ITEM 680.84028911 M VARIABLE MESSAGE SIGN ASSEMBLY, LED, TYPE A – 3 LINES (FULL MATRIX)

DESCRIPTION

This work item shall consist of the furnishing and installation of a complete amber LED Variable Message Sign assembly at locations indicated in the contract documents. This special provision describes minimum specifications for the light emitting diode (LED) variable message sign(s) as required by the contract.

MATERIALS

To insure compatibility and interchangeability with equipment furnished under previous projects, all LED VMS and field controllers supplied, as part of this item shall be manufactured by Daktronics, Inc. of Brookings, South Dakota, Model no. VF-2020-27x105-18-A.

Daktronics, Inc.
331 32nd Avenue
Brookings SD 57006
Toll Free: 888-325-8766
Phone: 605-697-4000

General

VMS Display Capability
The VMS Type A shall be a Vanguard® Variable Message Sign Full Matrix, Amber, Walk-In Access 18-Inch (460mm) with a 30 Degree Viewing Cone. It shall also contain a full display matrix measuring a minimum of 27 rows high by 105 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. 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 centers of all adjacent pixels shall be spaced 2.6 inches (66mm) apart, both vertically and horizontally. The pixel matrix shall be capable of displaying alphanumeric character fonts measuring a minimum of 18 inches (460 mm) high to a maximum of the display matrix height. The VMS shall be able to display messages composed of any combination of alphanumeric text, punctuation symbols, and graphic images across multiple frames. VMS messages shall be legible within a distance range of 150 ft (45.72m) to 900 ft (274.3m) from the VMS display face under the following conditions:

- When the VMS is mounted so its bottom side is positioned between five (5) feet (1,524 mm) and 20 feet (6,096 mm) above the roadway surface.
- Whenever the VMS is displaying alphanumeric text that is 18-inches (460 mm) high.
- 24 hours per day and in most normally encountered weather conditions.
- During dawn and dusk hours when sunlight is shining directly on the display face or when the sun is directly behind (silhouetting) the VMS.
- When viewed by motorists and travelers that have 20-20 corrected vision.

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When motorists’ and travelers’ eye level is three (3) feet (914mm) to 12 feet (3,658 mm) above the roadway surface.

Display of Alphanumeric Text
For message creation, the VMS, VMS sign controller, and VMS control software shall support the storage and use of a minimum of three (3) alphanumeric character font files. Each font file shall include the following characters:

- The letters “A” through “Z”, in both upper and lower case
- Decimal digits “0” through “9”
- A blank or space
- Eight (8) directional arrows
- Punctuation marks, such as:.,!?-’”
- Other characters, such as: #&*+()[]<> 

During message creation, individual characters shall be selectable with either a single computer keystroke, such as [M], or a two-keystroke operation, such as [shift] [M].

Inter-character (horizontal) spacing, which separates adjacent text characters, shall be operator selectable during message creation using the VMS control software.

Inter-line (vertical) spacing, which separates adjacent text lines, shall be operator selectable during message creation using the VMS control software.

The VMS shall provide a minimum of three (3) pixel rows of vertical space between adjacent text lines, whenever multiple lines of seven-pixel high (18-inch, 460mm) text are being displayed.

The following character font files shall be supplied with the VMS:

- **7x4 Single Stroke** – a typical font is seven (7) pixel rows high by four (4) pixel columns wide, has a single-pixel stroke width, and provides one pixel column of inter-character spacing
- **7x6 Double Stroke** – a typical font is seven (7) pixel rows high by six (6) pixel columns wide, has a two-pixel stroke width, and provides one pixel column of inter-character spacing
- **7x5 Single Stroke** – a typical font is seven (7) pixel rows high by five (5) pixel columns wide, has a single-pixel stroke width, and provides one pixel column of inter-character spacing
- **11x7 Double Stroke** – a typical font is eleven (11) pixel rows high by seven (7) pixel columns wide, has a two-pixel stroke width, and provides two pixel columns of inter-character spacing

Display of Graphic Images
NTCIP version 2 shall support communication and display of graphic image data files. The VMS sign controller, and VMS control software shall provide the ability to create and display graphic images by storing the images as bitmap files. The VMS shall be able to display messages containing graphic images of any size that will fit on its display matrix.

Message Effects
The VMS shall be able to display messages using the following types of effects:

- **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
- **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
- **Scrolling Message** - The message moves across the display face from one side to the other. The

2 of 41

June 24, 2004
Revised 5/16/06
direction of travel is user selectable as either left-to-right or right-to-left

- **Multiple-Page Message** - A message contains up to six (6) 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.

A VMS message shall be able to utilize a combination of these effects.

**VMS Control and Communications**

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

The VMS sign controller shall be able to receive instructions from and provide information to a computer containing VMS control software using the following communication modes:

- **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 VMS sign controller with an RS232 signal having a baud rate of 2400 bps minimum.
- **Locally** - Via direct connection with a laptop computer that is connected directly to the sign controller using a null modem connection and a baud rate of 2400 bps minimum.

**Diagnostic and Status Information**

VMS operational status, as well as the functional status of major VMS components and VMS sign controller communications, shall be reportable to VMS control software residing in both remote and local computers. This shall minimally include the following information:

- **Sign Controller Communications** - As “Normal” or “Failed”
- **Message Display Status** - As {name of message being displayed} or “Blank Message”
- **LED Intensity Level** - The percentage of the maximum brightness at which the LED display is currently operating, whether the intensity control is in automatic or manual mode.
- **LED Intensity Level Control Method** – As “Automatic” or “Manual”
- **LED Pixel Status (for all pixels)** – Displayed upon operator request in a graphical user interface (GUI) format and as “Normal” or “Stuck-Off”
- **Real-Time VMS Message Verification** – Presents the exact content of the displayed message in real-time. Currently running message can be viewed using the VMS control software
- **Regulated DC Power Supply Output Status (for all supplies)** – As “Pass” or “Failed”
- **Internal VMS Temperature** – The internal VMS air temperature measured by an internally located sensor. This shall be reported in degrees F and C
- **Ambient VMS Site Temperature** – Outdoor air temperature measured by an external temperature sensor. This shall be reported in degrees F and C

**Material, Manufacturing, and Design Standards**

VMS provided for this contract shall comply with the most recent revision of the following standards, if no revision date is given:

- **Aluminum Welding** - The VMS housing shall be fabricated, welded, and inspected in accordance with ANSI/AWS D1.2-97 Structural Welding Code-Aluminum (1997)
- **Electrical Components** – High-voltage components and circuits (120 VAC and greater) shall be wired and color-coded per the National Electric Code
- **Environmental Resistance** – The VMS housing shall comply with type 3R enclosure criteria as described in NEMA Standards Publication 250-1997, Enclosures for Electrical Equipment (1000 Volts Maximum)
- **Maintenance Access** – The LED display matrix and other internal VMS components shall be accessible
through doorways located on side walls (left and/or right) of the sign housing (perpendicular to the LED display matrix)


**Structural Integrity** – The VMS housing shall be designed and constructed to withstand a minimum sustained wind load of 120 mph (193 kph). The VMS housing shall support a front face ice load of 4 pounds per square foot (19.5 kg per square meter). The VMS housing shall be designed and constructed to comply with all applicable sections of *AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals, Fourth Draft, 2001*, as well as the fatigue resistance requirements of *NCHRP Report 412, Fatigue-Resistant Design of Cantilevered Signal, Sign, and Light Supports*

**Communication Protocols** – The sign controller hardware/firmware and VMS control software shall conform to the applicable National Transportation Communication for ITS Protocol (NTCIP) standards as defined in the Special Provisions for NTCIP later in this document.

**Digital Control Unit/VMS Sign Controller**

The sign controller shall have the following characteristics:
- Stand-alone microprocessor-based unit with integrated watchdog circuitry
- Internal regulated DC power supply
- Memory for storing changeable and permanent messages, schedules, and other necessary files for controller operation.
- Includes front panel user interface with LCD and keypad for direct operation and diagnostics
- Mounts in a standard EIA 19-inch (480 mm) equipment rack using the supplied mounting hardware
- Maximum weight of 10 pounds, including its enclosure
- Built-in rechargeable battery backup circuit that can provide the controller with power briefly when the primary AC power source fails
- Three (3) NTCIP-compliant RS232 communication ports. One (1) of the serial ports shall have a secondary RS422 interface option
- One (1) Ethernet port with RJ45 connector supporting NTCIP communication
- Built-in Hayes-compatible modem with standard RJ11 connector
- Operate successfully throughout a temperature range of -34°C to +74°C (-30°F to 165°F)
- Communicate directly with the distribution board located in the VMS, which communicates with all sensors, LED drivers, and other devices
- Include VMS-specific control firmware (embedded software) that shall handle all external and internal sensors and communication inputs and drive the display modules as directed by external control software

**Memory/Sign Messages**

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

- Monitor the current status of the sign controller, including the status of all sensors and a representation of the message visible on the display face
- Perform diagnostics testing of various system components, including pixels, power systems, sensors, and more
- Activate messages stored in memory
- Configure display parameters, including display size, colors, and communications

The front panel interface shall also include:

- Power switch to turn the controller on and off and an LED “on” indicator
- A “local/remote” switch with an LED indicator that places the controller in local mode such that it can be controlled from the front panel interface, instead of via the primary communication channel
- Reset switch to quickly restart the controller
- LED “Active” indicator blinks when the controller is operating
- LED to indicate when any of the NTCIP communication channels are active

A serial communication port (“Local”) shall allow connecting a laptop directly to the controller.

Serial Communication Ports
The VMS sign controller shall contain 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 optics.

The baud rate, connection type, and NTCIP communication protocol shall be configurable. The baud rate for each port shall be set to any typical serial baud rate ranging from 1200 to 115,200. All three (3) 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) profiles. Only one each of the transport and sub network profiles shall be active at any time on each port.

Each port’s default settings shall be set as listed below.

<table>
<thead>
<tr>
<th>Port</th>
<th>Baud Rate</th>
<th>Connection Type</th>
<th>NTCIP Sub network Profile</th>
<th>NTCIP Transport Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Auxiliary Control”</td>
<td>9600</td>
<td>Modem (External)</td>
<td>NTCIP 2103 – PPP</td>
<td>NTCIP 2202 – Internet</td>
</tr>
<tr>
<td>“Central Control”</td>
<td>9600</td>
<td>Direct</td>
<td>NTCIP 2101 – PMPP</td>
<td>NTCIP 2201 – Null</td>
</tr>
<tr>
<td>“Local”</td>
<td>9600</td>
<td>Direct</td>
<td>NTCIP 2101 – PMPP</td>
<td>NTCIP 2201 – Null</td>
</tr>
</tbody>
</table>

The VMS sign controller shall contain one (1) 10/100 Ethernet communication port. This port shall be available for optional use for communicating from the central control system to the VMS sign controller when an Ethernet network is available.

