WEST VIRGINIA DEPARTMENT OF TRANSPORTATION

DIVISION OF HIGHWAYS

SPECIAL PROVISION

FOR

STATE PROJECT NUMBER: ____________________________

FEDERAL PROJECT NUMBER: ____________________________

SECTION 667

LED DYNAMIC MESSAGE SIGNS
FRONT ACCESS DOOR
AMBER AND / OR RGB FULL MATRIX

667.1 – DESCRIPTION:

This work shall consist of furnishing and installing various types of Dynamic Message Sign systems. It shall include, but not be limited to, dynamic message signs and the related communications equipment between the sign and the Traffic Management Center to be installed in accordance to this Specification, as shown on the Plans or as directed by the Engineer.

All electrical work shall conform to current requirements of the National Electrical Code, latest edition, all local codes and Section 631 of the Standard Specifications.

All details not specified or not shown on the Plans shall conform to the requirements of the latest issue of the Manual on Uniform Traffic Control Devices, (referred to as the MUTCD). This Manual is published by the Federal Highway Administration of the U.S. Department of Transportation and supplemented by the publication "Official Ruling on Request" and the West Virginia Division of Highways Traffic Engineering Division Directives.

667.1.1 – Glossary: The following abbreviations and definitions shall govern this specification:

- **AASHTO** – American Association of State Highway and Transportation Officials

- **AllInGaP** – Aluminum Indium Gallium Phosphide - Refers to the chemical composition of an LED.

- **ANSI** – American National Standards Institute

- **AWS** – American Welding Society
- **Bin** – Group of LEDs categorized and sorted by intensity or color. Each “bin” has upper and lower intensity or color specifications and contains only LEDs that are measured to be within that range. LED manufacturers sort LEDs into bins to ensure consistent intensity and color properties.

- **Control Computer/ Central Controller** – A desktop or laptop computer used in conjunction with DMS control software to communicate with DMS sign controllers. The control computer can instruct a DMS sign controller to program and control the DMS, monitor DMS status, and run DMS diagnostic tests. A control computer can be used for remote control of one of more DMS, as well as for local control of a single DMS.

- **Display** – Same as message.

- **Dynamic Message Sign (DMS)** – An industry term that applies to various types of changeable sign technology, such as DMS, CMS and BOS. It includes the following major components: sign face, sign housing, controller, and if present, the controller cabinet.

- **Font** – The style and shape of alphanumeric characters that are displayed on the DMS matrix to create messages viewed by motorists and travelers.

- **Frame** – see page

- **FSORS** – An NTCIP term meaning “Full, Standardized Object Range Support.” See the NTCIP standards for additional information.

- **GUI** – Graphical user interface

- **ITE** – Institute of Transportation Engineers

- **ITS** – Intelligent Transportation System

- **LED** – Light Emitting Diode

- **Message** – Information displayed on the DMS for the purpose of visually communicating with motorists. A DMS message can consist of one or more pages of data that are displayed consecutively.

- **Management Information Base (MIB)** – Set of object definitions that define the attributes, properties and controllable features of devices on a network, which can be remotely monitored, configured and controlled. The information is provided in a format called Abstract Syntax Notation 1 (ASN.1), which is an international standard for defining objects.

- **Module** – Assembly consisting of a two-dimensional LED pixel array, pixel drive circuitry, and mounting hardware. Modules are installed in the display
adjacent to each other to form the display matrix.

- **NEMA** – National Electrical Manufacturers Association
- **NCHRP** – National Cooperative Highway Research Program
- **NTCIP** – National Transportation Communications for ITS Protocol
- **Object** – An NTCIP term referring to an element of data in an NTCIP-compatible device that can be manipulated to control or monitor the device.
- **Page** – An NTCIP term referring to the data that is displayed on the DMS display matrix at a given moment in time. Also referred to as a “frame”.
- **Pitch** – Distance measured from center to center of adjacent pixels within a matrix. This distance is measured both horizontally and vertically.
- **Pixel** – Any of the small discrete elements that, when arranged in a pixel matrix, create a character. A pixel contains a cluster of LEDs.
- **PMPP** – Point to multi-point protocol
- **PPP** – Point to point protocol
- **Pole** – The central controller and laptop computer are said to “poll” a sign when they request the sign’s status information. The term is derived from the periodic status polling which a central controller can perform, but is loosely used to refer to any status request.
- **PWM** – Pulse width modulation
- **RGB** – Red, Green, and Blue
- **Schedule** – A set of data that determines the time and date when a DMS sign controller will cause a stored message to be displayed on the DMS
- **Sign** – The sign housing and its contents.
- **Sign Controller** – A stand-alone computer that is located at a DMS site, which controls a single DMS. A sign controller received commands and sends information to a control computer. The controller can be located in a ground cabinet or in the sign (as detailed in the plans).
- **Stroke** – Refers to the vertical and horizontal width of the lines and curves of a display font. “Single stroke” denotes character segments that are one pixel wide. “Double stroke” denotes character segments that are two pixels wide.
- **True Message Display Verification (TMDV)** – The ability of the DMS to display the state of each pixel as it is currently displayed to the motorist, including any errors. The TMDV is an actual real time read of the current
flowing through each string of LEDs at the time of the associated sign poll or message download, rather than a simulation of errors based on the last pixel test.

- **Variable Message Sign (VMS)** – A type of DMS that is fully programmable such that the content of its messages are fully changeable remotely and electronically.

- **WYSIWYG** – *What You See Is What You Get*. More specifically, what you see on the DMS control computer monitor is a scaled representation of how a message will appear when it is being displayed on the DMS. Similarly, after a pixel diagnostic test routine has been run, what you see on the control computer monitor is a scaled representation of the functional status of each pixel in the DMS display matrix.

667.1.2 – Manufacture Requirements: This section describes the minimum qualifications required for a dynamic message sign manufacturer to be selected. This section also details the product documentation that must be provided by the contractor.

667.1.2.1 – Manufacture Qualifications:

To be valid for these experience requirements, the LED DMS must meet this specification and be designed for State Highway or Interstate Highway use.

Non-LED DMS, hybrid DMS, lift-face DMS, non-highway DMS, portable DMS, indoor DMS, smaller DMS and commercial DMS will not satisfy these experience requirements. A DMS manufacturer must meet these minimum qualifications prior to bidding.

Manufactures shall meet the following requirements:

1. Have been in the business of manufacturing large outdoor permanently mounted LED DMS, which are used to manage vehicular roadway traffic, for minimum period of ten (10) years prior to the contract bid date.
2. Have in operation a minimum of one hundred (100) large outdoor permanently mounted LED DMS as defined above. Each of these DMS shall have successfully operated for a minimum period of three (3) years prior to the contract bid date.
3. Have in operation as of the contract bid date a minimum of ten (10) State or City Department of Transportation (DOT) owned and operated LED DMS systems. Each of the ten (10) systems shall use the NTCIP as their primary communication protocol. Each of the DMS signs shall be communicating over dial-up telephone, cellular telephone, spread spectrum radio, and/or fiber optic networks.
4. Utilize a documented in-house quality management system that has been in place for no less than five (5) years prior to the contract bid date.
5. Have been in business under the same corporate name for a period of no less than ten (10) years prior to the contract bid date.
6. Have previously demonstrated that their DMS controller is NTCIP compliant via compliance testing performed by an independent 3rd party testing organization. The testing shall have been completed using industry accepted test tools such as
the NTCIP Exerciser, Trevilon’s NTester, Intelligent Devices’ Device Tester, and/or Frontline’s FTS for NTCIP.

7. Utilize a documented certified welding procedure.

667.1.2.2 – Material, Manufacturing and Design Standards: The design of the DMS shall comply with the following standards. If no revision date is specified, the most recent revision of the standard applies:

1. General DMS Requirements – The DMS shall be designed in accordance with NEMA Standards Publication TS 4, Hardware Standards for DMS, with Requirements.

2. Aluminum Welding – All welding shall be by an inert gas process and shall be designed, fabricated, welded and inspected in accordance with ANSI/AWS D1.2/D1.2M Structural Welding Code for Aluminum.

3. Electrical Components – High-voltage components and circuits (120 VAC and greater) shall be designed, wired, and color-coded per the National Electric Code (NEC).

4. Environmental Resistance – The DMS housing shall be designed to comply with type 3R enclosure criteria as described in NEMA Standards Publication 250-2003, Enclosures for Electrical Equipment (1000 Volts Maximum).

5. Product Electrical Safety – All DMS and associated equipment and enclosures shall be listed by the Underwriters Laboratories (UL) and shall bear the UL mark. DMS shall be listed as conformant to UL 48 Standard for Electric Signs and UL 50 Enclosures for Electrical Equipment. Control equipment and enclosures shall be listed as conformant to UL 1433 Standard for Control Centers for Changing Message Type Electric Signs.

6. Radio Frequency Emissions – All equipment shall be designed in accordance with Federal Communications Commission (FCC) Part 15, Subpart B as a “Class A” digital device.

7. Maintenance Access and Safety – The DMS equipment provided shall be compliant with all relevant OSHA requirements.


10. Communication Protocols – The sign controller hardware/firmware and DMS control software shall conform to the applicable National Transportation Communication for ITS Protocol (NTCIP) standards. Refer to the NTCIP section of this specification for detailed NTCIP requirements for this contract.

11.
667.1.2.3 – Pre Build Product Testing: The DMS manufacturer shall provide documentation indicating that the DMS product has been tested to the following standards. It shall be acceptable for the testing to be performed on scale-sized versions of the actual DMS provided that the test unit is functionally and structurally equivalent to the full size DMS.

Third party test reports shall be submitted for the following testing:

1. NEMA Standards Publication TS 4, Hardware Standards for Dynamic Message Signs (DMS), with NTCIP Requirements – Section 2, Environmental Requirements. Test report shall detail results of mechanical vibration and shock, electrical noise and immunity, temperature, and humidity.
2. Underwriters Laboratories (UL), UL 48 Standard for Electric Signs, UL 50 Enclosures for Electrical Equipment, and UL 1433 Standard for Control Centers for Changing Message Type Electric Signs. The UL report number(s) for all DMS and control equipment manufactured by the DMS manufacturer shall be listed by the UL or an accredited 3rd party testing organization such as ETL Semko, and shall bear the organization’s mark.
3. NTCIP Standards:
   A. NTCIP 1101:1996, and Amendment 1 – Simple Transportation Management Framework (STMF)
   C. NTCIP 1201:1996, and Amendment 1 Global Object (GO) Definitions
   D. NTCIP 1203:1997 and Amendment 1 Object Definitions for Dynamic Message Signs
   E. NTCIP 2001:1996 and Amendment 1, Class B Profile
   F. NTCIP 2101:2001, Point to Point Protocol (PMPP) Using RS-232 Subnetwork Profile
   G. NTCIP 2103:2003, Point to Point Protocol (PMPP) Using RS-232 Subnetwork Profile
   H. NTCIP 2104:2003, Ethernet Subnetwork Profile
   I. NTCIP 2201:2003, Transportation Transport Profile
   J. NTCIP 2202:2001, Internet (TCP/IP and UDP/IP) Transport Profile
   K. NTCIP 2301:2001, Simple Transportation Management Framework (STMF) Application Profile

667.1.2.4 – Pre Build DMS Housing Structural Certification

A Professional Engineer registered in the State of West Virginia shall analyze the DMS structural/electrical design and shall certify that the DMS:

1. Will withstand the temporary effects of being lifted by the lifting eyebolts provided
2. Will comply with the applicable requirements of AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic...

