Electrical Manufacturers Association (NEMA) TS4.
M. AASHTO/NSBA Steel Bridge Fabrication Guide Specification.
N. AASHTO/NSBA Steel Bridge Design and Detailing Guidelines.

If codes, standards or the requirements are in conflict with a Special Provision; the stricter standard or requirement will govern the Contractor. The Engineer will be the final authority in the resolution of any and all conflicts relating to codes and standards versus Special Provisions.

3. DMS vendor experience and qualifications.

A. MDOT requires that the Contractor propose a DMS vendor for this project that is capable of demonstrating a positive track record for delivery of functional and reliable DMS and the very highest levels of post delivery support and service. In keeping with this desire for a proven DMS vendor, the Department reserves the right to contact references to verify all submitted past performance information and to assess the quality of the vendor based on the results of the verification and assessment.

B. As an integral portion of the submittal process, the Contractor is required to submit to MDOT the following proposed DMS vendor information (see Table 1), said information and references must be a representation of a single corporate entity and that corporate entity alone.

Table 1: DMS Vendor Information

Number of References	Type of Reference	Minimum Reference Description
10	DMS Vendor Project	• Each project consisting of 10 or more LED DMS • Freeway application • DMS used by State DOT or Toll Agency • Within past five years
6 (may be included in 10 above)	DMS Vendor Project	• Each project consisting of 10 or more LED DMS • Freeway application • Walk-in enclosures • Permanently mounted • DMS used by State DOT or Toll Agency • NTCIP-compliant DMS controlled by NTCIP-compliant central computer
1	DMS Vendor Total Projects	• A minimum of One Hundred (100) DMS in continuous use for at least three years
10 *(one for each project above)*	DMS Vendor Customer	• Project name • Customer name • Customer contact person name • Current customer contact person phone and e-mail
1	DMS Vendor Financial	• DMS vendor financial resources statement (Bank Reference and DUNS Report minimum) • The financial ability to provide long-term support
1	Standards	• Statement with independent concurrence regarding NTCIP Standard compliance
1	Demonstration	• The Contractor agrees to provide DMS Factory Acceptance Test (FAT) for up to three MDOT representatives at no cost to MDOT
1	Post Award Verification	• The DMS vendor confirms in writing to conduct a factory testing process as required within this Special Provision, required burn-in of each DMS prior to shipment and final acceptance testing on-site post installation • Contractor provides proof of the DMS vendor's compliance from independent sources regarding: o NEMA Standards Publication TS 4, Hardware Standards for Dynamic Message Signs (DMS) o NEMA Requirements – Section 2, Environmental Requirements o UL 48 Standard for Electric Signs o UL 50 Enclosures for Electrical Equipment o UL 1433 Standard for Control Centers for Changing Message Type Electric Signs

4. DMS Testing and Acceptance Requirements.

It is the responsibility of the Contractor to conduct such tests as necessary to ensure each DMS meets the requirements and specifications. The Engineer and/or MDOT Representative reserve the right to witness and /or verify, or to appoint a representative to witness all product testing during manufacture of the DMS.

A. Manufacturing Process Testing and Burn-in.

Furnish to the Engineer, for approval, a complete DMS vendor manufacturing process testing and Quality Control and Assurance Plan. This Plan must include all appropriate

tests from the component level to sign assembly completion, including a required 96 hour burn-in of each DMS.

B. Factory Acceptance Testing (FAT).

(1) The Contractor is required to furnish a factory acceptance test (FAT) at no additional cost to the Department. The Contractor will bear all travel expenses including air fare, hotel and meals for up to three representatives of MDOT for the FAT and product testing event. The FAT will be performed at the DMS vendor's manufacturing facility. FAT is required prior to installation of any DMS. FAT tests include, but are not limited to:

(2) Passage the NEMA 250 water spray test with no visible signs of water leakage through any of the sign housing seams.

(2) Proof of the 96 hours of continuous operation of the FAT DMS.

(3) Post FAT, the Engineer will audit and accept all burn-in test logs for each DMS prior to that DMS shipping from the factory.

(4) The physical verification through inspection by the Engineer and/or the MDOT Representative that the DMS meets the Special Provision and the approved submittal and shop drawings.

C. Post delivery testing and operation.

Upon delivery of each DMS to the location designated by the Engineer as shown on the project plan sheets, provide permanent power within 72 hours of delivery for the demonstration of the DMS functions in accordance with the requirements and specifications and that it has not been damaged during shipment. Maintain the DMS's power feed from the day of delivery to final acceptance, thereby protecting the interior electronics within the DMS from environmental degradation. If the project site depicted within the plans is not completely prepared for the installation of the DMS, the Contractor will be required to store the DMS at a secure and protected location. Said location will be approved by the Engineer. The DMS, while in the storage location, will be fully powered up within 72 hours of delivery. This temporary storage will be at the Contractor's expense.