Communications on this 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.
Dial-Up Modem Communication Port
The VMS sign controller shall include one (1) built-in Hayes-compatible dial-up modem. It shall be available via a connector labeled “Phone Line.”

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.

Battery Backup
The VMS sign controller shall include a built-in, rechargeable battery backup circuit that shall allow the controller to operate for a minimum of 30 minutes if the incoming AC power source fails. The battery backup circuit shall supply enough power to backup all internal systems of the VMS sign controller, including RS232, Ethernet and dialup modem communications.

Internal Clock
The VMS sign controller shall contain a computer-readable time of year clock that has a lithium battery backup. The battery shall keep the clock operating properly for at least 10 years without external power, and the clock shall automatically adjust for daylight savings time and leap year using hardware or software, or a combination of both. The clock shall be set by the sign controller microprocessor and shall be accurate to within one (1) minute per month.

Computer Commands
The sign controller shall receive and interpret commands sent by a host device and cause the requested message to be displayed on the sign, and shall provide a return message to the computer that provides information concerning the status of the sign.

Display Interface
The VMS sign controller shall transmit and receive data packets to and from a distribution board. The distribution board shall communicate with all sensors, drivers, and other devices using multiple networks running throughout the VMS.

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

Communication from the sign controller to the distribution board shall be using fiber optic cables that connect at the rear of the VMS sign controller. The controller shall also offer optional copper connections as an alternative to the fiber optic cable.

Sign Controller Addressing
The VMS sign controller shall use multiple types of addressing when operating on NTCIP communication networks. The addressing shall be configurable through the front panel user interface.

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

When operating on Ethernet networks (NTCIP 2104) a static IP address and subnet shall be used. If a dial-up or direct connect serial network is configured for PPP (NTCIP 2103), then no addressing shall be required.
Warning “Traps”
The VMS sign controller shall be capable of automatically informing a central control system of the occurrence of important event or subsystem failures. This shall be handled via NTCIP “traps.” When one of these events occur, the sign controller shall create a data packet for transmission to the central controller that shall contain details about the event.

Traps shall be generated for the following events:
- **Sign controller restart** – Indicates that the sign controller restarted due to a power interruption, intentional restart, or other event.
- **Power supply failure** – Indicates that a diagnostic sensor detected a power supply that is not operating correctly.
- **Door open** – Indicates that one of the doors on the VMS housing or control equipment cabinet has been opened. Note: This feature requires that an optional sensor be installed in the sign.
- **Over Temperature Shutdown** – Indicates that the maximum safe operating temperature has been reached or exceeded, resulting in the blanking of the display.

Sign Controller Software
*Message Presentation of the VMS Display Matrix*
The sign controller shall instruct the LED driver circuitry in a manner that causes the desired message to display on the VMS sign controller. At a minimum, the sign controller shall support the following features as described in the VMS specification:
- Display of alpha numeric character fonts and graphic pictures
- Message format details such as centering text on a display line, right justification, left justification, and legible spacing of letters and words
- Selection of a particular character font style
- Display of static messages
- Flashing of all or part of a message
- Message scrolling
- Alternating between pages of a multi-page message

Message Activation
Messages shall be activated on a VMS in three (3) ways:
- **Manual** – An operator using the Vanguard control software manually instructs a particular message to be activated.
- **Schedule** – The internal time-based scheduler in the VMS 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.
- **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.

A displayed message shall remain on the sign until the controller receives a command to change the message or blank the sign, or a schedule stored in the sign controller memory indicates that it is time to implement a different message. 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 overwritten.
Schedule Activation
The VMS sign controller shall support the following message scheduling functions, which may be initiated by the VMS control software:

- Cause the sign controller to implement a message schedule stored in its memory
- Cause the sign controller to implement a new schedule entered via the control software
- Completely replace a message schedule stored in the sign controller memory
- Cause the sign controller to report the contents of any message schedule stored in its memory
- Override a scheduled message

The sign controller shall be able to implement a message stored in its memory at a particular time and date, as supported by a message schedule feature.

Display of Alphanumeric Text
The VMS sign controller and control software shall support the storage and use of up to eight (8) character font sets from which messages can be created. A font file shall include the following characters:

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

During the creation of a VMS message, an individual character font shall be selected using a single or double computer keystroke.

The VMS supplier shall make available the fonts listed in the following table with the control software. The operator shall be able to easily install any of these fonts in the VMS. A font editor shall be included so that the user may create custom fonts from scratch or by modifying any of these existing fonts.

<table>
<thead>
<tr>
<th>Font Name</th>
<th>Character Height</th>
<th>Character Width (avg.)</th>
<th>Variable or Fixed Width</th>
<th>Stroke Weight</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>
<tr>
<td>14x8</td>
<td>14</td>
<td>8</td>
<td>Fixed</td>
<td>Double (2)</td>
</tr>
<tr>
<td>14x10</td>
<td>14</td>
<td>10</td>
<td>Variable</td>
<td>Double (2)</td>
</tr>
<tr>
<td>Graphic 15</td>
<td>15</td>
<td>N/A</td>
<td>Variable</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Display of Graphic Images
The VMS control software shall be able to create and communicate graphic images to a VMS sign controller as font (text) files. VMS Intensity Control

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

- Utilize three (3) photoelectric sensors, which are provided and installed as described in the VMS specification. It shall use these measurements to automatically determine which LED intensity level will provide the best legibility for the given ambient light condition.
- Select from a minimum of sixteen LED intensity levels. LED intensity levels shall be available in a range of 1% to 100% of the maximum display intensity, and in increments of 1%
- Not cause any flickering of the LED display matrix
- Allow manual and automatic intensity control modes to be user selectable using the VMS control software, although the typical control mode shall be “automatic”
- Allow manual intensity control from both local and remote locations.

LED Diagnostic Test Capability
Upon command from either a remote computer or local laptop running the central control software, the sign controller shall test the operation of all LED pixels and determine whether their functional status is: “Normal” or “Stuck-Off”. Pixel status shall be determined via A/D conversion of the LED pixel forward voltage, and the resulting data shall be communicated to the VMS control software.

The resulting data shall be transferred and monitored via the front panel and NTCIP interfaces.

Real-Time VMS Message Verification
The VMS sign controller and LED module hardware shall be capable of enabling the VMS Central Control operator to verify the actual message displayed on the VMS on a real-time basis. This message verification shall be presented in a WYSIWYG format without disrupting the message displayed on the VMS. This shall be accomplished each time the VMS is polled for status by the central control software. A graphical user interface (GUI) capable of displaying this type of information must be present in the central VMS control software.

Power Supply Diagnostic Test Capability
The sign controller shall be able to determine the functional status of regulated DC power supplies located in the VMS by monitoring diagnostic outputs located on the supplies. This information shall be reportable as “Pass” or “Failed” to the VMS control software.

Response to Errors
In the event of communication error between the VMS sign controller and the system control computer, the “communications loss message” shall be displayed. This shall be factory disabled.

In the event of a power failure, the “power recovery message” shall be displayed. This shall be factory set to blank the VMS.

The VMS sign controller shall contain a hardware watchdog that automatically resets the controller’s microprocessor in the event of a controller lock-up.

Over Temperature Shutdown
The VMS shall utilize an internal temperature sensor circuit that shall be monitored by the sign controller. The VMS shall be capable of being configured to automatically blank the sign face if the internal temperature of the VMS exceeds a configurable threshold. If this occurs, the sign controller shall also notify the central control system.
Manual Reset
The sign controller shall have a momentary contact switch that can be used to reset the sign controller.

Manual Test Switch
The sign controller shall have a switch that initiates a manual test of each pixel in the sign.

Hardware Watchdog Timer
The sign controller shall have a hardware watchdog timer that shall check its own operation. While the sign controller program is running, the hardware watchdog timer shall be reset periodically. If the watchdog timer is not reset, the watchdog timer shall reset the sign controller.

Sign Controller Cabinet
The sign controller shall be installed in a Type 334 series cabinet at the roadside within 300m of the sign as indicated in the plans. Communication and control lines between the sign and the control cabinet shall be opto-isolated. AC wiring between the two shall be protected from transient voltages. A 0.75 inch minimum diameter conduit shall be installed to accommodate the communication lines between the cabinet and the sign.

The sign controller cabinet shall contain the following assemblies:
- Power distribution assembly containing thermomagnetic circuit breakers for the sign and controller cabinet
- Hardened PC Based controller with industry standard components
- Modem
- Opto-isolated sign interface assembly
- Cabinet light and switch
- Local/remote control switch and LED indicator
- RS-232 plug-in connection for the laptop computer
- RS-232 cable a minimum of 1.20 m long to connect the laptop computer to the sign controller
- Sign to ground voice communication with FM radios
- For dialup installations, an RJ-11 jack for connecting the dialup phone line shall be installed
- Cabinet fan, thermostat and filtered vent
- GFI duplex utility outlet rated for 15 amps minimum
- Uninterruptible power supply
- A slide-out work tray, for the laptop computer, mounted on ball bearing slides.

Cabinet lamps shall be used to illuminate the internal controller cabinet when either of the cabinet doors is opened. The lamps shall be extinguished when the cabinet doors are closed. The lamps shall be positioned and shielded to prevent light from shining in a person's eyes.

Sign to Controller Cabinet Interconnect
Cables between the sign and the sign controller cabinet shall be provided for operation of the sign.

Signal control and data cables shall be 22 or 24 AWG, stranded, twisted pair, 300 V cable. These cables shall terminate using CHAMP IDC type connectors. As an alternative, the signal cable shall be a multi-mode fiber optic cable. These cables shall be terminated using ST type connectors.

The power cables shall provide 240/120 VAC at 50 amps to the sign housing.

Power and signal cables shall be in separate conduits for twisted pair cable. Power and fiber optic cable
shall be placed in a single conduit or separate conduits.

CONSTRUCTION DETAILS

VMS General Specifications
The VMS housing shall provide walk-in service access for all LED display modules, electronics, environmental control equipment, air filters, wiring, and other internal VMS components.

Dimensions –VMS housing dimensions shall not exceed 7’10”/2.39m high by 24’11”/7.60m wide. The front-to-back housing depth shall not exceed 3’8”/1.12m at its widest point, including the rear ventilation hoods.