3. Will support a front face ice load of 4 pounds per square foot (19.5 kg/square meter)


The Professional Engineer shall analyze the complete DMS structural design. This includes the housing, mounting brackets, and lifting eyebolts, as well as the bracket-to-housing mounting hardware (nuts, bolts, washers, direct tension indicators, etc.) provided by the DMS manufacturer. Analysis shall include, but shall not be limited to:

1. The quantity and type of lifting eyebolts to be provided
2. The quantity and type of mounting brackets to be provided
3. The quantity and type of hardware (nuts, bolts, washers) used to attach the mounting brackets to the DMS
4. Verification that no dissimilar metals problem will exist and/or affect the structural integrity of the DMS-to-bracket attachment points
5. A recommendation of the number of attachment points, as well as the attachment locations, that the installing contractor should use when mounting the DMS to its support structure

The DMS manufacturer shall include a signed and sealed copy of this P.E. certification, including all supporting calculations, with the pre-build technical submittal.

667.1.2.3 – Pre-Build Technical Submittal

The DMS manufacturer shall provide a complete pre-build technical submittal within 30 days of contract award and shall not proceed with DMS manufacture until the Engineer has approved the submittal. The DMS manufacturer shall provide five (5) copies of the submittal both in electronic format on CD and in paper format in three-ring binders.

The submittal shall include:

1. All DMS manufacturer qualification information, as specified herein.
2. DMS shop drawing, including an illustration of the recommended installation method.
3. DMS structural calculations and certification by a registered professional engineer from the State of West Virginia.
4. DMS site riser diagram.
5. AC site power requirements, including the number of legs, current draw per leg, and maximum and typical site power consumption.
6. Major DMS schematics in block diagram form, including AC power distribution inside and outside the DMS, DC power distribution within the DMS, and control signal distribution inside and outside the DMS.
7. Drawings of major DMS components, including LED display modules, driver boards, control/logic components, environmental control assemblies, DMS sign controller, control equipment cabinet assembly, and control cabinet mounting footprint.
8. Catalog cut sheets for major DMS components, including front face paint
material, polycarbonate face material, LEDs, regulated DC power supplies, circuit board conformal coating material, hookup wire, signal cable, surge suppression devices, load center, circuit breakers, utility outlets, sign controller, ventilation/cooling fans, heaters, ventilation filter, thermostats, and any other major system components.

9. Test reports and certification for all items identified in the “Product Testing” specifications herein.

10. DMS control software operator’s manual.

Documentation that proves the DMS manufacturer complies with these specifications shall be provided with the DMS manufacturer’s pre-build technical submittal. A cross-matrix shall be provided that lists each specification point and indicates whether the manufacturer meets that requirement.

This submittal shall also include three (3) references from states that have had NTCIP-compliant DMS from the manufacturer installed for a minimum of two (2) years and project information for all of the manufacturer’s DMS customers of the last five (5) years, including:

1. Equipment owner/operator agency name.
2. Contact person name, telephone number, fax number, and email address.
3. DMS system name and location of operations control center (project name/number, roadway name/number, state, county, and country).
4. DMS commissioning date (first date of successful on-site operation).
5. DMS quantity.
6. DMS display pixel technology (LED, fiber optic, flip disk, etc.).
7. DMS display matrix size (pixel rows by pixel columns) and type (full matrix, line matrix, or discrete character).
8. DMS housing access type (walk-in, front, rear, or other specific access type).
9. Communications protocol used (NTCIP or proprietary; if proprietary, provide a name or description).
10. Type of communications backbone used (telephone, fiber optic, direct, etc.).
11. NTCIP compliance test reports prepared by independent testing companies, including contact information.

The pre-build submittal shall also include the following background information about the DMS manufacturer:

1. Full corporate name.
2. Corporate address.
3. Contact person name, telephone number, fax number, and email address.
4. Names and qualifications of the primary project team members, including the following: sales person, project manager, product manager, application engineer, and manufacturing manager.
5. Number of years in business under the current corporate name.
6. Copy of the DMS manufacturer’s in-house quality management system.
7. Copy of the DMS manufacturer’s certified welding procedure.
8. Copy of welding certifications for all personnel who will perform welding of the DMS housing.
10. DMS product literature.

Failure to provide complete and accurate submittal information, as specified herein, will be cause for rejecting the DMS manufacturer.

667.2 – MATERIALS:

All materials furnished, assembled, fabricated or installed under this item shall be new, corrosion resistant and in strict accordance with the details shown in the plans and as detailed in this specification. All details and functionality listed in this specification will be thoroughly inspected and tested by the department. Failure to meet all details and functionality detailed in this specification shall be grounds for rejection of the equipment.

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

The DMS housing shall provide front service access for all LED display modules, electronics, environmental control equipment, air filters, wiring, and other internal DMS components.

The DMS shall contain a full display matrix measuring a minimum of 96 rows high by 240 pixel columns wide. The matrix shall display messages that are continuous, uniform, and unbroken in appearance to motorists and travelers.

Each display pixel shall be comprised of multiple monochrome amber LEDs or full color RGB LEDs according to the contract plans. Other pixel technologies, such as fiber optic, flip disk, combination flip disk-fiber optic, combination flip disk-LED, liquid crystal, and incandescent lamp, will not be accepted.

The pixel matrix shall be capable of displaying alphanumeric character fonts measuring a minimum of 5.5 inches (140 mm) high to a maximum of the display matrix height.

The sign shall be designed for a minimum life of 15 years.

The sign shall be designed and constructed so as to present a clean and neat appearance. Poor workmanship shall be cause for rejection of the sign.

All cables shall be securely clamped/tied in the sign housing. No adhesive attachments will be allowed.

The DMS shall be designed and manufactured in the USA. To ensure proper service, support and logistics, US-based DMS service and support personnel are required. The bidder shall certify that it will comply with the requirements of Section 1048 of the Intermodal Surface

The complete sign housing shall be designed and manufactured in-house by the LED DMS Sign Manufacturer.

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

The DMS hardware, along with the sign controller hardware, software and firmware, shall support all DMS functionality described throughout the remaining specification sections.

The DMS assembly shall be listed by an accredited 3rd party testing organization for conformance to Underwriters Laboratories (UL) standards 48 (Standard for Electric Signs) and 1433 (Control Centers for Changing Message Signs). Proof of this conformance shall be provided with submittal materials.

The Department acknowledges there may be alternative methods to meet the intent of the specification without meeting the exact wording of the specification. The Department encourages DMS Manufacturers to propose advances in technology and alternates to meet the Department's intent. Each deviation of the written specification must be clearly shown and the benefits explained in the bid proposal. The Department reserves the right to reject any specification alternate without reason to the DMS Manufacturer.

667.2.1 Electronic Materials and Components:

All electronic components, except printed circuit boards, shall be commercially available, easily accessible, replaceable and individually removable using conventional electronics repair methods.


All electronic components shall comply with Section Electronic Materials and Construction Methods, located in this document.

667.2.1.1 Printed Circuit Boards

Printed Circuit Board (PCB) design shall be such that components may be removed and replaced without damage to boards, traces or tracks.

Only FR-4 0.062 inch minimum thickness material shall be used. Inter component wiring shall be copper clad track having a minimum weight of 2 ounces per square foot with adequate cross section for current to be carried. Jumper wires will not be permitted, except from plated-through holes to component. The maximum number of jumper wires allowed per circuit board is two.
All Printed Circuit Boards (PCBs), except for the UPS PCBs, modem PCBs shall be completely conformal coated with an acrylic resin conformal coat. The material used to coat the PCBs shall meet the military specification: MIL-I-46058C Type SR and IPC-CC-830.

All PCBs shall be finished with a solder mask and a component identifier silk screen.

667.2.1.2 Components

All components shall be of such design, fabrication, nomenclature, or other identification so as to be purchased from a wholesale electronics distributor, or from the component manufacturer, except for printed circuit board assemblies.

Circuit design shall be such that all components of the same generic type, regardless of manufacturer, shall function equally in accordance with the specifications.

All discrete components, such as resistors, capacitors, diodes, transistors, and integrated circuits shall be individually replaceable. Components shall be arranged so they are easily accessible for testing and replacement.

667.2.1.2.1 Capacitors

The DC and AC voltage ratings as well as the dissipation factor of a capacitor shall exceed the worst case design parameters of the circuitry by 50%.

A capacitor which can be damaged by shock or vibration shall be supported mechanically by a clamp or fastener.

Capacitor encasements shall be resistant to cracking, peeling and discoloration.

667.2.1.2.2 Resistors

Any resistor shall not be operated in excess of 50% of its power rating.

667.2.1.2.3 Semiconductor Devices

All transistors, integrated circuits, and diodes shall be a standard type listed by EIA and clearly identifiable.

667.2.1.2.4 Connectors

All display circuits PCB edge connectors and cable connectors, except for those found in the power supply, UPS, modem and sign controller, shall be base plated with nickel and finished with 30 micro-inches of gold.

667.2.2 Mechanical Components

All external screws, nuts, and locking washers shall be stainless steel. No self-tapping external screws shall be used. All parts shall be made of corrosion resistant materials, such as
plastic, stainless steel or aluminum. All materials used in construction shall be resistant to fungus growth and moisture deterioration. Dissimilar metals shall be separated by an inert dielectric material.

667.2.3 Sign Controller

This section describes the minimum specifications for the dynamic message sign (DMS) controllers and auxiliary control panels to be provided with this contract. The contractor shall provide all the materials, software, and services necessary to install DMS controllers, auxiliary control panels, and any associated equipment that fully comply with the functional requirements specified herein, including incidental items that may have been inadvertently omitted.

667.2.3.1 General Controller Requirements

Each DMS shall be controlled and monitored by its own sign controller. The sign controller shall be a stand-alone microprocessor-based system, which does not require continuous communication with DMS control software in order to perform most DMS control functions.

The sign controller shall meet the following electrical and mechanical requirements:

1. All printed circuit boards shall be sealed with an acrylic conformal coating
2. Mount in a standard EIA 19-inch (480 mm) equipment rack with a maximum 4U space requirement
3. Weigh no more than 10 pounds, including its enclosure
4. Consume no more than 30 watts of power
5. Powered by an internal regulated DC power supply capable of operating on 120VAC or 240VAC at both 50Hz and 60Hz
6. The DMS shall operate on 120 VAC.

The sign controller shall meet the following operational requirements:

1. Communicate using the NTCIP protocol.
2. Contain memory for storing changeable and permanent messages, schedules, and other necessary files for controller operation.
3. Include a front panel user interface with LCD and keypad for direct operation and diagnostics as described herein.
4. Contain a minimum of three (3) NTCIP-compliant RS232 communication ports.
5. Contain a minimum of one (1) NTCIP-compliant Ethernet port with RJ45 connector.
6. Contain a built-in or external Hayes-compatible modem with standard RJ11 connector or communications equipment specified in the Plan Documents.
7. Monitor all external and internal sensors and communication inputs and control the display modules as directed by external control software and the front panel interface.

667.2.3.1.1 Equipment Cabinet and Sign Controller Location

The DMS sign controller shall be located in a pole mounted control equipment cabinet within a 336S-type or equivalent cabinet. The cabinet shall be provided with two (2) mounting clamps.
and appropriate stainless steel straps suitable for pole-mount straps. The cabinet shall enclose the sign controller panel board, 120 VAC electrical outlets, and remote communication devices, such as a modem.

The DMS cabinet shall meet NEMA enclosure Type 3R standards, as described in NEMA Standards Publication 250-1997, Enclosures for Electrical Equipment (1000 Volts Maximum).

Internal cabinet component hardware shall be fabricated from hot dipped galvanized steel, stainless steel, aluminum, nylon or other durable corrosion-resistant materials suitable for roadway signage applications.

The DMS controller cabinet shall be constructed using a minimum of 0.125 inch thick aluminum alloy 5052-H32. The exterior of the controller cabinet shall be natural mill-finish aluminum.

The DMS cabinet shall provide safe and convenient access to all modular assemblies. The base of the cabinet shall be mounted at three (3) feet above ground. The minimum cabinet dimensions shall be 36 inches in height, 21 inches wide, and 18 inches in depth. There shall be one (1) door extending the full length of the cabinet, with a full-length stainless steel hinge and mounting hardware. The door shall latch to a double-flanged door opening with a three-point draw-roller mechanism. The door handle shall be stainless steel. The doors shall each be equipped with a #2 Corbin lock.