(1) Post delivery test plan. Develop and submit to the Engineer for approval a post delivery test plan. The test plan must demonstrate the complete functionality and integrity of the DMS after shipment and post delivery. The plan will describe test procedures, detail features being tested and the expected values that demonstrate DMS compliance

(2) Testing schedule. All DMS will be tested in accordance with the post delivery test Plan. Schedule and conduct the post delivery tests at a time approved by the Engineer. Power to the delivered DMS and the power up of the DMS subsystems, including all ventilation systems, must be accomplished within 72 hours of delivery

D. Reporting requirements.

(1) Submit vendor and third-party reports verifying testing procedures, testing dates and testing results. The report will document comparison of test results to the

specifications detailed herein. The report will clearly identify any failure to conform to the specifications

(2) Failure to conform to testing procedures will be considered a defect in the equipment and thereby be subject to rejection by the Engineer and/or MDOT Representative. Rejected equipment may be offered again for a retest, provided that non-compliances have been corrected and the DMS successfully retested by the vendor or third party. Evidence thereof must be submitted to the Engineer and/or the MDOT Representative

(3) Failure of any DMS to conform to the specifications will be considered a defect and the DMS is thereby subject to rejection by the Engineer and/or the MDOT Representative. Rejected equipment may be offered again for a retest, provided that all non-compliances have been corrected and retested by the vendor and evidence thereof has been submitted to the Engineer and/or Representative

(4) Final FAT and product test reports showing complete compliance with specifications must be submitted and approved by the Engineer before the Contractor releases the DMS for shipment

E. Final inspection and acceptance of the DMS will be made after:

(1) Approval of the product testing report
(2) Approval of the FAT report
(3) Delivery of the DMS to a site designated by the Department
(4) Proof and verification of the DMS continuous operation post delivery
(5) Approval of the reports documenting the results of the post delivery test

F. The Contractor will provide a factory-trained technician who will be present when the DMS is installed on its designated support structure and integrated with the ITS Cabinet, power supply and communication network. The technician will verify that the installation is in full compliance with the vendor's installation specifications and certify that the DMS vendor's warranty is in full force and in effect after the DMS and all appurtenances have been installed; are fully operational; and final acceptance has been completed.

b. Materials.

1. The source of steel and iron.

All steel and iron materials permanently incorporated in this project will be produced in the States, Territories, or Possessions of the United States, unless the materials are no longer produced in the United States. These materials will include steel, steel products, and products that include steel components.

A. All manufacturing processes, including application of a coating for these materials and products, must have occurred within the States, its Territories or Possessions of the United States.

B. Coating includes all processes that protect or enhance the value of the material to which the coating is applied. This specification allows the minimal use of foreign steel materials on the project; if the total invoice cost of the materials permanently incorporated

in the project does not exceed one-tenth of one percent of the total contract cost or $2,500, whichever is greater.

C. For purposes of this specification, the total cost is that shown to be the total value of the steel products and materials as they are delivered to the project. Written certification of compliance will be submitted by the Contractor to the Engineer.

2. Electrical work.

Conduit, grounding, and risers will meet Section 918 of the Standard Specifications for Construction. Other material required will meet local utility company specifications and the National Electric Code (NEC).

3. DMS functional requirements.

The Concept of Operations defines the minimum sign functionality in each of the following areas. The Contractor must demonstrate, to the satisfaction of the Engineer, compliance with each of these functional requirements:

A. The DMS must be capable of receiving message commands and control from the designated Traffic Management Center (TMC) or other operation centers using NTCIP Protocol central system software.

B. The DMS will provide sign and communication maintenance, and diagnostic information to the operators at the TMC as depicted within the plans or other operation centers as determined by the Department.

C. The DMS will be available for use for traffic and incident management regardless of environmental conditions.

D. The DMS must be capable of delivering back to the operator accurate displayed message verification by way of “what-you-see-is-what-you-get” (WYSIWYG).

E. Command and control requirements.

(1) MDOT will communicate with the DMS using NTCIP compliant software. All features and capabilities of the sign must be controllable through the MDOT NTCIP-compliant software.

F. Maintenance and diagnostics detection and reporting requirements.

(1) The DMS is to be capable of detecting faults with any component within the DMS Housing and ITS Cabinet and reporting those faults to the appropriate MDOT operation center. The diagnostic report will clearly describe the nature of the problem; the components involved; and any other information necessary to facilitate timely and efficient maintenance.

G. DMS environmental requirements.

(1) The DMS display will be enclosed in a walk-in housing

(2) The DMS enclosure, components, heating and ventilation and workmanship must be of new components; corrosion resistant; and adequate to ensure full sign

functionality and durability in the Michigan environmental conditions

(3) All field equipment must perform to the minimum environmental and sign hardware requirements of -29.2°F to 165°F and a relative humidity range of 0 percent to 95 percent, non-condensing

(4) All outdoor enclosures must resist water infiltration during hose-directed water per NEMA 250 – Class 3R requirements.