Weight –VMS weight shall not exceed 3400/1542 pounds/kg

Power –Maximum AC power shall not exceed 4374 watts, when the following circuits are operational and fully loaded:
- LED display pixel matrix, with 100% of the pixels operating at their maximum possible drive current
- VMS environmental control system
- Utility outlet circuit
- VMS sign controller

Typical VMS AC operating power shall not exceed 2465 watts, with the following circuit loadings:
- LED display pixel matrix, with 25% of the pixels operating at their maximum possible drive current
- VMS sign controller

VMS shall operate from one of the following power sources:
- 120 VAC, 60Hz single-phase, including neutral and earth ground
- 120/240 VAC, 60Hz single-phase, including neutral and earth ground
- Two legs of 120/208 VAC, 60Hz three-phase, including neutral and earth ground

The VMS housing shall be constructed to have a neat, professional appearance. The housing shall protect internal components from rain, ice, dust, and corrosion in accordance with NEMA enclosure Type 3R standards, as described in NEMA Standards Publication 250-1997, Enclosures for Electrical Equipment (1000 Volts Maximum). The VMS 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.

VMS and sign controller components shall operate in a minimum ambient (outdoor) temperature range of −40° to +115° F (−40° to +46° C) and a relative humidity range of 0 to 99%, non-condensing. VMS and sign controller components shall not be damaged by temporary exposure to temperatures of −50° to +185°F (−45° to +85° C).

Internal VMS component hardware (nuts, bolts, screws, standoffs, rivets, fasteners, etc.) shall be fabricated from hot dipped galvanized steel, stainless steel, aluminum, nylon, or other durable corrosion-
resistant materials suitable for the roadway signage application.

No internal electrical wiring or internal electrical components of any type (fans, power supplies, transformers, LED display modules, circuit boards, surge suppression devices, fuses, relays, power and signal termination panels, utility outlets, and other electrical components) shall be located within 4 inches (102 mm) of the VMS housing floor. This will prevent short circuits from occurring, in the event of internal water buildup. The only allowable exception to this requirement shall be the bottom-facing photo sensor assembly, which shall be insulated to prevent water-related short circuits.

VMS and sign controller components shall be 100% solid-state, except for the environmental control fans and thermostats. All high voltage electrical components (exceeding 24 VDC) used in the VMS and the sign controller shall be UL (Underwriter’s Laboratory) listed and meet all local NEC codes applicable to VMS applications.

The presence of ambient radio signals and magnetic or electromagnetic interference, including those from power lines, transformers, and motors, shall not impair the performance of the VMS system. The VMS system shall not radiate electromagnetic signals that adversely affect any other electronic device, including those located in vehicles passing underneath or otherwise near the VMS and its sign controller.

**VMS Housing Frame and Mounting Brackets**

VMS housing’s right, left, and rear walls shall be vertical. The top and bottom sides shall be horizontal. The front VMS wall shall be built with a permanent forward tilt angle of three (3) degrees, so that the top of the VMS housing is deeper than its bottom. LED display modules shall be mounted parallel to the front wall, so they are tilted three degrees forward toward the viewing motorists and use of the legible LED viewing area is optimized.

The VMS housing structural frame shall consist of aluminum extrusions made from alloy number 6061-T6. All sides of the VMS housing exterior, except the front, shall be covered with 0.125-inch (3.17 mm) thick aluminum sheets made from 5052-H34 aluminum alloy. This external aluminum skin shall be attached to the structural framework using a proven method of attachment.

One method shall be to bond the skin to the aluminum extrusion. The adhesive shall be a two-part epoxy in a continuous bead run between the skin and the aluminum to ensure a watertight seal.

Another method of attachment shall be to stitch-weld the skin to the aluminum extrusion. All exterior sheet seams shall be continuously seam welded to the VMS frame to form a single structure. The VMS housing shall be welded and inspected in accordance with the requirements of *ANSI/AWS D1.2-97 Structural Welding Code-Aluminum (1997)*. Compliance with this standard shall include, but shall not be limited to, the following:

- Welding shall be performed according to documented in-house welding procedures
- Personnel who perform welding on the VMS housing shall be certified to meet *AWS D1.2-97* for all weld types required for housing fabrication
- A Certified Welding Inspector (CWI) shall inspect VMS welding on a daily basis and shall complete written reports that document welding progress, weld integrity, and any corrective action taken. The VMS manufacturer shall archive these reports and make them available for review, upon request of the Engineer.

Multiple mounting brackets in the form of I-beams or Z-extrusions shall be bolted to the VMS housing’s exterior rear wall to facilitate attachment of the VMS to the support structure. Mounting brackets shall be:
Extruded from aluminum alloy number 6061-T6
Attached to the VMS structural frame members, not just the exterior sheet metal
Installed at the VMS manufacturer’s factory
Attached to the VMS using Type B-8 stainless steel bolts
Attached to the VMS using direct tension indicators to verify that mounting hardware is tightened with the proper amount of force
Installed such that all bracket-to-VMS attachment points are sealed and water-tight
Designed and fabricated such that the installing contractor can drill into them without penetrating the VMS housing and compromising the housing’s ability to shed water

For moving and installation purposes, multiple steel lifting eyebolts shall be attached to the top of the VMS housing. Eyebolts shall attach directly to the VMS housing structural frame and be installed at the VMS factory. All eyebolt-mounting points shall be sealed to prevent water from entering the VMS housing. Lifting eyebolts, as well as the housing frame, shall be designed so that the VMS can be shipped and handled without damage or too much stress being applied to the housing prior to or during VMS installation on its support structure.

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

VMS 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.

**Front Face Construction**

The VMS front face shall be constructed with multiple rigid panels, each of which supports and protects a full-height section of the LED display matrix. Panel exteriors shall be fabricated from aluminum sheeting, and panel interiors shall be polycarbonate sheeting. Face panels shall be bolted to the VMS housing and to each other using stainless steel hardware. Seams that separate adjacent panels shall be sealed. Panels shall be removable and shall not be welded to the VMS housing.

Front face panels shall provide a high-contrast background for the VMS display matrix. The aluminum mask of each panel shall be painted black and contain an opening optimizing the contrast ratio for each LED pixel. Openings shall be large enough to not block any portion of the LED-viewing angle.

Polycarbonate sheets shall be securely attached to the inside of the aluminum panels and shall cover the pixel openings. The polycarbonate shall be sealed to prevent water and other elements from entering the VMS. Polycarbonate shall contain UV inhibitors, which protect the LED display matrix from the effects of ultraviolet light exposure and prevents premature aging of the polycarbonate itself. Polycarbonate sheets shall have the following characteristics:

- Tensile Strength, Ultimate: 10,000 PSI
- Tensile Strength, Yield: 9,300 PSI
- Tensile Strain at Break: 125%
- Tensile Modulus: 330,000 PSI
- Flexural Modulus: 330,000 PSI
- Impact Strength, Izod (1/8”, notched): 17 ft-lbs/inch of notch
- Rockwell Hardness: M75, R118
- Heat Deflection Temperature Under Load: 264 PSI at 270F and 66 PSI at 288F
- Coefficient of Thermal Expansion: 3.9X10-5 in/in/F

June 24, 2004
Revised 5/16/06
LED display modules shall mount to the inside of the VMS front face panels using a standard hand tool for removal and replacement.

VMS front face borders (top, bottom, left side, and right side), which surround the front face panels and LED display matrix, shall be painted black to maximize display contrast and legibility.

In the presence of wind, the VMS front face shall not distort in a manner that adversely affects LED message legibility.

**Exterior Finish**
VMS front face panels and front face border pieces shall be coated with semi-gloss black Kynar 500 resin or an equivalent brand of oven-fired fluoropolymer coating, which has an expected outdoor-service life of 20 years.

All other VMS housing surfaces, including the access doors and VMS mounting brackets, shall be natural mill-finish aluminum.

**VMS Housing Structural Certification**
A Professional Engineer registered in the State of New York shall analyze the VMS structural design and shall certify that the VMS:
- Will withstand the temporary effects of being lifted by the lifting eyebolts provided
- Will withstand a wind velocity of 120mph (193 kph)
- Will support a front face ice load of 4 pounds per square foot (19.5 kg/square meter)
- Complies with the applicable requirements of *AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, Fourth Draft, 2001*
- Complies with the fatigue resistance requirements of *NCHRP Report 412, Fatigue-Resistant Design of Cantilevered Signal, Sign, and Light Supports.*
- Design calculations verify that the sign enclosure meets all design criteria specified in this document and Article 730-27 of the Standard Specifications.

The Professional Engineer shall analyze the complete VMS 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 VMS manufacturer. Analysis shall include, but shall not be limited to:
- The quantity and type of lifting eyebolts to be provided
- The quantity and type of mounting brackets to be provided
- The quantity and type of hardware (nuts, bolts, washers) used to attach the mounting brackets to the VMS
- Verification that no dissimilar metals problem exist and/or affect the structural integrity of the VMS-to-bracket attachment points
- A recommendation of the number of attachment points, as well as the attachment locations, that the installing contractor should use when mounting the VMS to its support structure
The VMS manufacturer shall include a signed and sealed copy of the P.E. certification for all items listed above, including all supporting calculations, with the pre-build technical submittal.

Serviceability

The VMS housing shall provide safe and convenient access to all modular assemblies, components, wiring, and other materials located within the VMS housing, excluding front face panels, external mounting brackets, and VMS support structure members. All internal components shall be removable and replaceable by a single technician.

One (1) vertically hinged door shall be located on each end (left and right side) of the VMS housing. Each access door shall be mounted to an integral doorframe, which bolts to the VMS housing using stainless steel hardware. A continuous vertical stainless steel hinge shall support each door, and all doors shall open outward. In the closed position, each door shall latch to its frame with a three-point draw-roller mechanism. The latching mechanism shall include an internal handle and release lever. Door release levers shall be located so that a person with no key and no tools cannot become trapped inside the housing.

Access doors, when open at 90-degree angle from the VMS housing rear wall, shall not extend more than 38-inches (965 mm) from the housing. The bottom edge of each door shall be at least 6-inches (152mm) from the bottom edge of the VMS housing. This will provide clearance for the doors to swing open over external access catwalks.

Doorframes shall be double flanged on all sides to shed water. Each door shall close around its flanged frame and compress against a closed-cell foam gasket, which adheres to the door. All doors shall contain a stop that retains the door in a 90-degree open position. When a door is open, the door and its stop shall not be damaged by a 40 mph (64 kph) wind.

Each door shall be furnished with a lock that is keyed to the engineer’s requirements.

Minimum headroom of 72-inches (1,829mm) shall be provided. This free space shall be maintained across the entire width of the VMS housing, with the exception of structural frame members. Structural members shall be designed not to obstruct the free movement of maintenance personnel throughout the VMS interior.