A fluorescent lamp shall be located at the top of the controller cabinet to illuminate the cabinet interior. A switched mounted near the front door shall automatically turn on the light when the door is opened.

The cabinet shall contain a full-height EIA 19-inch rack. This rack shall contain a minimum of one (1) pull-out drawer. The drawer shall be able to latch in the out position to function as a laptop/utility shelf.

The cabinet shall contain a power panel board and circuit breakers that meet the following minimum requirements:
- Service entrance-rated
- Minimum of 12 circuit breaker mounting positions
- Short circuit ratings of 22,000 amps and 10,000 amps for the main and Service branch circuits respectively
- UL listed

The cabinet shall contain a utility outlet circuit consisting of a minimum of two (2) 15-A NEMA 15-R, 120 VAC duplex outlets, with ground-fault circuit interrupters. The outlets shall be mounted inside the cabinet and located near the panel board. The cabinet shall include one (1) earth ground lug that is electrically bonded to the cabinet. All earth grounding shall conform to the National Electrical Code.

One (1) thermostatically controlled 100 cfm exhaust fan shall be mounted near the top of the control cabinet. Filtered air intake ports shall be located on the bottom third of each access door. The fan and air filters shall be removable and replaceable from inside the cabinet.
The sign controller cabinet shall include the following:
- Communications equipment
- Display system interface circuits
- Local/remote control switch
- Local control LED indicator
- AC and Communication surge protection
- RS-232 plug-in connection for a laptop computer
- RS-232 cable (minimum of four feet long)
- Uninterruptible Power Supply

667.2.3.1.2.1 Front Panel User Interface

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

1. Monitor the current status of the sign controller, including the status of all sensors and a monochromatic -What-You-See-Is-What-You-Get (WYSIWYG) representation of the message visible on the display face
2. Perform diagnostics testing of various system components, including pixels, power systems, sensors, and more
3. Activate messages stored in memory
4. Configure display parameters, including display size and colors
5. Configure communications port settings and NTCIP options

The front panel interface shall also include:

1. Power switch to turn the controller on and off
2. LED power “on” indicator
3. “Local/remote” switch that places the controller in local mode such that it can be controlled from the front panel interface, instead of via the primary NTCIP communication channel
4. LED to indicate state of the “local/remote” mode switch
5. Reset switch to quickly restart the controller
6. LED “Active” indicator that blinks when the controller is operating correctly
7. LED to indicate when any of the NTCIP communication channels are active

667.2.3.1.2.2 Memory

The sign controller shall have non-volatile electronically changeable memory. This memory shall be formed by flash or battery-backed static RAM integrated circuits that retain the data in memory for a minimum of 30 days following a power loss. This changeable memory shall be used to store messages and schedules. The controller memory shall be capable of storing a minimum of 100 changeable messages in non-volatile RAM.

667.2.3.1.2.3 Internal Clock

The DMS sign controller shall contain a computer-readable clock that has a battery backup circuit. The battery shall keep the clock operating properly for at least 30 days without external power, and the clock shall automatically adjust for daylight savings time and leap year using
hardware, software, or a combination of both. The clock shall be set electronically by the sign controller microprocessor and shall be accurate to within one (1) minute per month.

667.2.3.1.2.4 System Status Monitoring/Diagnostics

The DMS controller shall be capable of monitoring the status of DMS components and subsystems in real-time and/or manual modes. The DMS controller shall provide the following:

1. Message Display Status – Monitor and display the currently active message on the controller’s front LCD display. This display shall be in a WYSIWYG format.
2. LED Pixel Testing – Upon command from either the front panel interface or via NTCIP remote control software, the controller shall direct all of the LED modules to perform diagnostic tests of all pixels.
3. Power Supply Operation – The sign controller shall monitor and report the functional status of regulated DC power supplies located in the DMS by monitoring diagnostic outputs located on the supplies. The power supply voltages shall be measured to the nearest tenth of a volt and the fuse status shall be indicated as pass or fail.
4. Door State – The DMS shall monitor and report “door open status”.
5. Fan Operation – The DMS will be equipped with fan diagnostic systems and the controller shall monitor and report the status of the fans.
6. Environmental Conditions – The DMS controller shall monitor the readings of all light, temperature, and humidity sensors installed within the DMS housing.

667.2.3.1.2.5 Error Notification

The DMS controller shall be capable of automatically informing a maintenance operator (via the local LCD panel) and the central control system (via NTCIP communications) of the occurrence of important events and subsystem failures. The major component and subsystem errors shall be indicated on the controller’s LCD front panel. The controller shall be capable of sending event notifications to the control system via SNMP “traps” as allowed by NTCIP.

The following errors and events that the controller shall report as defined above:

- Over Temperature Shutdown – The DMS controller shall continuously monitor the DMS housing’s temperature sensors and shall automatically shut down the DMS if the internal cabinet temperature exceeds a safety threshold. This threshold shall have a default value of +140 degrees Fahrenheit and shall be configurable at the controller. If the temperature approaches the threshold the controller shall reduce the brightness of the sign face. If the temperature continues to increase and exceeds that threshold, the controller shall trigger a warning notification event and blank the face of the sign. The sign shall remain blank until the temperature begins to drop. The sign controller shall include a visual indication on the controller’s front panel LCD.

- Controller Restart – When the Controller detects that is been restarted due to a manual reset or error condition, it shall send a notification to the central system.

- Power Loss – When the DMS controller detects that it has lost power, it shall automatically indicate that on the front panel LCD. It shall also send a
notification to the central system

- Power System Failure – The DMS controller shall automatically monitor the major power systems in the sign and detect when one of them has failed. This failure shall be reported and notified to the central system.

- Door Opened – When the sign controller detects that one of the sign cabinet or control cabinet doors have been opened, it will report this alarm to the central system.

- Communication Loss – The DMS controller shall monitor the frequency of communication packets from the central system for longer that a configurable timeout, then the controller will automatically activate a communication loss message as defined by NTCIP.

667.2.3.3 Auxiliary Control System

The DMS shall include an auxiliary control panel that will provide a secondary user interface panel for DMS control, configuration, and maintenance. The auxiliary control panel shall meet the same electrical, mechanical and environmental specification as the DMS controller. It shall be powered independently from a 120 VAC outlet.

This auxiliary system shall be located inside the DMS cabinet to facilitate operation by maintenance personnel while working inside the DMS.

The auxiliary control panel shall interface to the DMS controller using Category 5 copper cable. It shall be capable of operating up to 4000 feet from the DMS controller.

The auxiliary control system shall be an extension of the sign controller and shall have the following characteristics:

1. Have a LCD panel and keypad identical to those found on the DMS Controller.
2. Run diagnostic tests and display any faults.
3. Ability to program messages for display on sign without connecting a laptop Computer,
4. Display pixels in a WYSISYG format.
5. RS-232 that meet the same specifications as the DMS Controller.
6. Local/remote switch
7. Reset switch
8. Status LEDs
9. Two – 120 VAC GFI duplex outlets

667.2.3.4 Communication Modes

All remote communication ports shall be NTCIP-compatible as defined in the “Requirements for NTCIP Compatibility” section of these specifications.

The DMS sign controller shall be able to receive instructions from and provide information to a computer containing DMS control software using the following communication modes:
1. Remotely via direct or dial-up communications with a remotely located computer. The system communications backbone, as well as all field modems or signal converters, shall provide the DMS sign controller with an RS232 signal.

2. Locally via direct connection with a laptop computer that is connected directly to the sign controller using an RS232 null modem connection.

Communication between the central controller and the sign controller must be capable of operating with one of the modem(s) described below:

**667.2.3.4.1 Dial-Up Modem**

The DMS sign controller shall include one (1) built-in dial-up or external modem. The modem port shall have a standard RJ11 connector.

This modem shall be configured to support either the NTCIP 2101 (PMPP) or the NTCIP 2103 (PPP) sub network profile. At least one of the following transport profiles shall also be available for configuration: NTCIP 2201 (Null) or NTCIP 2202 (Internet). Only one each of the transport and sub network profiles shall be active at any time on the port.

The modem shall be configurable to support both incoming and outgoing calls as supported by NTCIP. The modem shall support a communication speed up to 33.6 Kbps.

**667.2.3.4.2 Multi-Drop Modem**

The multi-drop modem shall be a Model 496SA with a transmission speed of 9600bps, and shall match the communications characteristics of the multi-drop modem at the central office.

**667.2.3.4.3 Fiber-Optic Modem**

The fiber-optic modem shall be a Model FO212 Multimode modem, and shall match the fiber and communications characteristics of the fiber-optic modem at the central office.

**667.2.3.4.4 Ethernet Port**

The DMS sign controller shall contain a minimum of one (1) 10/100Base-T Ethernet communication port. This port shall 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 shall have a standard RJ45 connector.

Communications on the Ethernet port shall be NTCIP-compatible using the NTCIP 2202 Internet transport profile and the NTCIP 2104 Ethernet sub network profile. This shall permit the controller to be operated on any typical Ethernet network using the TCP/IP and UDP/IP protocols.

**667.2.3.4.6 Serial Communication Ports**

The DMS sign controller shall contain a minimum of three (3) NTCIP-compatible RS232 communication ports. These ports shall support multiple communication interfaces, including,
but not limited to, direct null-modem (for local laptop control), dial-up and leased-line modems, radio systems, cellular modems, and fiber optic modems. The RS232 ports shall all have standard DB9M connectors.

The baud rate, connection type, and NTCIP communication protocol shall be configurable. Each port must support all typical serial baud rates ranging from 1200 to 115,200 baud. All three ports shall be capable of supporting either of the following sub network profiles: NTCIP 2101 (PMPP) or NTCIP 2103 (PPP). They shall also be capable of supporting either NTCIP 2201 (Null) or NTCIP 2202 (Internet) transport profiles. Only one each of the transport and sub network profiles shall be active at any time on each port.

667.2.3.4.5 Switching Between Dial-Up, Multi-Drop and Fiber-Optic Operation

Switching between dial-up, multi-drop and fiber-optic operation shall require no software or hardware modifications. No tools, other than a standard screw driver, shall be required. No jumpers or switches shall be changed, except for front-panel switches to set baud rate or other communication parameters. The only required changes shall be:

1. The existing modem shall be removed and replaced with the new modem.
2. The sign’s communication type shall be easily reconfigured at the controller front panel.

667.2.3.4.6 Controller Addressing

The DMS sign controller shall use whatever addressing scheme is appropriate for the NTCIP network types used for communications. The controller addressing shall be configurable through the front panel user interface.

NTCIP 2101 (PMPP) networks shall be configured with an address in the range 1 to 255 with a default address of 1. NTCIP 2104 (Ethernet) networks shall use a static IP address. Both the IP address and subnet shall be configurable. NTCIP 2103 (PPP) networks shall not require network addressing.

667.2.3.5 Uninterruptible Power Supply (UPS)

A UPS shall be provided to allow the sign controller to notify the central controller when an improper power condition at the DMS persists for longer than a user selectable “short power loss time”.

The UPS shall meet the following minimum specifications:

3. Capacity: Must be able to operate controller & modem for 10 minutes
4. Voltage Nominal: 120VAC
5. Voltage Range: 92-135 VAC
6. Transfer time: <150 ms typical
7. Battery: Sealed, maintenance-free lead acid
8. Battery recharge time: 2-8 hours; must be temperature-compensated
9. Over current protection: UPS automatic shutdown if overload exceeds 110% of nominal for 3 minutes.
10. Communications: RS-232 Interface (monitor, control and calibrate), DB-9 connection
11. Front panel display indicators: Fault, Test, Low Battery, On Battery, On Line
12. Operating temperature range: -37°C to +74°C

(NOTE: The UPS shall be mounted and operated in a manner to meet the temperature range requirements of the DMS as outlined in Section 667.2.4 (-40°C to 74°C (-40°F to 165°F) with a relative humidity of up to 100% condensing).