(5) Install all the field equipment to be capable of operating in all weather conditions and withstand a wind load of 90 mph without permanent damage to sign, sign structure, or mechanical and electrical equipment

(6) All connections, internal or external to the DMS, must be watertight

(7) If the DMS is subjected to temporary storage, the DMS will be protected from impacts and intrusion from animals, insects, water or other potentially damaging situations. Any DMS in temporary storage is required to have an energized 120/240 volt power source connected to the DMS with all subsystems operations during the storage period

H. Messaging requirements.

(1) The DMS static RAM will be capable of storing and displaying pre-worded messages, message sequences and message lists. Message wording, language and formatting will comply with applicable NTCIP standards

(2) The DMS will be capable of displaying user-created messages not contained within the message library

(3) Supply the most current version of NTCIP. The Department, at its discretion, can require, at no additional cost to the Department, one firmware upgrade during the warranty period

I. Display Requirements.

(1) The DMS will be a LED full-matrix sign

(2) The DMS display will be comprised of LED formed into pixels

(3) Each character will be up to 7 pixels tall and five 5 pixels wide

(4) The full-matrix DMS will be capable of displaying a minimum 21 characters on a 125 X 27 pixel sign, per line with a character height of 18-inches

(5) Each character is to be separated by the minimum width of one unlit pixel column

(6) Each line of characters is to be separated by the height of three unlit pixel columns

(7) Minimum DMS visibility distance is to be from 200 to 1,000 feet

(8) The DMS, including enclosure and mounting hardware, will weigh no more than 5,000 pounds for Large walk-in DMS and will range from 2,700 to 3,300 pounds for Large rear and front access DMS. A verification of the total weight must be documented and included in the certificate of compliance for each DMS

J. General requirements.

(1) All electrical components must operate on 120/240 volt 60 Hz electricity, or Contractor must provide appropriate DC conversion for any equipment requiring DC power

(2) The DMS vendor is to utilize new, identical and completely interchangeable components within each DMS

(3) The Contractor is to utilize equipment designed to protect personnel from exposure to high voltage during equipment operation, adjustment and maintenance

K. Mounting requirements.

(1) DMS must be furnished with multiple lifting eyes or marked equipment hoisting points. Lift eyes will be designed in such a way as not to negatively impact the aesthetics, water tightness or functionality of the sign. If the lifting eye bolts are removed from the DMS after installation, bolts will be supplied to plug and seal the holes to prevent water from entering the DMS housing

(2) When mounting the sign to a new structure, the design of the DMS and its mounting structures and hardware must be fully compatible and similar in structure type to the proposed MDOT standard DMS structure depicted for information only in the contract documents. The DMS vendor must supply all mounting hardware for each sign to include, but not limited to, “Z” bars, brackets, connectors and clamps

L. Communication requirements.

(1) All DMS components must be capable of specified NTCIP compliant communications.

(2) All data detected by the DMS (e.g., diagnostic data) is transmitted to the Communications Network and all data required by the DMS is received by the DMS from the communications network

M. Surge protection.

(1) The DMS surge protection will be a cascade protection system. A primary surge protection device (SPD), connected in parallel with the load, will have a surge capacity of 150kA, providing protection modes between line to neutral, line to line, and line to ground. A secondary SPD will be a series-connected device; either "power strip" type, if modules are "plug-in", or hard-wired if the DMS modules are hard wired. The secondary SPD will have a surge current capacity of no less than 50kA and a current load of minimum 12 amps neutral to ground

(2) The primary surge protection device will utilize metal oxide varistor (MOV) technology. The secondary surge protector will be a multi-stage hybrid utilizing various technologies

(3) The surge protection units will have both over-current and thermal safety fuses

(4) The surge protection system will reset automatically and be maintenance free

(5) The primary and secondary surge protection devices will have status indicators showing "power on", good condition and failed condition

(6) Dry contacts will be incorporated into the primary surge protection device will provide remote status indication in the event of a failure & fuse activation

(7) All wiring to/from the DMS will have "circuit appropriate" surge protectors installed at both ends, if the circuits are between the sign and controller cabinet

(8) Operational temperature rating of the surge protection system must be a minimum -30ºF to +140ºF

4. Equipment specifications.

A. The Contractor must comply with these specifications in addition to the above requirements. The specifications are intended to supplement and clarify the functional requirements. Notify the Engineer of any apparent conflict between the requirements and specifications and request clarification.

B. DMS specifications.

(1) DMS housing

(a) The DMS housing must be constructed to present a clean, neat appearance

(b) The DMS housing will be 38 inches plus or minus 4.5 inches wide (depth) at the bottom of the housing containing a 24 inch wide plus or minus 2 inches interior walkway manufactured of pre-approved, removable flat aluminum panels with non-skid material applied to the walkway's surface. The interior walkway must give an absolute minimum of 6 feet of head clearance within the sign housing for the length and width of the walkway area. The interior walkway must extend the entire interior length of the DMS

(c) The housing must be furnished with a housing entrance door at one end of the sign; the location of the door is to be as depicted on the proposed MDOT standard DMS Structure drawing attached to this Special Provision

(d) The housing entrance doors must have three-point latching systems, with closed cell resilient gasket material applied for weather proofing. Door locks will be standard #2 key locks and pad lock capable

(e) The DMS housing must be fabricated from a minimum 0.125 inch thick aluminum alloy 5052-H32 and must be designed to withstand an ice load as specified in the latest AASHTO LTS-4 publication entitled “Standard Specification for Structural Supports for Highway Signs, Luminaries and Traffic Signals”, with most recent interims or versions

(f) All exterior seams and joints will be continuously welded by an inert gas welding process. The exterior housing panel material will be stitch welded to the internal structural members to form a unitized structure according to standards specified by the American Welding Society (AWS)

(g) Exterior mounting assemblies are to be fabricated from aluminum alloy 6061 T6 extrusions with a minimum thickness of 0.1875 inches