A level walkway shall be installed in the bottom of the VMS housing. The walkway shall be a minimum of 24-inches (610 mm) wide, and it shall run the entire length of the housing, from access door to access door. The walkway’s top surface shall be non-slip and shall be free of obstructions that could trip service personnel. The walkway shall support a load of 300 pounds (136 kg) per linear foot, and it shall be constructed of multiple, removable panels.

The VMS housing shall contain a utility outlet circuit consisting of a minimum of three (3) 15-A NEMA 15-R, 120 VAC duplex outlets, with ground-fault circuit interrupters. One outlet shall be located near each end of VMS housing interior, and the third outlet shall be located near the housing’s center.

The VMS housing shall contain a minimum of one (1) 4-foot (1,200 mm), 60-watt fluorescent lamp fixture for every eight (8) feet (2,438 mm) of VMS housing width. Lamps shall be evenly spaced across the housing ceiling, so they provide uniform light distribution for maintenance purposes. Wire cages shall protect lamps. Lamp ballasts shall be rated for cold weather operation down to 0°F (-17 C). One light switch shall be located within easy reach of each access door.
The VMS shall be equipped with a removable safety rail assembly, which prevents service personnel from falling out of the VMS when placed across an open access door. The rail assembly shall be designed to fit on either access door. The safety rail shall be a single-piece assembly that extends a minimum of 48-inches (1,219 mm) above the interior walkway, and contains multiple horizontal rails that are no more that 12-inches (305 mm) apart. The rail assembly shall attach to the VMS using stainless steel hardware that requires simple or no tools for removal and replacement.

**LED Display Modules**

The VMS shall contain 9-pixel high by 5-pixel wide LED display modules, which are placed side-by-side to form a continuous LED pixel matrix. Modules shall be mounted to the inside of the VMS front face panels using hardware that requires only basic hand tools for removal and replacement. Each 9x5 display module shall be constructed as follows:

- The LED pixel circuit board(s) shall be mounted to the back of an aluminum panel to form the 9-pixel high by 5-pixel wide module. Pixel boards shall be mounted to the aluminum panel with durable, non-corrosive hardware.
- The aluminum panel shall contain a circular opening for each LED pixel. The openings shall be sized so they do not block any portion of the LED-viewing angle. The LED viewing angle shall be 30 degrees both vertically and horizontally.
- The side of the aluminum panel facing the viewing motorists shall be primed and coated with automotive-grade, flat black, acrylic enamel paint.
- One (1) LED driver circuit board shall be mounted to the back of each LED display module using durable non-corrosive hardware.
- LED display module electrical and signal connections shall be the quickdisconnect locking connector type. Removal of a 9x5 display module from the VMS, 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 VMS display matrix.
- All 9x5 LED display modules, as well as the LED pixel boards and driver circuit boards, shall be identical and interchangeable throughout the VMS.

Removal of a single 9x5 display module from the VMS, or failure of a single module, shall not affect the performance of any other module in the sign. Removal of one or more modules shall not affect the structural integrity of the sign housing or of the rest of the LED display matrix.

**LED Display Boards**

Each 9x5 display shall contain a printed circuit board to which LED pixels are soldered. Each module shall contain forty-five (45) LED pixels. Each pixel shall contain a circular grouping of a minimum of six (6) and shall not exceed twelve (12) discrete LEDs. LED boards shall conform to the following specifications:

- The distance from the center of one pixel to the center of all adjacent pixels, both horizontally and vertically, shall be 2.6-inches (66 mm)
- Each pixel shall consist of two strings of discrete LEDs
- Current limiting resistors or constant current LED driver ICs shall be used to prevent LED forward current from exceeding 30 mA whenever a forward voltage is applied. LED drive currents greater than 30 mA will not be allowed to maximize LED service life.
- The failure of an LED string shall not cause the failure of the other LED string or pixel in the VMS. Failure of a pixel shall not cause a failure to any other pixel in the VMS
- Each pixel string shall contain an identical quantity of LEDs
- Pixels shall contain the quantity of discrete LEDs needed to generate a sign display luminous
VARIABLE MESSAGE SIGN ASSEMBLY, LED, TYPE A – 3 LINES (FULL MATRIX) Continued

- The intensity of 9,200 Cd/m² minimum when the pixel is driven with a forward current of 20 mA DC per LED string
- LED pixel forward voltage drop, measured from the DC power supply output to ground, shall not exceed 24 VDC. This includes the drive circuit voltage drop and any internal DC line loss
- LED pixel power shall not exceed 1.5 watts
- Discrete LEDs shall be soldered so that the base of their lenses are flush with and parallel to the printed circuit board
- All exposed metal on both sides of the LED pixel board, except the power connector, shall be protected from water and humidity exposure by a thorough application of acrylic conformal coating. Bench level repair of individual pixels, including discrete LED replacement and conformal coating repair, shall be possible. The LED driver board shall be able to determine if the pixel is operating normally. This information shall be reported to a system control computer upon command from the VMS control software
- All LED pixel boards shall be identical and interchangeable throughout the VMS

Discrete LEDs

VMS pixels shall be constructed with discrete LEDs manufactured by the Toshiba Corporation or Agilent Technologies. Substitutes will not be accepted. Discrete LEDs shall conform to the following specifications:

- LEDs shall be non-tinted, non-diffused, high-intensity, solid-state lamps that utilize InGaA1P or A1InGaP semiconductor technology
- LED lenses shall be fabricated from UV light resistant epoxy
- The LED lens diameter shall be 0.2-inches (5mm) in a T1-3/4 style LED package
- LEDs shall emit amber light that has a peak wavelength of 591 ± 4 nm. Color sorting shall be performed by the LED manufacturer.
- LEDs shall be obtained from no more than two bins luminous intensity sort. Intensity sorting shall be performed by the LED manufacturer
- LEDs shall have a minimum half-power viewing angle of 30°.
- LED package style shall be through-hole flush-mount; LEDs with standoffs and surface mount LEDs will not be accepted
- All LEDs used in all VMS provided for this contract shall be from the same manufacturer and of the same part number
- The LED MTBF (Mean Time Before Failure) shall be on at minimum 100,000 hours of permanent use, at an operating temperature of 100 degrees Celsius or below. The LED MTBF shall be given for the specific forward current used to drive the LED.

Pixel Drive Circuitry

LED pixels shall be directly driven using pulse width modulation. This drive method varies the current pulse width to achieve the proper display intensity level for a given ambient light condition. The drive current pulse shall be modulated from a 1.024-millisecond period and pulse amplitude shall not be allowed to exceed 30 mA per LED string.

One (1) electronic driver circuit board shall be provided for each 9-pixel high by 5-pixel wide (9x5) LED display module and shall individually control all forty-five (45) pixels on that module.

Driver circuit boards shall conform to the following:

- A laminated fiberglass printed circuit board
- A diagnostic indicator shall be included on each LED driver circuit board. This diagnostic

June 24, 2004
Revised 5/16/06
indicator shall be in the form of a single-digit LED display approximately 0.7-inches or greater in height. This digit shall provide visual indication of the operational status of the LED module. At a minimum, this shall indicate failed pixel and failed communications conditions.

- All exposed metal on both sides of the LED driver circuit board, except power and signal connectors, shall be protected from water and humidity exposure by a through application of acrylic or silicone conformal coating.
- LED drive circuitry shall support a minimum refresh rate of 10 frames per second
- All driver circuit boards shall be identical and interchangeable throughout the VMS
- Removal or failure of a single driver circuit board shall not affect the performance of any LED display module in the VMS, except the 9x5 module that it drives.
- Individual addressing of the each driver circuit shall be hard coded by way of jumpers

**Regulated DC Power Supplies**

The LED pixel display matrix shall be powered with regulated switching DC power supplies that operate from 120 VAC/60 Hz input power and have an output of no more than 24 VDC. Power supplies shall:

- Protect the LED pixel matrix and driver circuitry in the event of power spikes or surges
- Maintain the appropriate LED display intensity in the event of a brownout (low power) condition.

Power supplies shall be wired in a redundant parallel configuration that uses multiple supplies for the VMS display matrix. Supply outputs shall be tied together, and each group of supplies shall have a “current sharing” ability, which allows them to provide equal amounts of current to the display modules. Current sharing shall be independent of the quantity of pixels being powered at any given time.

Power supplies shall be rated such that if one supply fails, the remaining supply(s) shall be able to operate 100% of the pixels in that display section at full brightness when the internal VMS air temperature is less than or equal to +140°F (60°C).

Regulated DC power supplies shall conform to the following specifications:

- Maximum output power rating of 1000 watts
- Operating input voltage range: +90 to +250 VAC
- Operating temperature range: -40 to +140°F (-40 to +60°C)
- Power supply output at an ambient temperature of +140°F: minimum of 65% of the supply’s room temperature (+72°F/ +22°C) output
- Power supply efficiency: 75%, minimum
- Power factor rating: 0.95, minimum
- Short circuit protection: DC power off, with automatic reset
- Minimum overload allowance protection: 105%
- UL listed

Power supplies shall be identical and interchangeable throughout the VMS.

The VMS sign controller shall be able to monitor power supply operational status (as “pass” or “failed”) by reading a diagnostic signal located on each supply’s DC output. The operational status of all power supplies shall be reported to the VMS control software upon request.

**Interior VMS Environmental Control**

**Housing Exhaust System** – The VMS shall contain a ventilation system that exhausts air out of the
housing whenever the internal VMS air temperature exceeds +90°F (+32°C). This system shall be designed to keep the internal VMS 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 on the top end of the rear VMS wall. No fewer than two (2) fans shall be installed per each exhaust port.

One filtered air intake port shall be provided for each exhaust port. Intake ports shall be located on the bottom end of the rear VMS 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 inside the VMS housing.

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

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

A manual override timer switch shall be located just inside the access door to manually activate the ventilation system. The switch shall be adjustable up to four hours.

**Front Face Panel Defog/Defrost System**

The VMS shall contain a defog/defrost system that warms the VMS front face when the internal VMS air temperature falls below +40°F (+4°C). This system shall keep the front face polycarbonate panel free of frost and condensation. The heat generated by the defog/defrost system shall not damage the polycarbonate panels, aluminum mask or LED modules. A thermostat shall automatically activate the defog/defrost system.

**Ambient Light and Temperature Measurement System**

Sensors that measure outdoor ambient light levels at the VMS site, as well as the outdoor ambient temperature, shall be mounted in-line with the VMS housing walls. This ambient light and temperature measurement system shall consist of three (3) photoelectric sensors and one (1) internal temperature sensor, and one (1) external temperature sensor.