667.2.4 Front Access Housing

The front access housing dimensions and total weight shall be as shown in the plans. The front access housing shall be designed and manufactured to be rain and weather tight.

The sign housing skin shall be constructed of aluminum alloy 5052-H32 which shall not be less than 1/8" thick, unless otherwise specified in this document. Framing structural members shall be made of aluminum alloy 6061-T6 and/or 6063-T5.

The equipment within the sign housing shall be protected from moisture, dust, dirt and corrosion. The sign housing shall meet NEMA 3R enclosure criteria as defined in NEMA Standards Publication 250-1997, “Enclosures for Electrical for Electrical Equipment (1000 Volts Maximum).

The sign housing shall be engineered to 2001 AASHTO and NCHRP Report 411 specifications for basic AASTHO wind speeds and centerline sign heights up to 40ft. The sign housing shall also be engineered to withstand group loading combinations as outlined in 2001 AASHTO including: sign weight, repair personnel and equipment, snow (40 psf), ice and wind loads, and shall also meet strength requirements for truck-induced gusts as specified in NCHRP Report 412.

667.2.4.1 Surface Finish

The face or front face panels and front face border pieces shall be coated with a semigloss black KYNAR 500 Resin or an equivalent brand of oven-fired fluoropolymer-based coating system that has an outdoor expected service life of 20 years.

All other DMS surfaces shall be uniform in appearance and completely free from distortion, gouges and any other flaws or defects, and shall be natural aluminum – no painted surfaces shall be allowed.

The DMS housing structural frame shall be constructed of 5052-H32 aluminum alloy members. The structural framework members shall be permanently attached to each other using proven chemically bonding structural adhesive. The structural bonds created by the adhesive shall be adequate to meet the structural requirements of these specifications and other pertinent standards and codes.

All sides of the DMS housing exterior, except the front of the LED modules, shall be covered with 5052-H32 aluminum alloy sheets with a minimum thickness of 0.090-inches (3.17 mm). This external aluminum skin shall be attached to the structural framework using a proven
chemically bonding structural adhesive.

The DMS housing’s right, left, front and rear exterior walls shall be vertical. The top and bottom walls shall be horizontal. LED display modules shall be mounted parallel to the front wall so the legible LED viewing area is optimized.

DMS structural assembly hardware (nuts, bolts, washers, and direct tension indicators) shall be stainless steel or galvanized A325 high-strength steel and shall be appropriately sized for the application.

Chemical Bonding

The external aluminum sheets shall be attached to the cabinet frame members using a two-part chemically bonding structural adhesive. The adhesive shall be applied in a continuous bead on all cabinet frame surfaces that contact the aluminum sheet. The adhesive shall ensure a watertight seal is obtained around the entire perimeter of the cabinet and where any aluminum sheets are spliced.

To ensure that appropriate procedures are followed to bond the aluminum sheet and cabinet frame members, the structural adhesive manufacturer shall certify the DMS manufacturer’s adhesive application process. The DMS manufacturer is responsible for performing all necessary testing of the adhesive to meet all requirements of the contract specifications.

Exterior Finish

DMS front face border shroud shall be coated with semi-gloss black Prism® automotive acrylic enamel coating with an expected outdoor service life of 10 years. All other DMS housing surfaces and DMS mounting brackets shall be natural mill-finish aluminum.

667.2.4.4 Internal Structure

The interior housing structural members shall be 6061-T6 and 6063-T5 aluminum alloy extrusions, and shall be designed to accommodate air distribution to the LED display modules.

667.2.4.5 Mounting

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

The exterior mounting assemblies shall be 6061-T6 aluminum alloy extrusions, 3/16-inch minimum thickness.

Lifting Hardware

For moving and installation purposes, multiple galvanized steel lifting eyebolts shall be attached to the top of the DMS housing. Eyebolt hardware shall attach directly to the DMS housing structural frame and be installed at the DMS factory. All mounting points
for eyebolts shall be sealed to prevent water from entering the DMS housing. Lifting hardware, as well as the housing frame, shall be designed such that the DMS can be shipped and handled without damage or excessive stress being applied to the housing prior to or during DMS installation on its support structure.

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

DMS structural assembly hardware and mounting brackets hardware (nuts, bolts, washers, and direct tension indicators) shall be stainless steel or galvanized high-strength steel and shall be appropriately sized for the application.

667.2.4.7 Drain Holes

The DMS housing bottom side shall contain small weep holes for draining any water that may accumulate due to condensation. Weep holes and ventilation -exhaust hoods shall be screened to prevent the entrance of insects and small animals.

Housing Ventilation System

The DMS shall contain a thermostatically controlled ventilation system designed to keep the internal DMS air temperature lower than +140°F (+60°C), when the outdoor ambient temperature is +115°F (+46°C) or less.

Exhaust fans shall be the ball-bearing type and shall be mounted in a line across the upper rear DMS housing wall. One fan at a minimum shall be installed per each exhaust port. One filtered air intake port shall be provided for each exhaust fan. Intake ports shall be located in a line across the bottom portion of the rear DMS wall. Each intake port shall be covered with a filter that removes airborne particles measuring 500 microns in diameter and larger. Fans and air filters shall be removable and replaceable from the front of the DMS housing.

Each ventilation fan shall contain a sensor to monitor its rotational speed, measured in revolutions per minute. The fan speed shall be reported via a CAN (controller area network) communication network to the sign controller upon request.

An aluminum hood attached to the rear wall of the DMS shall cover each air intake and exhaust port. Openings shall be screened to prevent the entrance of insects and small animals. All intake and exhaust hoods shall be thoroughly sealed to prevent water from entering the DMS.

A thermostat used to activate the ventilation system shall be located near the top of the DMS interior.

Over Temperature Safety Shutdown
The DMS shall automatically shut down the LED modules to prevent damaging the LEDs if the measured internal cabinet air temperature exceeds a maximum threshold temperature. The threshold temperature shall be configurable and shall have a default factory setting of 140°F (+60°C).

Sign Controller Signal Interface

With the sign controller being located in a ground-mounted traffic cabinet, the communication signals from the external sign controller to the DMS shall use fiber optic cable with the following specifications:

- 62.5/125 μm diameter
- ST-style connectors
- Rated for indoor/outdoor use
- UL-rated
- PVC outer jacket
- Tight buffer inner jacket
- Operating temperature range: –40°F to +185°F (-40°C to +85°C)

A minimum of six (6) fibers shall be provided with one (1) for controller to sign commands, one (1) for sign to controller responses, and four (4) spares.

Amber LED Characteristics:

Amber LED Display Modules

The DMS front face shall be constructed of multiple LED display modules, each of which shall support and protect an array of LED pixels. The LED display modules shall be placed adjacently in a two-dimensional matrix to form the face of the DMS. Each display module shall be constructed as follows:

- Each LED display module shall have four (4) cam latches that fasten it to the DMS housing. The latching mechanisms shall be actuated by two (2) quarter-turn latching points on the front face of each LED display module, one at the top center and one at the bottom center. The module latches shall be actuated by one-eighth-inch Allen-wrenches.

- Seams that separate adjacent LED display modules shall be sealed. LED display modules shall not be welded to the DMS housing.

- Front face LED display modules shall provide a high-contrast background for the DMS display matrix. The front of each LED display module shall be black and contain louvers for the LED pixels. The louvers shall not block any portion of the LED viewing area.
• Removal of the LED modules shall provide access to the interior of the DMS cabinet. All LED display modules and internal components shall be removable and replaceable by a single technician through the front face of the DMS.

• In the presence of wind, rain and snow, the DMS front face shall not distort in a manner that adversely affects LED message legibility.

• Each LED display module shall contain one or two circuit boards. If two boards are used, they shall be mounted physically to each other using durable non-corrosive hardware. They shall be electrically connected via one or more header-type connectors. The header connectors shall be keyed such that the boards cannot be connected incorrectly.

• All LED modules shall be manufactured using laminated fiberglass printed circuit boards.

• The LED pixels in the module shall be protected by a black contrast-enhancing silicone elastomer that surrounds the base of the LEDs and seals the entire front face of the module to prevent water penetration and corrosion, while not obstructing the viewing angles of the LEDs.

• LED display module electrical connections shall use a quick-disconnect locking connector. Removal of an LED display module from the DMS, or a pixel board or driver circuit board from its display module, shall not require a soldering operation.

• It shall not be possible to mount a display module upside-down or in an otherwise incorrect position within the DMS display matrix.

• All LED display modules shall be identical and interchangeable throughout the DMS.

• Removal or failure of any LED module shall not affect the operation of any other LED module or sign component. Removal of one or more LED modules shall not affect the structural integrity of any part of the sign.

Amber LED Pixel Boards

Each LED module shall contain a printed circuit board to which LED pixels are soldered. The LED pixel matrix shall conform to the following specifications:

• Each LED pixel circuit board shall contain a minimum of 256 LED pixels configured in a two dimensional array. The pixel array shall be a minimum of sixteen (16) pixels high by sixteen (16) pixels wide.

• The distance from the center of a pixel to the center of each adjacent pixel, both horizontally and vertically, shall be 0.78 inches (20 mm).

• All pixels shall contain an equal quantity of discrete LEDs and LED strings. If a pixel contains four (4) or more discrete LEDs, then each pixel shall contain a minimum of two (2) independent and parallel strings of discrete LEDs.
• The failure of an LED string or pixel shall not cause the failure of any other LED string or pixel in the DMS.

• Each pixel shall also be capable of displaying amber colored light with a minimum luminous intensity of 9,200 candelas per square meter when operated within the forward current limits defined in these specifications.

• Each LED pixel shall not consume more than 1.5 watts.

• The circular base of the discrete LEDs shall be soldered so that they are parallel to the surface of the printed circuit board. The longitudinal axis of the LEDs shall be perpendicular to the circuit board.

Amber Discrete LEDs

DMS pixels shall be constructed with discrete LEDs manufactured by Avago Technologies (formerly Agilent Technologies), Toshiba Corporation, Nichia Corporation, OSRAM, or equivalent. Discrete LEDs shall conform to the following specifications:

• All LEDs shall have a nominal viewing cone of 30 degrees with a half-power angle of 15 degrees measured from the longitudinal axis of the LED. Viewing cone tolerances shall be as specified in the LED manufacturer’s product specifications and shall not exceed +/- 3 degrees.

• Amber LEDs shall utilize AlInGaP semiconductor technology and shall emit amber light that has a peak wavelength of 590 ± 5 nm.

• The LED lenses shall be fabricated from UV light resistant epoxy.

• The LED manufacturer shall perform color sorting of the bins. The LEDs shall be obtained from no more than two (2) consecutive color “bins” as defined by the LED manufacturer.

• The LED manufacturer shall perform intensity sorting of the bins. The LEDs shall be obtained from no more than two (2) consecutive luminous intensity “bins” as defined by the LED manufacturer.

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

• The LED package style shall be through-hole with standoffs. Surface-mount LEDs or LEDs without standoffs will not be accepted.

• All LEDs used in all DMS provided for this contract shall be from the same manufacturer and of the same part number, except for the variations in the part number due to the intensity and color bins.
The LEDs shall be rated by the LED manufacturer to have a minimum lifetime of 100,000 hours of continuous operation while maintaining a minimum of 70% of the original brightness.

RGB LED Characteristics:

RGB LED Display Modules

The DMS front face shall be constructed of multiple LED display modules, each of which shall support and protect an array of LED pixels. The LED display modules shall be placed adjacently in a two-dimensional matrix to form the face of the DMS. Each display module shall be constructed as follows:

- Each LED display module shall have four (4) cam latches that fasten it to the DMS housing. The latching mechanisms shall be actuated by two (2) quarter-turn latching points on the front face of each LED display module, one at the top center and one at the bottom center. The module latches shall be actuated by one-eighth-inch Allen-wrenches.