(h) Interior structure framing members are to be fabricated from aluminum alloy of 6061 T6 or 6063 T5 minimum thickness of 0.1875 inches

(i) Gasket channels, dual tracks and all supports welded to the housing must be fabricated of 0.1875 inch minimum thickness aluminum sheet. Bolted-on supports must be both the same material and thickness as the housing. Two dual tracks for screen assembly must be made of the same material and thickness as the housing

(j) A border made of the same material as the housing must encompass the LED matrix module section/array and enclose any open areas around the section/array. The border must be uniform and must be painted or treated

(2) Front face construction

(a) Unless otherwise approved by the Department, the DMS front face will be constructed with multiple rigid panels. Each panel supports and protects a full-height section of the LED display matrix. The panels will be fabricated using aluminum sheeting on the exterior and polycarbonate sheeting on the interior of the panel

(b) Front face panels are to provide a high-contrast background for the DMS display matrix. The aluminum mask of each panel will be semi-gloss black polyvinylidene fluoride (PVDF) coated and will contain an opening for each pixel. Openings must be large enough to not block any portion of the viewing cones of the LEDs

(c) Face panels will be attached to each other using stainless steel hardware. Seams that separate adjacent panels will be sealed. Panels will not be welded or otherwise permanently mounted to the DMS housing. Panels will be mounted in such a way that they are removable from the interior of the DMS housing

(d) Each panel will have a single polycarbonate sheet attached securely to the inside of the aluminum panel. The polycarbonate sheet will cover all of the pixel openings. The polycarbonate will be sealed to prevent water and other elements from entering the DMS. The polycarbonate will contain UV inhibitors that protect the LED display matrix from the effects of ultraviolet light exposure and prevent

premature aging of the polycarbonate itself. Polycarbonate sheets will have the following characteristics:

(i) Tensile Strength, Ultimate: 10,000 PSI
(ii) Tensile Strength, Yield: 9,300 PSI
(iii) Tensile Strain at Break: 125%
(iv) Tensile Modulus: 330,000 PSI
(v) Flexural Modulus: 330,000 PSI
(vi) Impact Strength, Izod (1/8 inch, notched): 17 ft-lbs/inch of notch
(vii)Rockwell Hardness: M75, R118
(viii) Heat Deflection Temperature Under Load: 264 PSI at 270F and 66 PSI at 288F
(ix) Coefficient of Thermal Expansion: 3.9X10-5 in/in/F
(x) Specific Heat: 0.30 BTU/lb/F
(xi) Initial Light Transmittance: 85% minimum
(xii)Change in Light Transmittance, 3 years exposure in a southern latitude: 3%
(xiii) Change in Yellowness Index, 3 years exposure in a southern latitude: less than 5%

(e) LED display modules will mount to the inside of the DMS front face panels. Common hand tools will be used for removal and replacement

(f) DMS front face borders (top, bottom, left side, and right side), which surround the front face panels and LED display matrix, will be black to maximize display contrast and legibility

(g) In the presence of wind, the DMS front face will not distort in a manner that adversely affects LED message legibility

(h) Each adjacent panel must be alternately mounted into one of two dual tracks attached to the front face of the DMS and located above and below the LED matrix module section. There must be a series of latches to lock the panels into a fixed position with adjacent side frames overlapping in order to minimize the blockage of LEDs

(i) If overlapping side frame panels are used, provide each panel with dampening materials to reduce vibration between the overlapping side frames of adjacent panels

(j) If overlapping side frame panels are used, they must be made of aluminum or stainless steel material and the means of latching the panels will use only common hand tools

(k) The DMS will be resistant, either by active or passive subsystem, to fog and frost on front face of the DMS

(3) Front face finish

(a) The front of the housing must be finished semi-gloss black. The sign face and all its parts must be coated with PVDF

(b) The PVDF coating is to be applied by the PVDF manufacturer's certified applier

(c) All other surfaces exposed to the atmosphere must be left their natural finish

(d) No open seams are allowed. All seams must be continuous welds with their water-tightness verified by water spray test

(4) Ventilation

(a) The DMS will contain an electronically-controlled ventilation system designed to keep the internal DMS air temperature lower than +140°F, when the outdoor ambient temperature is +115°F or less

(b) The sign must be designed to meet or exceed all International Mechanical (IM) standards (formally BOCA, ICBO and SBCCI) for human occupation.

(c) Air intake port(s) will be designed and located at optimum location(s) within the housing to comply with IM standards

(d) The Contractor must submit the DMS vendor's ventilation calculations that verify that the DMS meets all IM standards for human habitation

(e) Fans and air filters will be removable and replaceable from inside the DMS housing. To ease serviceability, the fans will be mounted at a pre-approved location that does not obstruct other subsystems while meeting ventilation requirements

(f) All intake and exhaust port openings will be screened to prevent the entrance of insects and small animals

(g) The sign housing will contain two electronic temperature monitoring devices to ensure failsafe monitoring of the interior temperature. The temperature monitoring devices will be wired independently. Failure of either device will cause an alarm message to be transmitted to the appropriate central control center

(h) A manual override timer switch will be located just inside the access door to manually activate the ventilation system. The switch will be adjustable from 0 to 4 hours minimum.