Two (2) of the photo sensors shall be placed such that they measure the ambient light levels striking the front and rear of the VMS. The third photo sensor shall be mounted to the floor of the VMS housing and shall face the ground. A change in the amount of light striking a photo sensor shall cause its output frequency to vary. The VMS sign controller shall continuously adjust LED display matrix intensity to a level that creates a legible VMS message.

An ambient temperature sensor shall be mounted to either the rear wall or bottom side of the VMS housing. The sensor shall be placed such that it is never in direct contact with sunlight or is in any location that will generate a false temperature measurement. The external temperature sensor output shall be continuously monitored by the VMS sign controller and shall reported to the VMS control software upon request.

**Dimming Circuit**

Brightness shall be manually settable from the front panel of the controller and remotely from the central
computer in 1% increments. Brightness control shall be able to be returned to automatic from the sign controller front panel and the central computer. The sign controller shall monitor the photocells in the sign and convert the measured light intensity into the desired pixel brightness. The photocell readings shall be correlated with a brightness table in the sign controller. The brightness table shall have a minimum of 255 brightness levels. Automatic adjustment of the LED driving waveform duty cycle shall occur in small enough increments so that brightness of the sign changes smoothly, with no perceivable brightness change between adjacent levels. The brightness table in each individual sign controller shall be adjustable from the central controller and can be customized according to the requirements of the installation site.

**Pixel Status Feedback**

Two separate types of pixel status feed back shall be provided to the central controller from the local sign controller. These include a pixel test and a pixel read.

**Pixel Test:** The pixel test shall be programmable by time of day and 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, module number, column number and row number for each defective pixel. The pixel test may briefly disturb the displayed message for less than 0.5 seconds.

**Pixel Read:** The pixel read shall be performed during a message download and during every sign poll from the central controller or laptop computer. The pixel read shall perform a real-time read of the displayed message and shall return the state of each pixel to the central controller as it is currently displayed to the motorist, including any errors. This shall allow the central controller operator to see what is visibly displayed to the motorist on an individual pixel basis. During a pixel read, the state of each pixel (full-on, half-on or 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 in a What You See Is What You Get (WYSIWYG) format. This pixel reading shall take place while a message is display 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.

**Internal Temperature Measurement System**

The VMS shall contain a minimum of one (1) temperature sensor that is mounted near the top of the VMS interior. Sensors shall measure a minimum temperature range of -40°F to +176°F (-40°C to +80°C). The internal temperature sensor output shall be continuously monitored by the VMS sign controller and be reported to the VMS control software upon request.

**Internal Wiring**

Wiring for LED display module control, environmental control circuits, and other internal VMS components shall be installed in the VMS 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 Electric Code.

**Power and Signal Entrances**

Two threaded conduit hubs shall be located on the rear wall of the VMS housing. One hub shall be for incoming AC power and the other shall be for incoming VMS signal cabling or a communications line.
Transient Protection
The VMS and sign controller signal and power inputs shall be protected from electrical spikes and transients as follows:

VMS Site AC Power – The AC power feed for all equipment shall be protected at the load center by a parallel-connection surge suppressor rated for a minimum surge of 10 kA.

AC Power for VMS Control Equipment – A series-connected surge suppressor capable of passing 15 Amps of current shall protect the sign controller and modem (or signal converter). This device shall conform to the following requirements:

• Withstand a peak 20,000 ampere surge current for an 8x20 microsecond waveform
• 20 minimum peak surge occurrences
• Clamp at 20,000 amperes: 340V, maximum
• Maximum continuous operating current of 15 amps at 120 VAC, 60 Hz
• Series inductance of 200 micro henrys (nominal)
• Temperature range of –40 to +176° F (-40 to +80° C)
• Approximate dimensions of 3-inches wide by 5-inches long by 2-inches high (76 mm by 127 mm by 50 mm)
• The device shall be UL-1149 recognized

Surge Suppression and Protection
All necessary equipment to protect all of the components of the variable message sign assembly from electric and electromagnetic surges shall be supplied as part of the variable message sign assembly. Such equipment shall consist of at a minimum, but not be limited to:

A 2 phase surge protector and radio interference filter shall be installed as a precautionary measure for the LED Display and digital control unit to guard against possible damage resulting from voltage surges on all incoming power lines. The single-phase surge protector shall incorporate a series choke at a maximum clamp voltage of 340 V at 20 kA with a 5 ns response. In addition, the surge protector shall have the capability of removing high-energy surges and block high-speed transients. The surge protector shall comply with the following specifications:

• Peak Current: 20,000 amps (8 x 20 sec wave shape)
• Occurrences: 20 times at peak current
• Minimum Series Inductance: 200 micro henries
• Continuous Series Current: Consistent with Sign Needs
• Temperature Range: -40°C to +85°C

If required by the contract to which the specification applies, a surrestor shall be installed for all communication lines. The surrestor shall comply with the following specification:

• Peak Surge Current: 10 kA amps (8 X 20 sec wave shape)
• Occurrences at 2,000 amps: 50 typical
• Response Time: <5 ns
• Voltage Clamp: 8, 12, 20, 30, or special
• Series Resistance: 24 ohms total
• Operating Temperature: -40°C to +85°C
• Primary Protector: Three element gas tube, 10 kA, 8 X 20 sec, per side
• Secondary Protector: Solid state clamps, 1.5 kW minimum
Driver Circuit Communications – RS485 data cable or optic fiber communication lines shall be provided to communicate between the sign controller and the LED driver circuit boards. Transient voltage surge suppressors connected to each data line shall protect the category 5 data cable. The fiber optic cable interface shall be multi-mode 62.5/125 code diameter cable terminated with ST style connectors at both the VMS and at the sign controller.

Sign Controller Communications – RS232, RS485, and Ethernet communication ports in the VMS sign controller shall be protected with surge protection between each signal line and ground.

Telephone Communications – A series/parallel two-stage suppression device that provides a 200-Volt clamp shall protect the incoming telephone communication line.

Earth Grounding
The VMS manufacturer shall provide one earth ground lug that is electrically bonded to the VMS housing. The lug shall be installed near the power entrance location on the VMS housing’s rear wall. The VMS installation contractor shall provide the balance of materials and services needed to properly earth ground the VMS.

Special Provision of NTCIP

General Requirements
The variable message signs required for this project shall comply with the following NTCIP communication protocol specifications.

References
This specification references several standards through their NTCIP designated names. The following list provides the full reference to the current version of each of these standards. In many cases, the standard is more widely known by its original NEMA assigned number; in these cases, the NEMA number is also identified.

Each NTCIP-compatible device covered by these project specifications shall implement the most recent version of the standard that is at the contract award date, including any and all Approved or Recommended Amendments to these standards as of the same date. It is the ultimate responsibility of the VMS manufacturer to monitor NTCIP standards development activities to discover any more recent documents. Refer to the NTCIP library at www.ntcip.org for information on the current status of NTCIP standards.

<table>
<thead>
<tr>
<th>Current Document Number</th>
<th>Old NEMA Document Number</th>
<th>Title</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>NTCIP 1101</td>
<td>NEMA TS 3.2</td>
<td>NTCIP 1101:1996 Simple Transportation Management Framework (STMF)</td>
<td>Use Amendment 1</td>
</tr>
<tr>
<td>NTCIP 1201</td>
<td>NEMA TS 3.4</td>
<td>NTCIP 1201:1996 Global Object Definitions</td>
<td>Use Amendment 1</td>
</tr>
<tr>
<td>NTCIP 1203</td>
<td>NEMA TS 3.6</td>
<td>NTCIP 1203:1997 Object Definitions for Dynamic Message Signs</td>
<td>Use Amendment 1</td>
</tr>
<tr>
<td>NTCIP 2101</td>
<td>None</td>
<td>NTCIP 2101:2001 Point to Multi Point Protocol (PMPP) Using RS-232 Sub network Profile</td>
<td></td>
</tr>
</tbody>
</table>
NTCIP

Subnet Level
Each serial port on each NTCIP-compatible device shall support NTCIP 2103 over a dial-up connection with a contractor provided modem with data rates of 28.8 kbps, 19.2 kbps, 14.4 kbps, 9600 bps, 4800 bps, and 2400 bps. The NTCIP-compatible device shall be able to make outgoing and receive incoming calls as necessary and support the following modem command sets:

- Hayes AT – Command Set
- MNP5
- MNP10
- V.42bis

Each serial port on each NTCIP-compatible device shall support NTCIP 2101 with data rates ranging from 9600 bps to 115.2 kbps.

NTCIP-compatible device may support additional Subnet Profiles at the manufacturer’s option. At any one time, only one subnet Profile shall be active on a given serial port of the NTCIP-compatible device. The NTCIP compatible device shall be configurable to allow a field technician to activate the desired Subnet Profile and shall provide a visual indication of the currently selected Subnet Profile.

Transport Level
Each NTCIP-compatible device shall comply with NTCIP 2201 on each serial communication port.

Modem communications with each NTCIP-compatible device shall comply with NTCIP 2201 and NTCIP 2202.

Ethernet communications with each NTCIP-compatible device shall comply with NTCIP 2202.

NTCIP-compatible devices may support additional Transport Profiles at the manufacturer’s option. Response datagrams shall use the same Transport Profile used in the request. Each NTCIP-compatible device shall support the receipt of datagrams conforming to any of the identified Transport Profiles at any time.

Application Level
Each NTCIP-compatible device shall comply with NTCIP 1101 and shall meet the requirements for Conformance Level 1 (NOTE – See Amendment 1 for clarification of Conformance Levels).
Each NTCIP-compatible device shall support SNMP traps.

An NTCIP-compatible device may support additional Application Profiles at the manufacturer’s option. Responses shall use the same Application Profile used by the request. Each NTCIP-compatible device shall support the receipt of Application data packets at any time allowed by the subject standards.

**Information Level**

Each NTCIP-compatible device shall provide Full, Standardized Object Range Support (FSORS) of all objects required by these procurement specifications unless otherwise indicated below.

The DMS shall support all mandatory Conformance Groups as defined in NTCIP 1201 and NTCIP 1203. Table 1 indicates the modified object requirements for these mandatory objects.