- Seams that separate adjacent LED display modules shall be sealed. LED display modules shall not be welded to the DMS housing.

- Front face LED display modules shall provide a high-contrast background for the DMS display matrix. The front of each LED display module shall be black and contain louvers for the LED pixels. The louvers shall not block any portion of the LED viewing area.

- Removal of the LED modules shall provide access to the interior of the DMS cabinet. All LED display modules and internal components shall be removable and replaceable by a single technician through the front face of the DMS.

- In the presence of wind, rain and snow, the DMS front face shall not distort in a manner that adversely affects LED message legibility.

- Each LED display module shall contain one or two circuit boards. If two boards are used, they shall be mounted physically to each other using durable non-corrosive hardware. They shall be electrically connected via one or more header-type connectors. The header connectors shall be keyed such that the boards cannot be connected incorrectly.

- All LED modules shall be manufactured using laminated fiberglass printed circuit boards.

- The LED pixels in the module shall be protected by a black contrast-enhancing silicone elastomer that surrounds the base of the LEDs and seals the entire front face of the module to prevent water penetration and corrosion, while not obstructing the viewing angles of the LEDs.
• LED display module electrical connections shall use a quick-disconnect locking connector. Removal of an LED display module from the DMS, or a pixel board or driver circuit board from its display module, shall not require a soldering operation.

• It shall not be possible to mount a display module upside-down or in an otherwise incorrect position within the DMS display matrix.

• All LED display modules shall be identical and interchangeable throughout the DMS.

• Removal or failure of any LED module shall not affect the operation of any other LED module or sign component. Removal of one or more LED modules shall not affect the structural integrity of any part of the sign.

**RGB LED Pixels**

Each LED module shall contain a printed circuit board to which LED pixels are soldered. The LED pixel matrix shall conform to the following specifications:

• Each LED pixel circuit board shall contain a minimum of 256 LED pixels configured in a two dimensional array. The pixel array shall be a minimum of 16 pixels high by 16 pixels wide.

• The distance from the center of a pixel to the center of each adjacent pixel, both horizontally and vertically, shall be 0.78 inches (20 mm).

• Each pixel shall consist of a minimum of one (1) independent string of discrete LEDs for each color. All pixels shall contain an equal quantity of LED strings.

• The failure of an LED string or pixel shall not cause the failure of any other LED string or pixel in the DMS.

• Each pixel shall contain the quantity of discrete LEDs needed to output white colored light at a minimum luminous intensity of 12,400 candelas per square meter when operated within the forward current limits defined in these specifications.

• Each pixel shall also be capable of displaying amber colored light with a minimum luminous intensity of 7,440 candelas per square meter when operated within the forward current limits defined in these specifications.

• Each LED pixel shall not consume more than 1.5 watts.

• The circular base of the discrete LEDs shall be soldered so that they are parallel to the surface of the printed circuit board. The longitudinal axis of the LEDs shall be perpendicular to the circuit board.

**RGB Discrete LEDs**

DMS pixels shall be constructed with discrete LEDs manufactured by Avago.
Technologies (formerly Agilent Technologies), Toshiba Corporation, Nichia Corporation, OSRAM, or equivalent. Discrete LEDs shall conform to the following specifications:

- All LEDs shall have a nominal viewing cone of 30 degrees with a half-power angle of 15 degrees measured from the longitudinal axis of the LED. Viewing cone tolerances shall be as specified in the LED manufacturer’s product specifications and shall not exceed +/- 3 degrees.

- Red LEDs shall utilize AlInGaP semiconductor technology and shall emit red light that has a peak wavelength of 639 ± 5 nm.

- Green LEDs shall utilize InGaN semiconductor technology and shall emit green light that has a peak wavelength of 525 ± 5 nm.

- Blue LEDs shall utilize InGaN semiconductor technology and shall emit blue light that has a peak wavelength of 470 ± 5 nm.

- The LED manufacturer shall perform color sorting of the bins. Each color of LEDs shall be obtained from no more than two (2) consecutive color “bins” as defined by the LED manufacturer.

- The LED manufacturer shall perform intensity sorting of the bins. Each color of LEDs shall be obtained from no more than two (2) consecutive luminous intensity “bins” as defined by the LED manufacturer.

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

- The LED package styles shall be through-hole with standoffs. Surface-mount LEDs or LEDs without standoffs will not be accepted.

- All LEDs used in all DMS provided for this contract shall be from the same manufacturer and of the same part number, except for the variations in the part number due to the intensity and color bins.

- The LEDs shall be rated by the LED manufacturer to have a minimum lifetime of 100,000 hours of continuous operation while maintaining a minimum of 70% of the original brightness.

Amber and RGB Pixel Drive Circuitry

Each LED display module shall contain electronic driver circuitry that shall individually control all pixels on that module. The driver circuitry shall conform to the following specifications:
• Each LED driver board shall be microprocessor-controlled and shall communicate with the sign controller on a wire or fiber optic communication network using an addressable network protocol. The microprocessor shall process commands from the sign controller to display data, perform diagnostic tests, and report pixel and diagnostic status.

• Constant current LED driver ICs shall be used to prevent LED forward current from exceeding the LED manufacturer’s recommended forward current whenever a forward voltage is applied. To maximize LED service life, LED drive currents will not be allowed that exceed the manufacturer’s recommendations for the 100,000-hour lifetime requirement.

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

• The LED driver circuitry shall receive updated display data at a minimum rate of ten (10) frames per second from the sign controller.

• Each LED driver circuit shall be powered by 24 VDC from external regulated DC power supplies. Each driver circuit shall receive power from a minimum of two (2) independent power supplies. Indicator LEDs shall be provided to indicate the status of each power source.

• Each LED driver circuit shall contain a microprocessor-controlled power regulation circuit that controls the voltage applied to the LED strings. The power circuit shall automatically adjust the voltage supplied to the LEDs to optimize power consumption efficiency as the temperature changes.

• The voltage of each power input shall be measured to the nearest tenth of a volt and reported to the sign controller upon request. Each driver circuit shall also contain one status LED for each power source that indicates if the power source is present or not.

• The LED driver circuitry shall be able to detect that individual LED strings or pixels are stuck off and shall report the pixel status to the sign controller upon request.

• The LED driver circuit shall contain a seven segment numeric LED display that indicates the functional status of the driver and pixel boards. At a minimum, it shall indicate error states of the LED pixels and communication network. The indicator shall be positioned such that a maintenance technician can easily view the status code for diagnostic purposes. The status codes shall also be reported to the sign controller upon request.
Amber and RGB Regulated DC Power Supplies

The LED pixel display modules shall be powered with auto-ranging regulated switching power supplies that convert the incoming AC to DC at a nominal voltage of 24 volts DC. Power supplies shall be wired in a redundant parallel configuration that uses multiple supplies for the DMS display matrix.

Power supplies shall be arranged in redundant pairs within the display such that each pair supplies power to a defined region of the sign. Each pair of power supplies shall contain two (2) physically and electrically independent supplies. Each pair of power supplies shall be parallel but shall not be wired in a current sharing configuration.

Power supplies within each pair shall be redundant and rated such that if one supply fails, the remaining supply shall be able to operate 100% of the pixels in that display region at 100% brightness when the internal DMS air temperature is +140°F (60°C) or less.

Each power supply within each pair shall receive 120VAC power from separate circuits on separate circuit breakers, such that a single tripped breaker will not disconnect power from both supplies. It shall be acceptable for a single circuit breaker to power multiple DC power supplies provided that none of those power supplies are in the same power supply pair.

The power supplies shall be sufficient to maintain the appropriate LED display intensity throughout the entire operating input voltage range.

The output of each power supply shall be connected to multiple circuits that provide power to the LED modules. Each output circuit shall not exceed 15 amperes and shall be fused.

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

The power supplies used to power the LED pixel modules shall be identical and interchangeable throughout the DMS.

Regulated DC power supplies shall conform to the following specifications:

- Nominal output voltage of 24 VDC +/- 10%
- Nominal maximum output power rating of 1000 watts
- Operating input voltage range shall be a minimum of 90 to 260 VAC
- Operating temperature range shall be a minimum of –30°F to +165°F (-34°C to +74°C)
- Maximum output power rating shall be maintained over a minimum temperature range of –30°F to +140°F (-34°C to +60°C)
- Power supply efficiency shall be a minimum of 80%
• Power factor rating shall be a minimum of 0.95
• Power supply input circuit shall be fused
• 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
• Power supplies shall be UL listed
• Printed circuit boards shall be protected by an acrylic conformal coating

667.2.9.4 Display Assembly

Display modules shall be assembled to achieve a full matrix. Each display module shall include an LED display circuit board. The driver board shall contain the solid state electronics necessary to control pixel data and read pixel status.

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

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

667.2.10 Power

The sign and its sign controller shall be capable of operating with 120 VAC, 60 Hz, single-phase power.

667.2.10.1 Power and Signal Entrances

Two threaded conduit hubs shall be located on the rear wall of the DMS housing. One hub shall be for incoming AC power and the other shall be for incoming DMS signal cabling or a communications line.

667.2.10.2 Load Center

The DMS shall contain a power load center and circuit breakers that meet the following minimum requirements:

1. Service entrance-rated
2. Minimum of 20 circuit breaker mounting positions
3. Short circuit ratings of 22,000 amps and 10,000 amps for the main and branch circuits, respectively
4. UL listed load center and circuit breakers

667.2.10.3 Internal Wiring

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

Wiring for LED display module control, environmental control circuits, and other internal DMS components shall be installed in the DMS housing in a neat and professional manner. Wiring shall not impede the removal of display modules, power supplies, environmental control equipment, and other sign components. Wires shall not make contact with or bend around sharp metal edges. All wiring shall conform to the National Electrical Code.

The presence of power transients or electromagnetic fields, including those created by any components of the system, shall have no deleterious effect on the performance of the system. The system shall 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.

667.2.10.4 Earth Grounding

The DMS manufacturer shall provide one earth ground lug that is electrically bonded to the DMS housing. The lug shall be installed near the power entrance location on the DMS housing’s rear wall. The DMS installation contractor shall provide the balance of materials and services needed to properly earth ground the DMS. All earth grounding shall conform to the National Electrical Code.

667.2.11 Surge Protection

The DMS and sign controller signal and power inputs shall be protected from electrical spikes and transients as follows:

Site AC Power

The AC power feed for all equipment shall be protected at the load center by a parallel connection surge suppression rated for a minimum surge of 10 kA.

Control Equipment Power

A series-connected surge suppressor capable of passing 15 amps of current shall protect the sign controller and other control and communications equipment. This device shall conform to the following requirements:

- Withstand a peak 50,000 ampere surge current for 8 x 20 microsecond waveform
- Maximum continuous operating current of 15 amps at 120 VAC, 60Hz
- Series inductance of 200 micro henrys (nominal)
- Temperature range of -40°F to +158°F (-40°C to +70°C)
- The device shall be UL-1449 recognized with a surge rated of 400 V or less.

Tripping of the surge protection shall cause the sign controller to report an error condition to the central operation, or report an error condition to central office on the next poll. Tripping of the surge protection shall prevent power from reaching any components of the sign until the surge
667.3 Operational Characteristics

The DMS System shall have the ability to produce the following message types, styles and fonts. These are the minimum required, but if the manufacture normally utilizes additional features, they shall not be removed to meet the wording in this specification.

667.3.1 Messaging

The DMS controller shall have the ability to display messages on the DMS display face as required herein.

667.3.1.1 Legibility

DMS messages shall be legible within a distance range of 150 ft (45.7 m) to 450 ft (137 m) from the DMS display face under the following conditions:

1. Whenever the DMS is displaying alphanumeric text that is 9-inches (230 mm) high
2. 24 hours per day and in most normally encountered weather conditions
3. During dawn and dusk hours when sunlight is shining directly on the display face or when the sun is directly behind (silhouetting) the DMS
4. When viewed by motorists and travelers that have 20-20 corrected vision
5. When the motorist eye level is 3 feet (914 mm) to 12 feet (3,658 mm) above the roadway surface.