(i) The intake air filter media must be readily available from at least three sources. The manufacturer recommended minimum filter replacement cycle must be a minimum of once every two months to a maximum of once every six months

C. Sign controller hardware and functional specifications.

(1) Each DMS will use an associated sign (local) controller. The sign controller and associated communication equipment may be installed using one of the following

methods:

(a) Inside a ground-mounted ITS cabinet located near the sign
(b) Inside a pole-mounted ITS cabinet attached to the DMS support structure

(2) The sign controller will have the following characteristics:

(a) Stand-alone microprocessor-based unit with integrated watchdog circuitry

(b) Internal regulated DC power supply

(c) Memory for storing changeable and permanent messages, schedules, and other necessary files for controller operation

(d) Includes front panel user interface with LCD and keypad for direct operation and diagnostics

(e) Mounts in a standard EIA 19-inch (480 mm) equipment rack using supplied mounting hardware

(f) Maximum weight of 10 pounds, including its enclosure

(g) Minimum one NTCIP-compliant RS-232 communication port for serial communications. One of the serial ports will have a secondary RS-422 interface option

(h) One Ethernet port with RJ-45 connector supporting NTCIP communication.

(i) Built-in Hayes-compatible modem with standard RJ-11 connector

(j) Operate successfully throughout a temperature range of -29.6°F to 165°F.

(k) Communicate directly with the distribution board located in the DMS, which communicates with all sensors, LED driver circuit subsystem, and other devices

(l) Include DMS-specific control firmware (embedded software) that will handle all external and internal sensors and communication inputs and drive the display modules as directed by external control software

(3) The sign controller will have non-volatile, changeable memory. This memory will be formed by a combination of Flash RAM and battery-backed static RAM integrated circuits that retain the data in memory for a minimum of 30 days following a power failure. This changeable memory will be used to store messages and schedules. The minimum number of changeable messages that can be stored within the sign controller will be 500

(4) Front panel user interface

(a) The sign controller's front panel will include a keypad and LCD. These devices will be used to perform the following functions with the sign controller and DMS:

(i) Monitor the current status of the sign controller, including the status of all sensors and a representation of the message visible on the display face

(ii) Perform diagnostics testing of various system components, including as a minimum, pixels, power systems and sensors

(iii) Activate messages stored in memory

(iv) Configure display parameters, including display size, colors and communications

(b) The front panel interface will also include:

(i) Power switch to turn the controller on and off and an LED “on” indicator

(ii) A “local/remote” switch with an LED indicator that places the controller in local mode such that it can be controlled from the front panel interface, instead of via the primary communication channel

(iii) Reset switch to quickly restart the controller

(iv) LED “Active” indicator blinks when the controller is operating

(v) LED to indicate when any of the NTCIP communication channels are active

(vi) A “local” serial communication port that will allow connecting a laptop directly to the controller

(5) Sign controller battery backup

(a) The DMS sign controller located within the ITS cabinet will be connected to a rechargeable battery backup system (UPS) that will allow the controller to operate for a minimum 30 minutes if the incoming AC power source fails. The UPS will supply power sufficient to backup all internal systems of the DMS sign controller, including RS-232, Ethernet and dialup modem communications components.

(6) Sign controller display interface

(a) The DMS sign controller will transmit and receive data packets to and from a distribution board. The distribution board will communicate with all sensors, drivers, and other devices using multiple networks running throughout the DMS

(b) Data transferred will include pixel states, sensor values, and I/O readings from various devices, such as door sensors and power supply monitors. Pixel data will include the states to be displayed on the sign face as well as diagnostic data retrieved from the LED driver circuit subsystem

(c) Communication from the sign controller to the distribution board will be using fiber optic cables or copper communications cable that connects the DMS sign controller to the DMS driver board subsystem

(7) Sign controller addressing

(a) The DMS sign controller will use multiple types of addressing when operating on NTCIP communication networks. The addressing will be configurable through the front panel user interface

(b) When operating over PMPP serial networks (NTCIP 2101), the controller's address will be configured in the range 1 to 255. The default address will be 1

(c) When operating on Ethernet networks (NTCIP 2104) a static IP address and subnet will be used

(d) If a dial-up or direct connect serial network is configured for PPP (NTCIP 2103), then no addressing will be required

(8) DMS intensity control

(a) Variable message signs will include an LED intensity control system that uses pulse width modulation (PWM). Over 100 intensity levels will be available. The DMS sign controller will be able to automatically adjust the LED display matrix intensity. A system operator will be able to override the automatic system, in order to manually change the LED intensity

(b) The DMS intensity control will:

(i) Utilize three photoelectric sensors, which are provided and installed as described in the DMS specification. It will use these measurements to automatically determine which LED intensity level will provide the best legibility for the given ambient light condition

(ii) Select from a minimum of 100 LED intensity levels. LED intensity levels will be available in a range of 1% to 100% of the maximum display intensity, and in increments of 1%

(iii) Not cause any flickering of the LED display matrix

(iv) Allow manual and automatic intensity control modes to be user selectable using the DMS control software, although the typical control mode will be "automatic"

(v) Allow manual intensity control from both local and remote locations

(9) LED diagnostic test capability.