<table>
<thead>
<tr>
<th>Object</th>
<th>Reference</th>
<th>Project Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module Table Entry</td>
<td>NTCIP 1201 Clause 2.2.3</td>
<td>Shall contain at least one row with module Type equal to 3 (software). The module Make object shall specify the manufacturer’s name, the module Model shall specify the manufacturer’s name of the component and the model Version shall indicate the model version number of the component</td>
</tr>
<tr>
<td>maxGroupAddresses</td>
<td>NTCIP 1201 Clause 2.7.1</td>
<td>Shall be at least 1</td>
</tr>
<tr>
<td>communitNamesMax</td>
<td>NTCIP 1201 Clause 2.8.2</td>
<td>Shall be at least 3</td>
</tr>
<tr>
<td>dmsMaxChangeableMsg</td>
<td>NTCIP 1203 Clause 2.6.1.1.1.4</td>
<td>Shall be at least 500.</td>
</tr>
<tr>
<td>dmsMessageMultiString</td>
<td>NTCIP 1203 Clause 2.6.1.1.1.8.3</td>
<td>The DMS shall support any valid MULTI string containing any subset of those MULTI tags listed in Table 3 (below)</td>
</tr>
<tr>
<td>dmsControlMode</td>
<td>NTCIP 1203 Clause 2.7.1.1.1.1</td>
<td>Shall support at least the following modes:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Local</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• External</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Central</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Central Override</td>
</tr>
</tbody>
</table>

*Table 1: Modified Object Ranges for Mandatory Objects*
The NTCIP Component shall also implement all mandatory objects of the following optional conformance groups:

- **Time Management, as defined in NTCIP 1201**
- **Time base Event Schedule, as defined in NTCIP 1201**

The following list indicates the modified object requirements for this conformance group:

<table>
<thead>
<tr>
<th>Object</th>
<th>Reference</th>
<th>Project Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>MaxTimeBaseScheduleEntries</td>
<td>NTCIP 1201 Clause 2.4.3.1</td>
<td>Shall be at least 28</td>
</tr>
<tr>
<td>MaxDayPlans</td>
<td>NTCIP 1201 Clause 2.4.4.1</td>
<td>Shall be at least 20</td>
</tr>
<tr>
<td>MaxDayPlanEvents</td>
<td>NTCIP 1201 Clause 2.4.4.2</td>
<td>Shall be at least 10</td>
</tr>
</tbody>
</table>

**Table 3: Modified Object Ranges for the Report Conformance Group**

Report as defined in NTCIP 1201
The following list indicates the modified object requirements for this conformance group.

### maxEventLogConfig

<table>
<thead>
<tr>
<th>Object</th>
<th>Reference</th>
<th>Project Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>maxEventLogConfig</td>
<td>NTCIP 1201 Clause 2.5.1</td>
<td>Shall be at least 50</td>
</tr>
</tbody>
</table>

### evenConfigurationMode

- The NTCIP Component shall Support the following Event Configuration: onchaintegraterThanValue smaller Than Value

### maxEventLogSize

<table>
<thead>
<tr>
<th>Object</th>
<th>Reference</th>
<th>Project Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>maxEventLogSize</td>
<td>NTCIP 1201 Clause 2.5.3</td>
<td>Shall be at least 200</td>
</tr>
</tbody>
</table>

### maxEventClasses

<table>
<thead>
<tr>
<th>Object</th>
<th>Reference</th>
<th>Project Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>maxEventClasses</td>
<td>NTCIP 1201 Clause 2.5.5</td>
<td>Shall be at least 16</td>
</tr>
</tbody>
</table>

**Table 4: Modified Object Ranges for the Time base Event Schedule Conformance Group**

### NumFonts

<table>
<thead>
<tr>
<th>Object</th>
<th>Reference</th>
<th>Project Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>NumFonts</td>
<td>NTCIP 1203 Clause 2.4.1.1.1.1</td>
<td>Shall be at least 8</td>
</tr>
</tbody>
</table>

### MaxFontCharacters

<table>
<thead>
<tr>
<th>Object</th>
<th>Reference</th>
<th>Project Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>MaxFontCharacters</td>
<td>NTCIP 1203 Clause 2.4.1.1.3</td>
<td>Shall be at least 255</td>
</tr>
</tbody>
</table>

**Table 5: Modified Object Ranges for the Font Configuration Conformance Group**

Upon delivery, the first font shall be a 7-pixel-high single-stroke font. The second font shall be a 7-pixel-high double-stroke font. The third font shall be an 11-pixel-high double-stroke font.

Upon delivery, the first three font sets shall be configured in accordance with the ASCII character set for the following characters:

- “A” thru “Z” – All upper case letters
- “0” thru “9” – All decimal digits
- Space (i.e., ASCII code 0x20)
- Punctuation marks shown in bracket [ .!?:"'‘"]
- Special characters shown in brackets [\$&*+< >]

### VMS Configuration, as defined in NTCIP 1203

### Multi Configuration, as defined in NTCIP 1203
The following list indicates the modified object requirements for this conformance group.

<table>
<thead>
<tr>
<th>Object</th>
<th>Reference</th>
<th>Project Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>defaultFlashOn</td>
<td>NTCIP 1203 Clause 2.5.1.1.1.3</td>
<td>The DMS shall support the full range of these objects with step sizes no larger than 0.5 seconds</td>
</tr>
<tr>
<td>defaultFlashOff</td>
<td>NTCIP 1203 Clause 2.5.1.1.1.4</td>
<td>The DMS shall support the full range of these objects with step sizes no larger than 0.5 seconds</td>
</tr>
<tr>
<td>defaultBackgroundColor</td>
<td>NTCIP 1203 Clause 2.5.1.1.1.1</td>
<td>The DMS shall support the black background color</td>
</tr>
<tr>
<td>defaultForegroundColor</td>
<td>NTCIP 1203 Clause 2.5.1.1.2</td>
<td>The DMS shall support the amber background color</td>
</tr>
<tr>
<td>defaultJustificationLine</td>
<td>NTCIP 1203 Clause 2.5.1.1.1.6</td>
<td>The DMS shall support the following forms of line justification:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Left</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Center</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Right</td>
</tr>
<tr>
<td>defaultJustificationPage</td>
<td>NTCIP 1203 Clause 2.5.1.1.1.7</td>
<td>The DMS shall support the following forms of page justification:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Top</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Middle</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Bottom</td>
</tr>
<tr>
<td>defaultPageOnTime</td>
<td>NTCIP 1203 Clause 2.5.1.1.1.8</td>
<td>The DMS shall support the full range of these objects with step sizes no larger than 0.5 seconds</td>
</tr>
<tr>
<td>defaultCharacterSet</td>
<td>NTCIP 1203 Clause 2.5.1.1.1.10</td>
<td>The DMS shall support the eight bit character set</td>
</tr>
</tbody>
</table>

Table 6: Modified Object Ranges for the MULTI Configuration Conformance Group

Multi Error Configuration, as defined in NTCIP 1203

Illumination/Brightness Control, as defined in NTCIP 1203

The following list indicates the modified object requirements for this conformance group.

<table>
<thead>
<tr>
<th>Object</th>
<th>Reference</th>
<th>Project Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>dmsIllumControl</td>
<td>NTCIP 1203 Clause 2.8.1.1.1.1.1</td>
<td>The DMS shall support the following illumination control modes: Photocell, and Manual</td>
</tr>
<tr>
<td>dmsIllumNumBrightLevels</td>
<td>NTCIP 1203 Clause 2.8.1.1.1.4</td>
<td>Shall be at least 255</td>
</tr>
</tbody>
</table>

Table 7: Modified Object Ranges for the Illumination/Brightness Control Conformance Group
Scheduling as defined in NTCIP 1203

The following list indicates the modified object requirements for the conformance group.

<table>
<thead>
<tr>
<th>Object</th>
<th>Reference</th>
<th>Project Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>numAction</td>
<td>NTCIP 1203 Clause 2.9.1.1.1</td>
<td>Shall be at least 200</td>
</tr>
<tr>
<td>TableEntries</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Table 8: Modified Object Ranges for the Scheduling Conformance Group |

Sign Status as defined in NTCIP 1203

Status Error as defined in NTCIP 1203

Pixel Error Status, as defined in NTCIP 1203

The NTCIP Components implement the following optional objects:

<table>
<thead>
<tr>
<th>Object</th>
<th>Reference</th>
<th>Project Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>eventConfigLogOID</td>
<td>NTCIP 1201 Clause 2.5.4.7</td>
<td>FSORS</td>
</tr>
<tr>
<td>eventConfigAction</td>
<td>NTCIP 1201 Clause 2.5.4.8</td>
<td>FSORS</td>
</tr>
<tr>
<td>eventClassDescription</td>
<td>NTCIP 1201 Clause 2.5.1.1.1.3</td>
<td>The DMS shall support the full range of these objects. With step sizes no larger than 0.5-seconds</td>
</tr>
<tr>
<td>defaultFlashOff</td>
<td>NTCIP 1203 Clause 2.5.1.1.4</td>
<td>The DMS shall support the full range of these objects with step sizes no larger than 0.5-seconds</td>
</tr>
<tr>
<td>dmsSWReset</td>
<td>NTCIP 1203 Clause 2.7.1.1.1.2</td>
<td>FSORS</td>
</tr>
<tr>
<td>dmsMessageTimeRemaining</td>
<td>NTCIP 1203 Clause 2.7.1.1.1.4</td>
<td>FSORS</td>
</tr>
<tr>
<td>dmsShortPowerRecoveryMessage</td>
<td>NTCIP 1203 Clause 2.7.1.1.1.8</td>
<td>FSORS</td>
</tr>
<tr>
<td>dmsLongPowerRecoveryMessage</td>
<td>NTCIP 1203 Clause 2.7.1.1.1.19</td>
<td>FSORS</td>
</tr>
<tr>
<td>dmsShortPowerLossTime</td>
<td>NTCIP 1203 Clause 2.7.1.1.1.10</td>
<td>FSORS</td>
</tr>
<tr>
<td>dmsResetMessage</td>
<td>NTCIP 1203 Clause 2.7.1.1.1.12</td>
<td>FSORS</td>
</tr>
<tr>
<td>dmsCommunicationsLossMessage</td>
<td>NTCIP 1203 Clause 2.7.1.1.1.12</td>
<td>FSORS</td>
</tr>
<tr>
<td>dmsTimeCommLoss</td>
<td>NTCIP 1203 Clause 2.7.1.1.1.12</td>
<td>FSORS</td>
</tr>
<tr>
<td>dmsEndDurationMessage</td>
<td>NTCIP 1203 Clause 2.7.1.1.1.15</td>
<td>FSORS</td>
</tr>
<tr>
<td>dmsMemoryMgmt</td>
<td>NTCIP 1203 Clause 2.7.1.1.1.16</td>
<td>The DMS shall support the following Memory management Modes:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• normal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• clearChangeableMessages</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• clearVolatileMessages</td>
</tr>
</tbody>
</table>
| dmsMultiOtherErrorDescription| NTCIP 1203 Clause 2.4.1.1.1.20| If the vendor implements any vendor-specific MULTI tags, the DMS shall provide meaningful error messages within this object whenever one of these tags
Table 9: Optional Object Requirements