667.3.1.2 Message Presentation on the DMS Display Matrix

The sign controller shall control the LED drivers in a manner that causes the desired message to display on the DMS sign. At a minimum, the sign controller shall support the following features as described in the DMS specification:

1. Display of alpha numeric characters, including letters, numbers, and punctuation
2. Selection of particular character fonts style
3. Horizontal alignment of text on the display, including left, center, and right justification
4. Vertical alignment of text on the display, including top, middle, and bottom justification
5. Adjusting the spacing horizontally between characters or vertically between lines of text
6. Alternating between pages of a multiple-page message
7. Display of graphic bitmaps of various sizes ranging to very small to the size of the entire DMS matrix

667.3.1.3 Message Effects

The DMS shall be able to display messages using the following types of effects:

1. Static Message – The selected message is displayed continuously on the sign face until the sign controller blanks the sign or causes the display of another message
2. Flashing Message – All or part of a message is displayed and blanked alternately at rates
between 0.1 seconds and 9.9 seconds. The flash rate is user programmable in increments of 0.1 seconds.

3. Scrolling Message – The message moves across the display face from one side to the other. The direction of travel is user selectable as either left-to-right or right-to-left.

4. Multiple-Page Message – A message contains up to six different pages of information, with each page filling the entire pixel matrix. Each page’s display time is user programmable from 0.1 seconds to 25.5 seconds, and adjustable in increments of 0.1 seconds.

**667.3.1.4 Message Activation**

Messages shall be activated on a DMS in three ways:

1. Manual – An operator using the front panel LCD/keypad interface or NTCIP-compatible control software manually instructs a particular message to be activated.

2. Schedule – The internal time-based scheduler in the DMS may be configured to activate messages at programmable times and dates. Prior to activation, these messages and their activation times and dates shall be configured using the control software.

3. Events – Certain events, like a power loss, may trigger the activation of pre-configured messages when they occur. These events must be configured using the control software.

**667.3.1.5 Message Display Functions**

A displayed message shall remain on the sign until one of the following occurs:

1. The message’s duration timeout expires
2. The controller receives a command to change the message
3. The controller receives a command to blank the sign
4. The schedule stored in the controller’s memory indicates that it is time to activate a different message
5. A special event, such as a loss of communication, occurs that is linked to message activation

It shall be possible to confer a “priority” status onto any message, and a command to display a priority message shall cause any non-priority message to be overridden.

The DMS shall also be capable of the following:

1. The sign controller shall also be able to accept a downloaded library from the central or laptop computer of a minimum of 25 changeable messages stored in non-volatile RAM. These messages may be called for display on the sign from the keypad on the front panel of the controller.
2. The sign controller shall also be capable of displaying messages on the sign that are downloaded from the central controller or laptop computer, but are not located in the library stored in non-volatile memory of the sign controller.
3. The sign shall have the capability to display automatically-scaled character fonts applied to a given message to maximize the font size of the displayed text, up to the full height of the display for a single line of text.
4. The sign controller shall have the capability to display graphic images and icons downloaded from the central controller.
5. There shall be no perceivable blinking, flickering or ghosting of the pixels at any time, except during a pixel test as described above. The displayed message will not be affected in any way at any time for the pixel status read as described above.

6. The sign controller shall be able to put a self-updating time, temperature and/or date display on the sign.

7. The sign controller shall allow a moving arrow to be displayed by the central controller or laptop computer. The moving arrow shall be on one line with a standard message on the other lines. The moving arrows shall be from the left or right and shall start from one end or in the middle of the sign and continue to the end of the sign.

**667.3.1.6 Schedule Activation**

The DMS sign controller shall support the activation of messages based on a time/date-based schedule. The format and operation of the message scheduler shall be per the NTCIP 1201 and NTCIP 1203 standards.

**667.3.1.7 Display of Alphanumeric Text**

The DMS sign controller shall support the storage and use of a minimum of twelve (12) font sets with which messages can be formatted and displayed. Each font shall support up to 255 characters. All text font files shall include the following characters:

1. The letters “A” through “Z”, in both upper and lower case
2. Decimal digits “0” through “9”
3. A blank space
4. Eight (8) directional arrows
5. Punctuation marks, such as: . , ! ? ~ ‘ ” : ;
6. Special characters, such as: # & * + / ( ) [ ] < > @

The DMS supplier shall provide the DMS controller with the following fonts preinstalled. The controller shall support changing or replacing these fonts from the central software using NTCIP.

<table>
<thead>
<tr>
<th>Font Name</th>
<th>Character Height</th>
<th>Character Width (avg.)</th>
<th>Variable or Fixed Width</th>
<th>Stroke Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>7x4</td>
<td>7</td>
<td>4</td>
<td>Variable</td>
<td>Single (1)</td>
</tr>
<tr>
<td>7x5</td>
<td>7</td>
<td>5</td>
<td>Fixed</td>
<td>Single (1)</td>
</tr>
<tr>
<td>7x6</td>
<td>7</td>
<td>6</td>
<td>Variable</td>
<td>Double (2)</td>
</tr>
<tr>
<td>Graphic 7</td>
<td>7</td>
<td>N/A</td>
<td>Variable</td>
<td>N/A</td>
</tr>
<tr>
<td>8x4</td>
<td>8</td>
<td>4</td>
<td>Variable</td>
<td>Single (1)</td>
</tr>
<tr>
<td>8x6</td>
<td>8</td>
<td>6</td>
<td>Variable</td>
<td>Double (2)</td>
</tr>
<tr>
<td>9x6</td>
<td>9</td>
<td>6</td>
<td>Variable</td>
<td>Double (2)</td>
</tr>
<tr>
<td>11x7</td>
<td>11</td>
<td>7</td>
<td>Fixed</td>
<td>Double (2)</td>
</tr>
</tbody>
</table>
667.3.1.8 Display of Graphic Image

The DMS control software shall support the inclusion of graphics in messages. If the NTCIP 1203 v2 standard has not reached a “recommended” or “approved” state by the time of contract award, the vendor shall support graphics using manufacturer-specific objects and MULTI tags.

If a manufacturer-specific means of supporting graphics is used, the vendor shall commit to provide NTCIP 1203 v2 firmware updates at no cost to the customer. These updates will include all current requirements of these specifications and also standard graphics support. The vendor shall install the updates no later than six months after the NTCIP 1203 v2 standard reaches the “approved” state.

667.3.1.9 Brightness Control

Automatic adjustment of the LED brightness shall occur in small enough increments so that the brightness of the sign changes smoothly, with no perceivable brightness change between adjacent levels. Provision shall be made to prevent perceivable brightening of the sign due to stray headlights shining upon the photo sensors at night. Pixel brightness shall be controlled by pulse width modulation of the DC current.

667.3.1.9.1 Brightness Table

The sign controller shall monitor the photo cell circuits in the sign and convert the measured light intensity into the desired pixel brightness. The photo circuit readings shall be correlated with a brightness table in the sign controller. The brightness table shall have a minimum of 256 brightness levels. Each sign shall have its own, independent brightness table.

The brightness table in each individual sign controller shall be downloadable, both locally and from the central controller, and can be customized according to the requirements of the installation site.

667.3.1.9.2 Automatic Brightness Control

The DMS shall be capable of automatically adjusting LED brightness to account for changing ambient light conditions. The system required for this function consists of three primary component groups: Photocells, an adjustable brightness table and the overall brightness capability of the DMS.

667.3.1.9.2.1 Photoelectric Sensor Devices
Three (3) photocells shall be installed in the sign. These devices shall permit automatic light intensity measurement of light conditions at each sign location. These photocells shall be mounted in a manner to measure front, rear and ambient light conditions.

667.3.1.9.3 Manual Brightness Control

Brightness shall be manually settable from the front panel of the controller and remotely from the central computer in 1% increments from one to 99 percent. Brightness control shall be able to be returned to automatic from the sign controller front panel and the central computer.

667.3.2 Monitoring Functions

The following monitoring functions shall be conducted automatically on a set schedule and/or upon request from the central controller (a poll).

667.3.2.1 Power Supply Monitoring

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

In addition, each group of power supplies may be monitored by a voltage monitor that is independent from the power supplies. This circuit shall monitor the voltage of each power supply. The power supply voltages shall be reported to the sign controller upon request.

This monitoring shall also be able to transmit to the central controller alert messages for:
1. AC power failure
2. AC power recovery
3. DC power supply failure
4. Surge protection has been tripped

667.3.2.2 Display Intensity Variation

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

667.3.2.3 Pixel Status Feedback

Pixel status feedback shall be provided to the central controller from the local sign controller and shall include the following:

667.3.2.3.1 Pixel Test

The pixel test shall be performed from the central controller on command and automatically
once a day. During a pixel test, the full operational status of each string of LEDs in each pixel shall be tested and then transmitted to the central controller or laptop computer. A list of defective pixels shall be provided, listing pixel status, line number, column number and row number for each defective pixel. The pixel test must be completed in less than 0.5 seconds, regardless of message status.

667.3.2.3.2 True Message Display Verification (TMDV)

The TMDV shall return the state of each pixel to the central controller as it is currently displayed to the motorist, including any errors. The TMDV shall be an actual real time read of the current flowing through each string of LEDs at the time of the associated sign poll or message download and shall not be accomplished by simulating errors based on the last pixel test. This shall allow the central controller operator to see what is visibly displayed to the motorist on an individual pixel basis.

The TMDV shall be performed during both message downloads and during every sign poll from the central controller or laptop computer. During a TMDV, the state of each pixel (full-on, or full off) in the sign shall be read by the sign controller to allow the central controller or laptop computer to show the actual message, including static, flashing and alternating messages, that is visibly displayed on the sign. This message shall be shown on the central controller screen as a graphic representation, on an individual pixel basis. This pixel verification shall take place while a message is displayed on the sign without disturbing the message in any way. Any flashing, flickering, blinking, dimming, or other disturbance of the message during this pixel read shall be cause for rejection of the sign.

667.3.2.4 Door States

If the DMS or control equipment cabinet is equipped with access doors and sensors to monitor their open status, the controller shall monitor the status of those doors. This information shall be transmitted back to the central controller.

667.3.2.5 Environmental Conditions

The DMS controller shall monitor the readings of all light, temperature, humidity, and fan status sensors installed in the DMS housing. This system shall also monitor and report the status of all ventilation devices install with-in the DMS housing. This information shall be transmitted back to the central controller.

667.4 Testing Requirements

The equipment covered by this specification shall be subjected to design approval tests (DAT), factory demonstration tests (FDT), stand-alone tests, systems tests and 72 hour and 90 day test periods to determine conformance with all the specification requirements. The Engineer may accept certification by an independent testing lab in lieu of the design approval tests to verify that the design approval tests have previously been satisfactorily completed. The DMS
vendor shall arrange for and conduct the tests in accordance with the testing requirements stated herein. Unless otherwise specified, the DMS vendor is responsible for satisfying all inspection requirements prior to submission for the Engineer’s inspection and acceptance. The contract periods will not be extended for time lost or delays caused by testing prior to final Department approval of any items. The Engineer reserves the right to have his representative witness any and all tests. The results of each test shall be compared with the requirements specified herein. Failure to conform to the requirements of any test shall be counted as a defect, and the equipment shall be subject to rejection by the Engineer. Rejected equipment may be offered again for a retest, provided that all non-compliance’s have been corrected and retest by the DMS vendor and evidence thereof submitted to the Engineer.

Final inspection and acceptance of equipment shall be made after installation at the designated location as shown on the plans, unless otherwise specified herein.