(a) Upon command from either a remote computer or local laptop running the central control software, the sign controller will test the operation of all LED pixels and determine whether their functional status is: "normal" or "stuck-off". Pixel status will be determined via A/D conversion of the LED pixel forward voltage, and the resulting data will be communicated to the DMS control software.

(b) The resulting data will be monitored via the front panel and will be transferred to the NTCIP interfaces.

(10) Real-time DMS message verification

(a) The DMS sign controller and LED module hardware will be capable of

enabling the DMS central control operator to verify the actual message displayed on the DMS on a real-time basis

(b) This message verification will be presented in a WYSIWYG format without disrupting the message displayed on the DMS

(c) WYSIWYG will be performed automatically each time the DMS is polled for status by the central control software

(11) Power supply diagnostic test capability

(a) The sign controller will be able to determine the functional status of regulated DC power supplies located in the DMS by monitoring diagnostic outputs located on the supplies

(b) This information will be reportable as “pass” or “fail” to the DMS control software

(12) Response to errors

(a) In the event of communication error between the DMS sign controller and the system control computer; the “communications loss message” will be displayed. This will be factory disabled

(b) In the event of a power failure, the “power recovery message” will be displayed. This will be factory set to blank the DMS

(c) The DMS sign controller will contain a hardware watchdog that automatically resets the controller’s microprocessor in the event of a controller lock-up

(13) Over temperature shutdown

(a) The DMS will utilize an internal temperature sensor circuit that will be monitored by the sign controller

(b) The DMS will be capable of being configured to automatically blank the sign face if the internal temperature of the DMS exceeds a configurable threshold

(c) If this occurs, the sign controller will also notify the central control system

(14) Auxiliary control panel

(a) The DMS will include a 19 inch rack mountable or shelf mountable auxiliary control panel that will provide a secondary user interface panel for DMS control, configuration, and maintenance

(i) The auxiliary control panel will meet the same electrical, mechanical, and environmental specifications as the DMS controller

(ii) The auxiliary control panel will have an LCD panel and keypad identical to those found on the DMS controller

(iii) The ACP will interface with the DMS controller and provide sign control through the ACP key pad and LCD

(iv) The auxiliary control panel will include an identical menu system to the DMS controller with all of its features and functionality

(v) The auxiliary control panel is to be mounted inside the DMS housing

(15) Messaging

(a) Static RAM capacity:

(i) Minimum storage of 200 preprogrammed messages
(ii) Minimum storage of 100 user-originated messages
(iii) Minimum storage of 50 message sequences
(iv) Maintain a stored message list

(b) The sign must have the capability to display up to four messages in sequence with Dynamic timing in 500 millisecond maximum increments under computer control. The entire sign must completely change all lines of message copy in not more than 500 milliseconds.

(c) Control programming to present sequenced messages under operator control through keyboard entry.

(d) Full support of the most current adopted NTCIP standards for messages, storage of messages and communication is required

(16) Display

(a) Discrete light-emitting diode (LED) specification

(i) The LED will have a 15 degree viewing angle for freeway DMS. All 15 degree LEDs will have a nominal viewing cone angle of 15 degrees with a half-power angle of 7.5 degrees measures from the longitudinal axis of the LED. Viewing cone tolerances will be as specified in the LED manufacturer's product specifications and will be calculated by using the formula 2*Θ*1/2°.

(ii) Discrete LEDs will be manufactured by either the Toshiba Corporation or Avago Technologies formally Agilent Technologies. Substitutes will not be accepted. Discrete LEDs will conform to the following specifications:

1) LEDs will be non-tinted, non-diffused, high-intensity, solid-state lamps that utilize AlInGaP semiconductor technology
2) LED lenses will be fabricated from UV light resistant epoxy
3) The LED lens diameter will be 0.2 inches
4) LEDs will emit amber light that has a peak wavelength of 590 ± 5 nm LEDs will be obtained from no more than two consecutive color "bins"

(iii) The LED manufacturer will perform color sorting of the bins

1) LEDs will be obtained from no more than two luminous intensity "bins" The LED manufacturer will perform intensity sorting of the bins

2) The various LED color and intensity bins will be distributed evenly throughout the sign and will be consistent from pixel to pixel. Random distribution of the LED bins will not be accepted

3) All LEDs used in all DMS provided for this contract will be from the same manufacturer and of the same part number

4) The LEDs will be driven with a nominal current of 20mA

(b) Discrete pixel specification

(i) Each pixel will be a maximum of 1.375 inches ± 0.1 inches in diameter.for 15 degree LED DMS applications

(ii) Pixels will be spaced at 2.6 inches ± 0.2 pixel center to pixel center

(iii) The LEDs in each pixel will be clustered to maximize long-range visibility

(iv) Each pixel's intensity will be a minimum of 40 candelas. The brightness of each LED will be measured in accordance with the International Commission on Illumination (CIE) requirements detailed in Test Method A of the CIE 127 (1997) standard. The LED brightness and color bins that are used in each pixel will be provided to the engineer for approval. A letter of certification from the LED manufacturer that demonstrates testing and binning according to the CIE 127 (1997) standard will be provided with the submittals

(v) All pixels in all signs in a project, including spare parts, will have equal color and on-axis intensity

(c) Dual or Parallel LED Strings

(i) A pixel will contain dual or parallel strings of LEDs. The pixel strings will be powered from a regulated power source. The LED drive current will be no greater that the LED manufacturer recommended maximum drive current. The failure of an LED in one string within a pixel will not affect the operation of any other string or pixel. The LEDs will be individually mounted directly on a PCB, and will be easily replaceable and individually removable using conventional electronic repair methods. Pixels in which the LEDs are encapsulated will not be permitted

(d) Uniformity of brightness

(i) All LEDs will be mounted so that their mechanical axis is normally ± 1 degree to the sign's face to ensure uniformity of brightness over the sign's face.