<table>
<thead>
<tr>
<th>Object</th>
<th>Reference</th>
<th>Project Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>dmsIllumLightOutputStatus</td>
<td>NTCIP 1203 Clause 2.8.1.1.1.9</td>
<td>FSORS</td>
</tr>
<tr>
<td>watchdogFailureCount</td>
<td>NTCIP 1203 Clause 2.11.1.1.5</td>
<td>FSORS</td>
</tr>
<tr>
<td>dmsStatDoorOpen</td>
<td>NTCIP 1203 Clause 2.11.1.1.6</td>
<td>FSORS</td>
</tr>
<tr>
<td>fanFailures</td>
<td>NTCIP 1203 Clause 2.11.2.1.1.8</td>
<td>FSORS</td>
</tr>
<tr>
<td>fanTestActivation</td>
<td>NTCIP 1203 Clause 1.11.2.1.1.9</td>
<td>FSORS</td>
</tr>
<tr>
<td>tempMinCtrlCabinet</td>
<td>NTCIP 1203 Clause 2.11.4.1.1.1</td>
<td>FSORS</td>
</tr>
<tr>
<td>tempMaxCtrlCabinet</td>
<td>NTCIP 1203 Clause 2.11.4.1.1.2</td>
<td>FSORS</td>
</tr>
<tr>
<td>tempMinSignHousing</td>
<td>NTCIP 1203 Clause 2.11.4.1.1.5</td>
<td>FSORS</td>
</tr>
<tr>
<td>tempMaxSignHousing</td>
<td>NTCIP 1203 Clause 2.11.4.1.1.6</td>
<td>FSORS</td>
</tr>
</tbody>
</table>

Documentation

NTCIP documentation shall be provided on a CD-ROM and shall contain ASCII versions of the following Management Information Base (MIB) files in Abstract Syntax Notation 1 (ASN.1) format:

- The relevant version of each official standard MIB modules referenced by the device functionality.
- If the device does not support the full range of any given object within a standard MIB Module, a manufacturer specific version of the official standard MIB Module with the supported range indicated in ASN.1 format in the SYNTAX and/or DESCRIPTION fields of the associated OBJECT TYPE macro. The filename of this file shall be identical to the standard MIB Module except that it will have the extension "\.man".
- A MIB module in ASN.1 format containing any and all manufacturer specific objects supported by the device with accurate and meaningful DESCRIPTION fields and supported ranges indicated in the SYNTAX field of the OBJECT-TYPE macros.
- A MIB containing any other objects supported by the device.

Acceptance Testing

The acceptance test will use the NTCIP Exerciser, Trevilon’s NTester, Intelligent Devices’ Device Tester for NTCIP, or other testing tool approved by the Engineer.

The VMS manufacturer will submit an NTCIP test plan to the Engineer a minimum of 90 days prior to NTCIP acceptance testing. NTCIP acceptance testing will be performed on one of the VMS manufactured under this contract. Testing will be performed at the manufacturer’s or agency’s facility.

Interpretation Resolution

If the Engineer or VMS manufacturer discovers an ambiguous statement in the standards referenced by this procurement specification, the issue shall be submitted to the NTCIP DMS Working Group for resolution. If the Working Group fails to respond within 90 days, the Engineer shall provide an interpretation of the specification for use on the project.

June 24, 2004
Revised 5/16/06
VMS Control Software

General Specifications
VMS control software shall:

• Operate on desktop and laptop computers with Intel® Pentium® III or better processor and run Microsoft® Windows NT™ 4.0, 2000 Professional™, or XP Professional™
• Provide a user-friendly multi-color graphical user interface
• Be written as a native 32-bit Windows® program using Microsoft-certified software development tools (compilers, etc.)
• Control a network of at least 250 variable message signs
• Support VMS 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
• Support VMS control, monitoring, and diagnostic functions as specified herein
• Control VMS both remotely from a central location, and locally at the VMS site using a laptop computer
• Be accompanied by an easy-to-use software installation routine
• Include an operation manual that includes detailed instructions for configuring and using all parts of the software
• 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
• Be fully compliant with the communications protocol requirements of the NTCIP Special Provision specified herein

Software Security
VMS 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 VMS 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 denied.

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

List and Map Interfaces
The VMS list shall clearly display the following information about each VMS:

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

- Configurable bitmaps that may be used to show all or parts of the system geographically
- Icons for each sign that may be placed anywhere on the map
- Icon color changes to indicate the status of the VMS (i.e., yellow for warnings or red for errors)
- Icon flashes if a message is running on the VMS
- Sign name is visible if mouse is placed over a VMS icon

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

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

**Polling**
The software shall have a feature to poll all or a set of VMS 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.

**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:

- Send and activate stored messages from the libraries
- Blank the display
- Send and activate schedules
- Perform diagnostics of VMS subsystems, such as power supplies, sensors, etc.
- 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.

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

**Message Retention**
Retention duration, which defines how long the current message should remain in effect in the absence of communication with the central office, shall be specified.

**Message Frames**
The LED display shall be able to implement variable flashing rates ranging from 0.1 seconds to 9.99 seconds. This parameter shall be programmable by line.
The sign controller shall support a sequencing capability by line. A message may contain up to five frames. A parameter shall be specified as part of each message, which will determine how long each message frame will be displayed. This parameter shall range from 1 to 25.5 seconds. The sign controller will sequence through each message frame. After all frames are displayed, the first frame will be re-displayed until the sign controller is directed to bring-up another message.

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

The message editor GUI shall present a scaled image of the VMS display matrix, including a complete and accurate representation of the display matrix type (full or line) and the number of display pixels. The VMS 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:
- The number of pages that the message is to contain (shall be a maximum of six)
- Message text
- Message graphics, including pixel-by-pixel editing, lines, area fill, block move, etc.
- Character font type(s) used to construct the message
- The amount of inter-line spacing, measured in pixels
- Horizontal message justification on the VMS display matrix including left, center, and right
- Vertical message justification on the VMS display matrix including top, middle, and bottom
- The type of entry effect, as “static” or “scrolling”
- Message page on time and off time
- Message scroll rate, if a scrolling message
- The flash rate of all or part of a message page
- Message priority status
- The display status of any flashing beacons mounted to the VMS

The message editor shall provide a method for incorporating data fields into a VMS message. The following data fields shall be provided:
- Time, in 12-hour format
- Time, in 24-hour format
- Temperature, in degrees Fahrenheit and Celsius
- Speed, kilometers per hour and miles per hour (vehicle speed, for VMS sites that contain speed measurement equipment)
- Day of week (Monday, Tuesday, etc)
- Day of the month (1,2, …31)
- Month of the year (1,2, …12)
- Calendar year, in both two-digit and four-digit formats

The message editor shall provide convenient means for the operator to:
- Insert, add, or delete, message text
- Paste graphics from other programs using the Windows clipboard
- Clear the content of the editing page
- Save the message file under its existing name or a new name
- Delete a message file
- Save all new changes
It shall be possible to store message files in both the VMS control computer memory and the VMS sign controller memory.

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

**Message Libraries**
VMS control software shall support the creation and storage of message libraries (file directories), which allow the system operator to categorize message files by:
- VMS matrix size
- Message subject matter

The library editor shall allow a system operator to:
- Create a new library
- Store the same message in multiple libraries
- Select a message from an existing library and edit the message’s contents
- Search message libraries for messages with specified text in message’s name or its contents
- Copy/Paste a message from one library to another
- Delete a message file from a library
- Rename a library
- Delete a library
- Save all new changes

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

Software shall contain an editor, which allows messages to be scheduled via:
- Month of the year (January, February, etc.)
- Day of the week (Monday, Tuesday, etc)
- Day of the month (1,2, ….31)
- Time of day

The schedule editor shall provide a convenient means for the operator to:
- Create a new schedule
- Rename an existing schedule
- Delete a schedule
- Save all new changes

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

**Display Fonts**
The software shall support a minimum of three (3) fonts for each model of VMS. 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 VMS model configuration.

The software shall include a font editor to allow the operator to create custom fonts. The font editor shall
allow the VMS system operator to create new fonts or modify existing fonts. The operator shall have the capability 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 operator shall be downloadable to the VMS.

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

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

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

- User login/logout
- Failed login attempts
- Communication failures
- Message and schedule activation or display blanking
- Diagnostics test results
- Warning events sent from the sign
- Other system errors

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

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

- Sign models and individual signs
- Communication networks
- System error/warning alarms
- User security rights
- System maps and sign icon placement
- Default system option settings
- Default message parameters
- Message priority settings

**Sign Configuration**
Each sign in the VMS control software shall be configured with the following parameters:

- Sign viewing area height and width (for full-matrix signs)
- Number of lines and each line’s height and width (for line-matrix signs)
- Color capabilities (i.e., amber, tricolor, full-color, etc.)
- Site name
- VMS ID number
- Network address
Communication parameters

**Communication Settings**
Communication network configuration shall include:
- Creation and modification of sign communication networks
- Network type (i.e., direct serial, dial-up)
- Communication port (i.e., COM4)
- Baud rate
- Handshaking
- NTCIP transport protocols
- Communication retries
- Communication timeouts
- Dial-back port settings

**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:
- Communication failure
- Priority status conflict
- Sign restart
- Power supply failure
- Door open

**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.

**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.

**Message Editor Defaults**
The message editor shall automatically utilize the following default settings during the creation of new message files:
- Pixel spacing between adjacent lines of text
- Pixel spacing between adjacent text characters
- Display duration of a given message page
- Color palette to be used for color-capable signs
- Beacon activation status (for VMS that contain flashing beacons)
- Effect to be applied to text (i.e., static, scrolling, etc.)
- Effect rate, which shall determine the speed of scrolling messages
- Flash rate, which shall determine the speed of flashing messages
- Message priority classification
- Horizontal text justification supporting left, center, or right
- Vertical text justification supporting top, middle, and bottom
Message Priorities
User-definable defaults shall allow messages to be assigned a priority classification of:
• Emergency
• High
• Normal
• Low
• 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.

Software Use and Reproduction Rights
The VMS manufacturer shall provide a VMS control software site license with the VMS supplied for this contract. Ten (10) copies of the VMS 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 VMS system installed for this contract.

Software Documentation
The software shall be supplied with full documentation, including a CD-ROM containing ASCII versions of the following MIB files in ASN.1 format:

The relevant version of each official NEMA Standard MIB module referenced by the device functionality.

If the device does not support the full range of any given object within a NEMA Standard MIB Module, a manufacturer-specific version of the official NEMA Standard MIB Module with the supported range indicated in ASN.1 format in the SYNTAX field of the OBJECT-TYPE macro. The filename of this file shall be the same as the standard MIB filename with the extension “.man”.