667.4.1 Test Procedures

The DMS vendor shall provide five (5) copies of all design approval, factory demonstration, stand-alone and system test procedures and data forms for the Engineer’s approval at least sixty (60) days prior to the day the tests are to begin. The test procedures shall include the sequence in which the tests will be conducted. The test procedures shall have the Engineer’s approval prior to submission of equipment for tests.

The DMS vendor shall furnish data forms containing all of the data taken, as well as quantitative results for all tests. The data forms shall be signed by an authorized representative (company official) of the equipment manufacturer. At least one copy of the data forms shall be sent to the Engineer.

The DMS vendor shall be responsible for providing the test fixtures and test instruments for all the tests.

667.4.2 Design Approval Tests

Design approval tests shall be conducted by the DMS vendor on one or more samples of equipment of each type, as approved by the Engineer, to determine if the design of the equipment meets the requirements of this Specification. The test shall be conducted in accordance with the approved test procedures as described in Section 3.5.

If the design approval tests have not previously been satisfactorily completed by an independent testing lab and accepted by the Engineer, the Engineer shall be notified a minimum of thirty (30) calendar days in advance of the time these tests are to be conducted.

The design approval tests shall cover the following:

667.4.2.1 Temperature and Condensation

The DMS sign system equipment shall successfully perform all the functionality requirements listed in this specification under the following conditions in the order specified below:
1. The equipment shall be stabilized at –40°F (–40°C). After stabilization at this temperature, the equipment shall be operated without degradation for two (2) hours.

2. Moisture shall be caused to condense on the equipment by allowing it to warm up to room temperature in an atmosphere having relative humidity of at least 40% and the equipment shall be satisfactorily operated for two (2) hours while wet.

3. The equipment shall be stabilized at 165°F (74°C). After stabilization, the equipment shall be satisfactorily operated for two (2) hours without degradation or failure.

667.4.2.2 Primary Power Variation

The equipment shall meet the specified performance requirements when the nominal input voltage is 115 V ±15 V. The equipment shall be operated at the extreme limits for at least 15 minutes during which the operational test of the FDT shall be successfully performed.

667.4.2.3 Power Service Transients

The equipment shall meet the performance requirements, specified in the parent specification, when subjected to the power service transient specified in Section 2.1.6, “Transient, Power Service”, of the NEMA standard TS4. The equipment shall meet the performance requirements specified in the parent specification.

667.4.2.4 Relative Humidity

The equipment shall meet its performance requirements when subjected to a temperature of 149°F (65°C) and a relative humidity of 90%. The equipment shall be maintained at the above condition for 48 hours. At the conclusion of the 48 hour soak, the equipment shall meet the requirements of the operational test of the FDT within 30 minutes of beginning the test.

667.4.2.5 Vibration

The equipment (excluding cabinets) shall show no degradation of mechanical structure, soldered components, or plug-in components and shall operate in accordance with the manufacturer’s equipment specifications after being subjected to the vibration tests as described in Section 2.2.5, “Vibration Test”, of the NEMA standard TS4.

667.4.2.6 Consequences of Design Approval Test Failure

If the unit fails the design approval test, the design fault shall be corrected and the entire design approval test shall be repeated. All deliverable units shall be modified, without additional costs to the Department, to include design changes required to pass the design approval tests.

667.4.3 Factory Demonstration Tests

The DMS vendor shall be responsible for conducting Factory Demonstration Tests on all units at the DMS Vendor’s Manufacturing Facility. These tests shall be performed on each unit supplied. The Engineer shall be notified a minimum of thirty (30) calendar days before the start of tests. The DMS Vendor shall pay for all travel expenses, including airfare, rental car, hotel, meals, etc., for up to two department personnel for the Factory Demonstration Tests on the first unit at the Vendor’s Manufacturing Facility. All tests shall be conducted in accordance with the
approved test procedure of Section 3.5. All equipment shall pass the following individual tests:

667.4.3.1 Examination Tests

Each piece of equipment shall be examined carefully to verify that the materials, design, construction, markings and workmanship comply with the requirements of the Specification.

667.4.3.2 Continuity Tests

The wiring shall be checked to determine conformance with the requirements of the appropriate paragraphs in the Specifications.

667.4.3.3 Operational Test

Each piece of equipment shall be operated long enough to permit equipment temperature stabilization, and to check and record all performance characteristics to ensure compliance with the requirements of this Specification.

Equipment functionality will be thoroughly tested to verify complete compliance with all areas of this Specification.

667.4.3.4 Consequences of Demonstration Test Failure

If any unit fails to pass its demonstration test, the unit shall be corrected and another unit substituted in its place and the test successfully repeated.

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

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

667.4.4 Stand Alone Tests

The DMS vendor shall conduct an approved stand-alone test of the equipment installation at the field site. The test shall, as a minimum, exercise all stand-alone (non-network) functional operations of the field equipment with all of the equipment installed as per the plans, or as directed by the Engineer.

Approved data forms shall be completed and turned over to the Engineer as the basis for review and rejection or acceptance. At least two (2) working days’ notice shall be given prior to all tests to permit the Engineer or his representative to observe each test.

667.4.4.1 Consequences of Stand Alone Test Failure
If any unit fails to pass its stand-alone test, the unit shall be corrected or another unit substituted in its place and the test successfully repeated.

If a unit has been modified as a result of a stand-alone test failure, a report shall be prepared and delivered to the Engineer prior to the re-testing of the unit. The report shall describe the nature of the failure and the corrective action taken.

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

667.4.5 System Test

The DMS vendor shall conduct approved DMS system tests on the field equipment with the central equipment. The tests shall, as a minimum, exercise all remote control functions and display the return status codes from the controller. Approved data forms shall be completed and turned over to the Engineer as the basis for review and for rejection or acceptance.

667.4.5.1 Consequence of System Test Failure

If system tests fail because of any components(s) in the subsystem, the particular component(s) shall be corrected or substituted with other component(s) and the tests shall be repeated. If a component has been modified as a result of the system test failure, a report shall be prepared and delivered to the Engineer prior to retest.

667.4.6 72 Hours and 90 Days Test Failure

After the installation of the DMS system is completed and the successful completion of the System Test, the DMS system shall be subjected to one continuous 72-hour full operating test prior to a 90 day test period. The test shall consist primarily of exercising all control, monitor and communications functions of the field equipment by the central equipment.

The 90 days test period shall commence on the first day after the successful completion of the approved 72-hour continuous full operating test period.

During the 90 days test period, downtime, due to mechanical, electrical and/or other malfunctions, shall not exceed five (5) working days. The Engineer may extend the 90 days test period by a number of days equal to the downtime in excess of five (5) working days.

The Engineer will furnish the DMS vendor with a letter of approval stating the first day of the 90 days test period.

667.4.7 Final System Acceptance

Final system acceptance shall be defined as when all work and materials provided for in this item have been furnished and completely installed, and all parts of the work have been approved and accepted by the Engineer and the Dynamic Message Sign System has been operated continuously and successfully for ninety (90) calendar days with no more than five (5) working days downtime due to mechanical, electrical and/or other malfunctions.
667.4.8 Technical Assistance

The DMS manufacturer’s technical representative shall provide on-site technical assistance in following areas:

1. Sign housing to ground control cabinet cable termination
2. Initial sign turn on and stand alone test

The initial powering up of the sign(s) shall not be executed without the permission of the DMS manufacturer’s technical representative.

667.5 Requirements for DMS Control Software

This section describes the minimum specifications for the DMS sign control software. The contractor shall provide all software, software media, licenses, and documentation necessary to install and operate a dynamic message sign (DMS) control system that fully complies with the functional requirements herein, including incidental items that may have been inadvertently omitted.

667.5.1 General Specifications

DMS control software shall:

1. Operate on desktop and laptop computers with Intel® Pentium® IV or better processors and Microsoft® XP Professional® installed.
2. Provide a user-friendly multi-color graphical user interface.
3. Be written as a native 32-bit Windows® program using Microsoft-certified software development tools (compilers, etc.).
4. Control a network of at least 250 dynamic message signs.
5. Utilize a client-server architecture with the server handling sign communications and the clients connecting to the server via local and wide area networks (LAN and WAN).
6. Support DMS communications via any combination of dedicated hardwired serial network, fiber-optic network, dial-up telephone lines, leased phone lines, cellular telephone, CDPD, spread spectrum radio, Ethernet, or other as specified herein.
7. Support DMS control, monitoring, and diagnostic functions as specified herein.
8. Control DMS both remotely from a central location, and locally at the DMS site using a laptop computer.
9. Be accompanied by an easy-to-use software installation utility.
10. Include an operation manual that includes detailed instructions for configuring and using all parts of the software.
11. Contain an on-line help system that includes documentation for every screen or dialog box present in the software. It shall also be context sensitive such that pressing the help button or [F1] key on any screen will launch the help page for that particular screen.
12. Be fully compliant with the communications protocol requirements of the NTCIP Special Provision specified herein.

667.5.2 Software Security

DMS control software shall support the creation of user IDs and passwords for up to 100 system users. Only a “System Administrator” shall assign user creation, as well as individual
user access rights.

Before a system operator can use the DMS control software, the software shall request a "user name" and user "password." If the correct user name and password are not provided, access to the software shall be declined.

667.5.3 Client-Server Architecture

The software shall be of a modular design including a server and multiple client modules. The server shall handle all DMS communication and shall store all configuration data, messages, and other data. The client software modules shall send requests to and receive responses from the server over any TCP/IP-based network, including LANs and WANs. Separate clients shall be provided for each of the following software functions:

1. Shell client that handles user login and logout, as well as launching the other clients.
2. Display control client for controlling DMS messaging, monitoring system status, and performing DMS diagnostics.
3. Message editor client for creating DMS messages.
4. Message scheduler client for creating time and date schedules for activating messages.
5. Administration client for DMS system configuration and administration.

667.5.4 DMS Control

The DMS control software shall provide a user interface that presents the system’s DMS in both list and graphical formats. The software will allow the DMS to be grouped as needed by the administrator. The DMS list and map interfaces will include only the signs for the group currently selected.

667.5.4.1 List and Map Interfaces

The DMS list shall clearly display the following information about each DMS:

1. DMS ID number, as “1” through “250”.
2. DMS name, in a descriptive text format.
3. Iconic representation of the type of communication network used for the DMS (i.e. direct or dial-up).
4. Name and priority level of message file being displayed.
5. Date and time of last communication between the control software and the DMS sign controller.
6. Error and warning status, including pixel errors, power failures, communication error, etc.

The graphical interface shall include the following:

1. Configurable bitmaps that may be used to show all or parts of the system geographically.
2. Icons for each sign that may be placed anywhere on the map.
3. Visual indicators or Icon color changes to indicate the status of the DMS (i.e., yellow for
warnings or red for errors).
4. Visual indicators or Icon flashes if a message is running on the DMS.
5. Icon View with sign location and message displayed or Sign name is visible if mouse is placed over a DMS icon.

667.5.4.2 Direct Control Operations

The user interface shall provide a means for users to directly perform the following tasks for each sign:

1. Send and activate stored messages from the libraries
2. Blank the display
3. Activate an ad-hoc quick message that is created immediately, not loaded from a library
4. Send and activate schedules
5. Retrieve both messages and schedules from the sign
6. Perform diagnostics of DMS subsystems, such as power supplies, sensors, etc.
7. Perform tests of pixels
8. Monitor the sign’s event log

667.5.4.3 Polling

The software shall have a feature to poll all or a set of DMS at predefined intervals or at a specific time-of-day. During this poll, the software shall retrieve the most recent status information from the sign and present it to the user as appropriate in the list and map interfaces.

667.5.4.4 Scenarios

The administrator shall have the ability to create scenarios that act like macros or scripts to automate a series of often repeated tasks. These scenarios shall have the ability to perform the following actions:

1. Send and activate stored messages from the libraries.
2. Blank the display.
3. Send and activate schedules.
4. Perform diagnostics of DMS subsystems, such as power supplies, sensors, etc.
5. Perform tests of pixels.