(e) DMS Message Panel

(i) The DMS panel message background must be flat black in color

(ii) The sign panel must be designed so that external light reflection is minimized

(f) LED module panel

(i) The panel must be fabricated such that the structure integrity is maintained in all environmental conditions

(ii) Each LED display module will consist of one LED pixel board and a connection to a LED driver circuit subsystem. They will be electrically connected via one or more header-type connectors. The header connectors will be keyed such that the boards cannot be connected incorrectly

(iii) Each LED display module will be mounted to the rear of the display's front face panels using durable, non-corrosive hardware. No tools will be required for module removal and replacement. The modules will be mounted such that the LEDs emit light through the face panel's pixel holes and such that the face panel does not block any part of the viewing cone of any of the LEDs in any pixels

(iv) LED display module power and signal connections will be a quick-disconnect locking connector type. Removal of a display module from the DMS, or a pixel board from its display module, will not require a soldering operation

(v) Removal or failure of any LED module will not affect the operation of any other LED module or sign component. Removal of one or more LED modules will not affect the structural integrity of any part of the sign

(vi) It will not be possible to mount an LED display module upside-down or in an otherwise incorrect position within the DMS display matrix

(vii)All LED display modules, as well as the LED pixel boards and driver circuit subsystem boards, will be identical and interchangeable throughout the DMS

(g) Dynamic message sign internal interface panel

(i) Service equipment and conductors must be separated and isolated from the controller interface terminal blocks and harness

(ii) The equipment ground must be connected directly to the DMS frame

(iii) The driver circuit subsystem 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

(iv) Constant current LED driver IC's will be used to prevent LED forward current from exceeding the maximum discrete LED drive current defined by these specifications when a forward voltage is applied

(v) The LED pixels will be directly driven using pulse width modulation (PWM) of the drive current to control the display intensity. This LED driver circuitry will vary the current pulse width to achieve the proper display intensity levels for all ambient light conditions. The drive current pulse will be modulated at a frequency high enough to provide flicker-free operation and a minimum of 200 brightness levels

(vi) The power regulation circuit will monitor the incoming power supply feeds and automatically select one or more of them to power the LEDs. If any of the incoming power sources fail, the power system will automatically switch to one or more of the remaining power sources. The voltage of each power input will be measured to the nearest tenth-of-a-volt and reported to the sign controller upon request. The driver circuit subsystem will also visually indicate if the power source is or is not present

(vii)The LED driver circuitry subsystem will be able to detect that individual LED strings or pixels are stuck "off" and will report the pixel status to the sign controller upon request

(viii) The LED driver circuit subsystem will contain a seven-segment, numeric LED display that indicates the functional status of the driver circuit subsystem and pixel boards. At a minimum, it will indicate error states of the LED pixels and communication network. The indicator will be positioned such that a maintenance technician can easily view the status code for diagnostic purposes. The status codes will also be reported to the sign controller upon request

(ix) Light level control

1) The DMS will include sensors that monitor and report ambient (external) light level

2) The DMS will have sensors that measure the outdoor ambient light level. This ambient light measurement system will consist of three electronic light sensors

3) Two of the light sensors will be placed such that they measure the ambient light levels striking the front and rear of the DMS. The third light sensor will be mounted to the floor of the DMS housing and will face toward the ground. The DMS sign controller will continuously monitor the light sensors and adjust the LED display matrix intensity to a level that creates a legible message on the DMS face

(17) Regulated power supply

(a) The Underwriter's Laboratory (UL) report numbers for all DMS and control equipment manufactured by the DMS manufacturer will be submitted to the Department and the products will bear the UL mark.

(b) The following assemblies and their respective associated devices must electrically and mechanically inter-mate and be compatible with each other:

(i) LED driver subsystem assembly
(ii) Power distribution assembly
(iii) Power supply

(c) The electronic circuit design must be such that all components of the same generic type, regardless of manufacturer, must function equally in accordance with the specifications.

(d) Electrical.

(i) Applied Line Voltage: 120/240 VAC

(ii) Frequency: 60 (+/- 3.0) Hertz

(iii) All circuits, unless otherwise noted, must commence operation at or below 90 VAC as the applied voltage is raised from 50 VAC to 90 VAC at a rate of 2 (+/-0.5) volts per second.