Additionally, the CD-ROM shall contain ASCII versions of any and all manufacturer-specific objects supported by the device in ASN.1 format in a manufacturer-specific MIB with accurate and meaningful DESCRIPTION fields and supported ranges indicated in the SYNTAX field of the OBJECT-TYPE macros.

Test Pattern
The software shall initiate a test pattern that energizes and verifies each individual pixel in the sign. The software shall be able to report any failed pixels and shall utilize both a graphic and text display to identify the failures. The test pattern shall be supported by a test report that documents the results of the test. The test report shall also be directable to a standard text file.

Communications Monitoring
The software shall support a system monitoring function that will display on the screen of the portable computer the commands received by the sign controller from the system computer. It shall also display the response transmitted by the sign controller to the system computer. This function shall be real-time and be functional when the sign controller is operating in the system control mode.

Diagnostics
The software shall support the running of sign controller and display diagnostics. At a minimum, the
software shall initiate a test pattern that energizes and verifies each individual pixel in the sign. The test pattern shall be supported by a test report that documents the results of the test. Optionally, the test report shall be written to disk with ASCII characters.

Testing

The variable message signs shall be tested in the factory as defined below. Subsequent testing may be defined in the contract documents to which this specification applies.

Test Plan

The manufacturer shall provide a test plan for the factory testing. The test plan shall clearly identify each element being tested, the setup conditions, the steps to be followed during the test, and the anticipated test results. The test plan shall exercise all functions of the hardware and software.

Test Equipment

The test plan shall clearly identify all test equipment required to perform the tests. This equipment shall be made available for the duration of the testing program.

Test Reports

The Supplier shall maintain a complete record of each test performed including the results of the test and a record of who witnessed the test. At the completion of each test, the test forms shall be completed and provided to the Engineer for review. This document shall be the basis for acceptance or rejection. All test reports shall be signed by the Supplier's authorized representative.

Test Performance

The Supplier shall conduct all tests. All tests shall be performed in the presence of the Engineer. The Engineer may waive the right to witness certain tests.

Modified Units

If a unit is modified as a result of any test or demonstration 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, as defined by the Engineer, is identified, the Engineer may direct the modifications be made to all similar units without additional cost or time extensions.

Test Witnessing

Neither the witnessing of a test by the Engineer, nor the waiving of the right to witness a test, will relieve the Supplier of the responsibility of providing VMS equipment that is in compliance with this specification. The witnessing of any tests by the Engineer, or a representative of the Engineer, will not be deemed as acceptance of the equipment or systems under test.

Portable Data Input Unit/Laptop Computer

One portable data input unit shall be provided with the delivery of the first VMS sign. The portable data input unit shall consist of a digital microprocessor unit with built-in keyboard, monitors, carrying case, and data storage. The portable data input unit shall also consist of a portable printer and applications software.

The complete portable data input unit shall be fully debugged and must be capable of operation in the following environment:
Air temperature, -20 to 60 degrees Celsius
Humidity, 20% to 80%
Military spec for ruggedness (MIL-STD-810F) and meets the Ingress Protection rating of IP-54, for dust and water penetration.

The portable data input unit shall be supplied with an AC adapter which will power the unit while line voltage is within the range of 100 to 140 volts AC at 50-60 HZ. The unit shall also include a Lithium battery for field operation and a spare battery.

The portable data input unit shall utilize an Intel Pentium IV microprocessor. The clock speed shall be a minimum of M 1.7 Ghz Mobile with 512 KB L2 cache. The unit shall be manufactured by IBM, Gateway, Hewlett Packard or Compaq.

The portable data input unit shall be provided with an Integrated Wireline - 56K Kbps V.92 fax/modem MDC module and 10/100M bit Ethernet LAN.

The unit shall be Integrated Wireless - Up to 3RF modems can be integrated at one time (1 WAN, 1 LAN, and 1 PAN); GPRS, CDMA, Wireless LAN, Bluetooth.

The unit shall include 256 MB of random access memory, expandable to 1.024 GB with additional memory modules.

Data storage for the unit shall include as a minimum the following:
- One (1) 1.4 Mbyte 3-1/2" "Floppy Disk Drive"
- One (1) 80 GB Minimum Internal Hard Disk Drive
- 8X DVD/CDRW combo drive

The unit’s color graphic display type shall be TFT LCD, capable of displaying a minimum of 64K colors at XGA resolution.

Video card with a minimum of 16-MB memory for 32 bit color rendering and 3D graphics

PC card slot for (1) Type I, II, or III card with 32 bit card bus and support for zoomed video.

The unit shall have built-in RJ-11 and RJ-45 jacks for integrated fax/modem and Ethernet. 1 USB (1.1) connector, PS/2 connector for keyboard/mouse. 9-pin high-speed serial port. 68-pin multi I/O docking connector, optional adapter for parallel port connector. 15-pin external video (CRT). External speaker and microphone jacks.

- The unit shall include a mouse port and a mouse.
- The unit shall have two RS232 ports, a USB port and a Parallel Port.
- The unit shall have a Null Modem Cable of at least 6 m for connection to Sign Controller.
- The unit shall have a custom padded carrying case with accessory compartment.

**Documentation**

The documentation for the Variable Message Signs shall consist of manuals detailing the Communications Protocol, Operations, Maintenance Procedure Manual, Equipment Drawings, and
Electrical Schematic Diagrams. A copy of each manual shall be provided with each sign assembly delivered.

Communications Protocol
Access to the sign controller is provided via two possible techniques, via the fiber optic communications network, or via the local serial ports. This document shall clearly describe the communications protocol that must be used to gain access using each technique.

Operator's Manual
This document shall fully describe the operation of the Variable Message Signs using the DOS software that may run on the portable computer. This document shall clearly define all functions that are supported by the software. The manual shall define the normal operation of the signs and the software including resetting and restarting the software package.

Maintenance Procedure Manual
This manual shall document the preventive and corrective maintenance procedures that should be followed to maintain the Variable Message Signs at the highest level of operational efficiency. The manual shall include step-by-step field and bench trouble-shooting procedures to isolate and repair faults. The document shall include descriptions of normative waveforms and test voltages. A detailed parts list shall be included. For each part or assembly, a circuit diagram or pictorial shall be provided.

Equipment Drawings and Diagrams
A pictorial drawing showing the physical location and identification of each component shall be provided for each different electronic assembly and each different subassembly. Wiring diagrams shall be provided for each sign enclosure. These diagrams shall depict the location and interface of all components located within the sign enclosure.

Electrical Schematic Diagrams
An electrical schematic, wiring diagram, and a logic diagram shall be provided for each different type of equipment. A stage-by-stage explanation of the circuit theory shall be provided with the circuit wiring diagrams. Connection diagrams for each VMS subsystem including block diagrams, terminal numbers, and conductor color codes shall be provided. Three copies of these diagrams shall be supplied.

Training
Prior to the acceptance of the first VMS unit, training shall be provided for the Department's engineering, maintenance and operations staff, at a facility provided by the Department. The training shall include all material and manuals required for each participant. The training shall be as follows:

Maintenance Training
The training shall be provided for a minimum of 80 hours for at least ten (10) personnel with electronics background. The training shall include operation instructions, theory of operation, circuit description, field adjustments, preventive maintenance procedures, troubleshooting and repair of all components.

Engineering/Operators Training
The training shall be provided for a minimum of 24 hours for at least twenty (20) engineering and operations personnel. The training shall include a complete demonstration of the operation and capabilities of the VMS equipment. This session shall include a complete review of any field adjustments or calibration that may be required by the LEDs or any sign component. Particular attention shall be given to the operation of the software packages to be provided including procedures for configuring the...
signs, displaying messages, and diagnosing faults.

**Instructions and Guarantees**

One (1) set of the maintenance manuals for the LED Variable Message Sign, digital control unit and auxiliary equipment shall be supplied for each LED Variable Message Sign Assembly furnished. Additionally one (1) complete set of schematics of the electronics for the LED display and boards shall be furnished.

One (1) complete set of manuals for all software shall be provided.

No changes or substitutions in these requirements will be acceptable unless authorized in writing. Inquiries regarding this equipment shall be addressed to the New York State Department of Transportation.

The Supplier shall furnish any and all equipment that he deems necessary for safe and reliable operation of the LED Variable Message Sign.

The LED Variable Message Sign and All components supplied under this specification shall be warranted in accordance with Section 104-08, Warranties and Guarantees of the Standard Specification.

The Amber VMS Sign assembly to be provided must be manufactured by a firm experienced in the design and production of LED signs for use on freeways. This experience shall have included the successful design, manufacture, and installation of at least two (2) similar sign assemblies to those required by this specification. As part of the shop drawing submittal, the name, address, and telephone number of at least two (2) managers of the operating agency with responsible charge over the unit shall be provided.

The Manufacturer of the VMS sign shall hold Product Liability insurance covering the sign assembly for the intended operation. The policy shall provide minimum coverage of at least 5 million dollars. A copy of the policy shall be provided with the shop drawing submittals and shall be acceptable to the NYSDOT Risk Manager and written by a CLASS A company certified to do business in New York. The Manufacturer shall certify that the policy will remain in effect throughout the warranty period for the assembly and shall submit certificates evidencing this at least once per year or as requested by the Engineer.

All major components shall be identified with a metal plate containing the serial number with bar code identification.

**METHOD OF MEASUREMENT**

Discrete LED (Light Emitting Diode Variable Message Sign) bid item will be measured by the actual number of LED (Light Emitting Diode Variable Message Sign) Assemblies furnished, installed, activated, tested, integrated, and accepted.

**BASIS OF PAYMENT**

Payment will be made at the contract unit price for each LED (Light Emitting Diode Variable Message
VARIABLE MESSAGE SIGN ASSEMBLY, LED, TYPE A – 3
LINES (FULL MATRIX) Continued

Sign) Assembly which shall include all equipment, material, testing, documentation, and labor detailed in the contract documents for this bid item. Conduit and wire required to connect the VMS to power and communications shall be paid for under other work items as identified on the plans. All other conduit and wiring required to connect internal components of the assembly shall be included as part of this bid item.

Progress payments will be made in the following percentages of the bid price for each item after each milestone is reached. See System Integration specification for definition of milestones.

Successful Pre-Installation Test at the Contractor’s yard - 20%

No payment will be made beyond this point until power and communication are established. Once power and communication are established progress payments will be made as indicated below.

Successful Operational Stand-Alone Test of Assembly - 20%
Successful Group Site Verification Test 25%
Successful Subsystem Integration Test 25%
Successful System Acceptance Test - 10%