The scenarios shall be saved to libraries where system operators may activate them through the graphical user interface. The scenarios shall also be scheduled to automatically run at predetermined times and dates.

667.5.4.5 System Monitoring

The software shall be capable of monitoring and displaying to the operator the contents of any communications in progress with DMS. The status of all outgoing and incoming data packets will be visible.

667.5.4.6 Multi-Vendor Sign Control
The software shall be capable of controlling any NTCIP-compatible DMS regardless of the manufacturer. The software shall support all mandatory and optional features typical in LED DMS. The software shall be configurable to enable or disable support for any standard optional NTCIP objects.

667.5.5 Message Creation and Editing

A DMS system operator shall be able to use the DMS control software to create, edit, name, and store message files.

The message editor GUI shall present a scaled image of the DMS display matrix, including a complete and accurate representation of the display matrix type (full or line) and the number of display pixels. The DMS editor image shall actively show message content in a WYSIWYG format, while a new message is being created or an existing message is being edited.

The message editor shall provide the operator with the ability to program:

1. The number of pages that the message is to contain (shall be a maximum of six)
2. Message text
3. Message graphics, including pixel-by-pixel editing, lines, area fill, block move, etc.
4. Character font type(s) used to construct the message
5. The amount of inter-line spacing, measured in pixels
6. Horizontal message justification on the DMS display matrix including left, center, and right
7. Vertical message justification on the DMS display matrix including top, middle, and bottom
8. The type of entry effect, as “static” or “scrolling”
9. Message page on time and off time
10. Message scroll rate, if a scrolling message
11. The flash rate of all or part of a message page
12. Message priority status
13. The display status of any flashing beacons mounted to the DMS

The message editor shall provide a method of incorporating data fields into a DMS message. The following data fields shall be provided:

1. Time, in 12-hour format
2. Time, in 24-hour format
3. Temperature, in degrees Fahrenheit and Celsius
4. Speed, kilometers per hour and miles per hour (vehicle speed, for DMS sites that contain speed measurement equipment)
5. Day of week (Monday, Tuesday, etc)
6. Day of the month (1, 2, …31)
7. Month of the year (1, 2, …12)
8. Calendar year, in both two-digit and four-digit formats

The message editor shall provide a convenient means for the operator to:

1. Insert, add, or delete, message text
2. Paste graphics from other programs using the Windows clipboard
3. Clear the content of the editing page
4. Save the message file under its existing name or a new name
5. Delete a message file
6. Save all new changes

It shall be possible to store message files in both the DMS control computer memory and the DMS sign controller memory.

The system operators shall have the ability to print any message or library of messages.

667.5.6 Message Libraries

DMS control software shall support the creation and storage of message libraries (file directories), which allow the system operator to categorize message files by:

1. DMS matrix size
2. Message subject matter

The library editor shall allow a system operator to:

1. Create a new library
2. Store the same message in multiple libraries
3. Select a message from an existing library and edit the message contents
4. Search message libraries for messages with specified text in message name or contents
5. Copy/Paste a message from one library to another
6. Delete a message file from a library
7. Rename a library
8. Delete a library
9. Save all new changes

667.5.7 Schedule Creation and Editing

DMS control software shall support the creation of message schedules, which instruct the DMS sign controller to run specific messages at pre-determined times and dates.

Software shall contain an editor, which allows messages to be scheduled via:

1. Month of the year (January, February, etc.)
2. Day of the week (Monday, Tuesday, etc)
3. Day of the month (1, 2, …31)
4. Time of day

The schedule editor shall provide a convenient means for the operator to:

1. Create a new schedule
2. Rename an existing schedule
3. Delete a schedule
4. Save all new changes
It shall be possible to store schedule files in both the DMS control computer memory and the DMS sign controller memory.

667.5.8 Display Fonts

The software shall support a minimum of twelve (12) fonts for each model of DMS. These fonts shall be configurable by the system administrator. The fonts used shall be selectable from a library containing a minimum of 24 fonts provided by the software vendor. Each sign model shall be capable of using a different set of fonts. The software shall automatically adjust the available fonts in the message editor based on the DMS model configuration.

The software shall include a font editor to allow the operator to create custom fonts. The font editor shall allow the DMS system operator to create new fonts or modify existing fonts. The operator shall have the capabilities to graphically edit each character within a font in a pixel-by-pixel manner.

Any of the fonts provided by the software vendor or created/modified by the administrator shall be downloadable to the DMS.

667.5.9 Event Logging

The software shall include an event logging system that logs all significant system events. Each logged events shall include the following fields at a minimum:

1. Event ID number
2. Operator that initiated the event
3. Time and date that the event occurred
4. Description of the event (i.e., “Diagnostic Test Performed”)
5. Source of the event (i.e., DMS sign name)
6. Additional data relevant to the event (i.e., “Failed pixel: (4, 73)”)

The events logged shall include, but not be limited to, the following:

1. User login/logout
2. Failed login attempts
3. Communication failures
4. Message and schedule activation or display blanking
5. Diagnostics test results
6. Warning events sent from the sign
7. Other system errors

The system operators will have the ability to view, sort by category, and print the log file at any time.

667.5.10 System Configuration

The DMS control software shall allow system administrators, and other users with correct
security access right, to configure many system parameters and functions. The basic sets of configurable settings include the following:

1. Sign models and individual signs
2. Communication networks
3. System error/warning alarms
4. User security rights
5. System maps and sign icon placement
6. Default system option settings
7. Default message parameters
8. Message priority settings

667.5.10.1 Sign Configuration

Each sign in the DMS control software shall be configured with the following parameters:

1. Sign viewing area height and width (for full-matrix signs)
2. Number of lines and each line’s height and width (for line-matrix signs)
3. Site name
4. DMS ID number
5. Network address
6. Communication parameters

667.5.10.2 Communication Settings

Communication network configuration shall include the ability to configure and modify sign communication networks with the following parameters:

1. Network type (i.e., direct serial, dial-up)
2. Communication port (i.e., COM4)
3. Baud rate (ranging from 1200 to 115,200)
4. Hardware handshaking
5. NTCIP subnetwork and transport protocols
6. Communication retries and timeouts

667.5.10.3 System Alarms

Configurable settings shall allow the system administrator to determine which of the following events will trigger an audio and visual (on-screen) alarm:

1. Communication failure
2. Priority status conflict
3. Sign restart
4. Power supply failure
5. Door open

667.5.10.4 User Administration

The administrator shall have the ability to add, remove and modify users. The access rights
of each user shall be configurable to allow or deny access to each major software feature.

667.5.10.5 System Maps

It shall be possible to configure each sign group to appear on a map within the software. The administrator shall be able to use the software to select the map, identified as a bitmap file, which can then be imported into the software. Each sign shall have an icon that may be placed anywhere on the map.

667.5.10.6 Message Editor Defaults

The message editor shall automatically utilize the following default settings during the creation of new message files:

1. Pixel spacing between adjacent lines of text
2. Pixel spacing between adjacent text characters
3. Display duration of a given message page
4. Color palette to be used for color-capable signs
5. Beacon activation status (for DMS that contain flashing beacons)
6. Effect to be applied to text (i.e., static, scrolling, etc.)
7. Effect rate, which shall determine the speed of scrolling messages
8. Flash rate, which shall determine the speed of flashing messages
9. Message priority classification
10. Horizontal text justification supporting left, center, or right
11. Vertical text justification supporting top, middle, and bottom

667.5.10.7 Message Priorities

User-definable defaults shall allow messages to be assigned a priority classification of:

1. Emergency
2. High
3. Normal
4. Low
5. Minimal

A numeric priority range shall be assigned to each of these five priority classifications. The priority shall allow two different message files to be assigned the same classification, but within that classification, one message can be identified as having higher priority.

667.5.11 Software Use and Reproduction Rights

The DMS manufacturer shall provide a DMS control software site license with the DMS supplied for this contract. Ten (10) copies of the DMS control software shall be provided to the engineer on CD-ROM within thirty (30) days of contract award. The engineer shall have the right to request or reproduce an unlimited number of software copies for use on the DMS system installed for this contract.
CONSTRUCTION METHODS

667.6 General

Construction methods shall conform to the requirements of the Plans and the latest issue of the West Virginia Division of Highways Standard and Supplemental Specifications, except as modified.

667.7 Maintaining Traffic

During the installation of the DMS appurtenances, the roadway shall be kept open to all traffic by the Contractor in such a way that both local and through traffic will be adequately and safely accommodated through the work area. See the Manual, "Traffic Control for Street and Highway Construction and Maintenance Operations", and applicable sections of the Standard Specifications.

667.8 Warranty

Equipment furnished under this Specification shall be guaranteed to perform according to these specifications and to the manufacturer's published specifications. Equipment shall be warranted for a minimum of five years parts return to factory against defects and/or failure in design, materials and workmanship. Unless otherwise specified in the invitation for bids, warranty coverage shall become effective on the date of final acceptance of the system by the Department. The DMS manufacturer shall assign to the Department all manufacturer's normal warranties or guarantees, on all such electronic, electrical and mechanical equipment, materials, technical data, and products furnished for and installed on the project. Defective equipment shall be repaired or replaced, at the manufacturer's option, during the warranty period at no cost to the Department.

After the warranty has expired, the Manufacturer shall provide lifetime technical assistance to the Department to assist the Department in troubleshooting the sign for repair. This technical assistance will be by telephone and/or Manufacturer's representative site visit.

667.9 Method of Measurement

The LED DYNAMIC MESSAGE SIGN will be measured as each unit furnished, installed, made fully operational, tested, as well as training to be provided in accordance with this specification.

667.10 Basis of Payment

The work performed and materials furnished in accordance with this Item and measured as provided under “Method of Measurement” will be paid for at the unit price bid for “LED DYNAMIC MESSAGE SIGN.” This price shall be 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 necessary to complete the work.

667.10 Training

667.10.1 Description

The manufacturer/contractor shall provide training, manuals, and all other particulars regarding the DMS software in accordance with these specifications. This training shall follow the delivery of the equipment documentation.

667.10.2 General Provisions

The manufacturer shall provide training for not less than ten (10) WVDOT personnel on the operation and maintenance of the variable maintenance signs(s) (DMS), controllers, systems and controller software. The manufacturer shall utilize qualified instructors regarding all aspects of the DMS training. At least 30 calendar days prior to commencement of the training, the manufacturer shall submit detailed course curriculums, draft manuals, and handouts to the Traffic Engineering Division.

Training shall not last more than eight (8) hours in any given day. Training shall be a mixture of formal classroom and hands-on training with the majority of the training being hands-on. Training shall be conducted in the Charleston, West Virginia area as required by the Traffic Engineering Division. Training shall be completed prior to the end of the 30 day testing period. Training material generated for each course shall contain manuals and other handouts for each attendee which shall serve not only as subject guidance, but also a quick reference guide for use by the attendees.

There shall be a minimum of four (4) hours of classroom training to train personnel on the operational aspects of the signs and software. This training will be more suited to operators or those who are responsible for programming messages. In addition, there will be a minimum of eight (8) hours of training to train maintenance personnel. A portion of the maintenance training shall be in a classroom environment and aimed at operation, maintenance, and troubleshooting of field equipment. At least four (4) hours of the maintenance training shall be on-site.

Personnel attending this training shall be fully trained to use all features and functions of the equipment and software including diagnosing all system functions from the central control computers. Overview shall include data communications equipment, dynamic message sign, cabinets, and auxiliary equipment. In addition, this training shall include routine maintenance and troubleshooting procedures.

Training costs, as described within these specifications, shall be incidental within the cost of the contract. This incidental costs shall include the cost of course curriculum, instructor’s handouts, manuals, installation and removal of software. Travel and per diem costs for all instructors shall also be incidental to the total contract cost.

667.12 Pay Items
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<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
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<td>LED DYNAMIC MESSAGE SIGN</td>
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* Sequence number