(iv) All equipment, when housed with DMS sign housing, must be unaffected by transient voltages normally experienced on commercial power lines, by generators, or other anticipated power sources

(e) The LED pixel display modules will be powered with a system of redundant auto-ranging regulated power supplies

(f) Power supplies will be arranged in redundant fashion within the display such that each pair supplies power to a defined region of the sign, i.e., pixel module or row. Each pair of power supplies will contain two physically and electrically independent supplies. Power supplies must be wired in such a manner as to ensure that with the failure of one power supply, the redundant power supply will maintain uninterrupted power to the sign region or pixel module. Failure of any power supply will generate an alarm notification to the appropriate central control center

(g) Power supplies within each pair will be redundant and rated such that if one supply fails, the remaining supply will be able to operate 100% of the pixels in that display region at 100% brightness when the internal DMS air temperature is +140ºF or less

(h) The power supplies will be sufficient to maintain the appropriate LED display intensity throughout the entire operating input voltage range

(i) The output of each power supply will be connected to multiple circuits that

provide power to the LED modules. Each output circuit will not exceed 15 amperes and will be fused

(j) Each group of power supplies will be monitored by a microprocessor-controlled circuit. This circuit will monitor the voltage of each power supply and the status of each output circuit's fuse. The power supply voltages and fuse states will be reported via a controller area network (CAN) communication network to the sign controller upon request

(k) The power supplies used to power the LED pixel modules will be identical and interchangeable throughout the DMS

(l) Regulated DC power supplies will conform to the following specifications:

(i) Nominal output voltage of 24 VDC +/- 10%
(ii) Nominal maximum output power rating of 1000 watts
(iii) Operating input voltage range will be a minimum of 90 to 260 VAC
(iv) Operating temperature range will be a minimum of -30ºF to +165ºF
(v) Maximum output power rating will be maintained over a minimum temperature range of -30ºF to +140ºF
(vi) Power supply efficiency will be a minimum of 80%
(vii)Power factor rating will be a minimum of 0.95
(viii) Power supply input circuit will be fused
(ix) Automatic output shut down and restart if the power supply overheats or one of the following output faults occurs: over-voltage, short circuit or over-current.
(x) Power supplies will be UL listed

D. Communication specifications

(1) The DMS sign controller will contain a minimum of one 10/100Base-T Ethernet communication port. This port will be available for optional use for communicating from the central control system to the DMS sign controller when an Ethernet network is available. The Ethernet port will be a standard RJ-45 jack.

(2) The DMS equipment and software must comply with the most recent version of the following standards, including all recommended or approved amendments, in effect as of the bid date:

(i) NTCIP 1101, NTCIP Simple Transportation Management Framework (STMF)
(ii) NTCIP 1103, NTCIP Transportation Management Protocol (TMP)
(iii) NTCIP 1201, NTCIP Global Object (GO) Definitions
(iv) NTCIP 1203, NTCIP Object Definitions for Dynamic Message Signs (DMS)
(v) NTCIP 2202, NTCIP Internet (TCP/IP and UDP/IP) Transport Profile
(vi) NTCIP 2301, NTCIP AP-STMF

E. Software and NTCIP documentation

(1) Any and all software provided must be supplied with full documentation in hard

copy and on CD-ROM. The manufacturer must allow the use of any and all of the documentation described above by any party authorized by MDOT for system integration purposes; system maintenance; or system enhancement at any time; regardless of what parties are involved in the system integration effort.

(2) The Contractor must supply full documentation on a CD-ROM containing ASCII versions of the following management information base (MIB) files in Abstract Syntax Notation 1 (ASN.1) format

(3) If the device does not support the full range of any given object within a standard MIB module, a manufacturer-specific version of the official standard MIB module with the supported range indicated in ASN.1 format in the “syntax” and/or “description” field of the associated object type macro. The filename of this file must be identical to the standard MIB Module, except that it must have the extension “.man”

c. Construction.

1. The DMS Vendor is required to provide permanent power to the DMS within 72 hours of delivery.

2. The delivered DMS, when stored at the site, must be place on blocks thereby keeping the sign off the ground.

3. The DMS Vendor is to supply all mounting bracket and required Z-bars for the permanent mounting of the DMS.

4. If the lifting eyebolts are removed from the DMS after installation, bolts will be supplied to plug and seal the holes to prevent water from entering the DMS housing.

5. Warranty.

A. The DMS system must carry a manufacturer’s standard warranty (parts, labor, any required MOT) of five years from the date of final acceptance. The Contractor is required to supply a DMS factory-trained Technician to observe and oversee the DMS and ACP installation process for each sign. The technician is to verify that the installation practices follow the DMS vendor’s Standard Operating Procedure (SOP) and during the installation did not in any way void or limit the DMS vendor’s warranty. Once released by the Department and with the Contractor technician’s approval, the DMS Warranty will begin. The Contractor warrants that:

(1) All Work furnished pursuant to the Contract Documents will conform to all professional engineering principles generally accepted as standards of the industry in the State

(2) The Project will be free of defects

(3) Materials and equipment furnished under the Contract Documents will be new when installed

(4) The Work will meet all of the requirements of the Contract Documents

(5) The specifications and/or drawings selected or prepared for use during construction are appropriate for their intended use

(6) The Project will be fit for use for the intended function

d. Measurement and Payment. The Contractor will be paid for at the contract unit prices for the following contract items:

Contract Item	**Pay Unit**
Dynamic Message Sign, Large	Each

Dynamic Message Sign, Large will be measured as each sign furnished, installed, and integrated into the ITS Network. Dynamic Message Sign, Large will include walk in, front access and rear access as specified in plans and pay items.