**New Jersey Turnpike Authority**

**P.O. Box 5042, Woodbridge, NJ 07095**

***August 31, 2020***

# Document Change Announcement

## *2016 Standard Supplementary Specifications*

### *Intelligent Transportation Systems (ITS) Update*

### *DCA2020SS-05*

**Subject: Revisions to**

**Section 601 Common Electrical Provisions, Subsection 601.03 General Conditions**
**Section 601 Common Electrical Provisions, Subsection 601.05 Conduit**
**Section 918 Electrical Materials, Subsection 918.19 System Control Cabinet (SCC)**
**Section 918 Electrical Materials, Subsection 918.52 Variable Message Signs (VMS)**
**Section 918 Electrical Materials, Subsection 918.54 Hybrid Changeable Message Sign (HCMS)**

**Description of Change:**

This DCA contains updates to Intelligent Transportation Systems (ITS) standards, including System Controller Cabinets (SCC), Hybrid Changeable Message Signs (HCMS), and Variable Message Signs (VMS).

**Notice to New Jersey Turnpike Authority Staff and Design Consultants**

Effective immediately, all contracts currently in the design phase shall incorporate the revisions herein. For advertised contracts awaiting the opening of bids this revision shall be incorporated via addendum. Contact your New Jersey Turnpike Authority Project Manager for instruction.

The revisions may be accessed on the Authority's webpage: https://www.njta.com/doing-business/professional-services

**Recommended By:**

8/27/20

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**DCR0322 Table of Contents (for Review Purposes only)**

**NOTE: The following text are ADDITIONS to the latest version of the 2016 Standard Supplementary Specifications.**

# SECTION 605 – INTELLIGENT TRANSPORTATION SYSTEMS

## 605.01 Description.

**(A)** Definitions.

Add the following:

| | |
|---|---|
| Fixed Panel Sign Variable Insert (FPSVI) | An application of a Variable Message Sign that adds variable content to a fixed-panel sign and is attached to the fixed-panel sign. |

The following Paragraph is added:

**(I)** Fixed Panel Sign Variable Insert (FPSVI).

The work shall consist of furnishing and installing FPSVIs complete with controllers, mounting hardware, fixed-panel sign cutouts, power transformers, power and communications cabling, surge protectors, communications equipment and other items and appurtenances required to provide working systems.

The work shall also include installing and connecting System Control Cabinets (SCCs), furnishing and installing of power and communications wiring serving the FPSVI, and performing partial and final acceptance testing of the FPSVIs and their controllers after installation.

## 605.03 Methods of Construction.

The following is added:

**(J)** Fixed Panel Sign Variable Insert (FPSVI).

The work shall consist of performing all necessary work to furnish, install, and prepare the Variable Message Sign for integration and testing.

Furnish and install conduits and perform work as shown on the Plans to provide continuous communications and power raceway paths between the SCC and the VMS. Pull and terminate power and communications cables between the SCC and the VMS as shown on the plans.

Install structural supports as shown on the plans to position the VMS in the appropriate location in the fixed-panel sign. Recess the VMS such that the front of the VMS extends no more than one inch from the face of the fixed-panel sign. Verify actual dimensions of VMS prior to cutting into fixed panel sign.

Power cable type, size, and quantity of conductors shall be furnished and installed as shown on the Plans.

Ensure that no manufacturer or contractor text or graphics appears on the VMS face other than as shown on the contract plans.

# SECTION 918 – ELECTRICAL MATERIALS

## 918.19 System Controller Cabinet (SCC).

Delete the Subsection and replace it with the following:

This Subsection describes the requirements of the metal cabinet used for housing the sign controller and associated equipment separately from the HCMS at the roadside location. The System Controller Cabinet (SCC) shall be suitable for ground mounting and shall be provided with anchor bolts and other hardware required for installation.

### **(A)** General Requirements

The SCC shall be a Caltrans 332/334 style aluminum cabinet with front and back 19-inch equipment racks. It shall be designed to mount on a concrete pad, near the DMS. The cabinet shall enclose the sign controllers, fiber patch panel, UPS, batteries, 120 VAC electrical power panels and outlets, and remote communication devices, such as a modem and network switch.

If multiple sign controllers are required for DMS gantries consisting of two separate DMS, all controllers shall fit in the available rack space of one SCC.

#### (1) Cabinet Size

The controller cabinet shall be 66″ ± 1″ high by 24″ ± 0.5″ wide by 30″ ± 0.5″ deep. The front-to-back cabinet dimensions shall not exceed 38″ at its widest point, including the door handles, louvers, and roof overhang.

#### (2) Cabinet Weight

The controller cabinet weight shall not exceed 200 pounds (45.5 kg) when the cabinet is empty.

#### (3) Cabinet Construction

The controller cabinet shall be constructed to have a neat and professional appearance. The cabinet shall protect all 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).

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

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

#### (4) Serviceability

The controller cabinet shall provide safe and convenient access to all modular assemblies, components, wiring and other materials located within the cabinet. All internal components shall be removable and replaceable by a single technician.

Two (2) vertically hinged doors shall be mounted on the cabinet for interior access. One door shall be located on the front face and one door shall be located on the rear face of the cabinet. Each of the door openings shall not be less than 54″ (1,372 mm) high by 21″ (533 mm) wide. Each opening shall be sealed with a closed cell foam gasket.

The doors shall be attached to the cabinet by a full-length heavy-duty stainless steel hinge and stainless steel mounting hardware. Both doors shall open outward. In the closed position, each door shall latch to a double-flanged door opening with a three-point draw-roller mechanism. The door handle shall be stainless steel. Each door shall have a doorstop to hold the door in the open position. The doors shall each be equipped with a Corbin #2 lock. The #2 Corbin lock shall have a spring-loaded dust cover.

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

(5) Equipment Rack

The controller cabinet shall be equipped with a front and back full-height standard EIA 19-inch equipment rack. The rack shall be secured within the cabinet by mounts at the top and bottom.

a) Sliding Drawer

The rack shall contain a minimum of one (1) pullout stainless steel or aluminum drawer. The drawer shall have a hinged cover and be suitable for storing manuals and small tools, such as screwdrivers. The drawer shall be able to latch in the out position to function as a laptop/utility shelf.

b) Equipment Tray

The rack shall contain a minimum of one (1) stainless steel or aluminum fixed tray. The tray shall be suitable for optional or future non-rack mountable equipment, such as power-over-Ethernet injectors or surge protectors. The equipment shelf shall not be used for rack mountable equipment supplied with the SCC, such as sign controllers, UPS, or batteries. The approximate shelf dimensions shall be 5"H x 19"W x 18"D. The top edges of the tray shall be insulated with nylon edging to prevent the chafing of wires.

(6) Cabinet Base

The controller cabinet shall be installed on a 12-inch high aluminum base with approximately the same width and depth as the cabinet bottom. The base shall have an open top and bottom with a continuous lip for attachment to the cabinet and concrete pad. The base shall be attached to the cabinet with stainless steel bolts, nuts, washers, and lock washers provided with each cabinet.

(7) Local Control Compartment

The SCC front door for an HCMS shall contain a switch compartment for local message control of the DMS. The local control compartment door shall be vertically hinged and provided with a neoprene continuous gasket for a water-tight seal. The door shall be equipped with a brass skeleton key lock to match existing NJTA keying requirements and a swivel dust cover. One local control compartment key shall be provided with each cabinet.

**(B)** Electrical System

(1) Power Panels

a) Utility Power Panel

The cabinet shall contain a utility (non-UPS) power panel board and circuit breakers that meet the following minimum requirements:

- Service entrance-rated
- 50 Amps, main breaker input
- Minimum of 12 snap-in circuit breaker mounting positions
- Short circuit ratings of 10,000 Amps for the branch circuits
- UL listed
- Printed branch circuit label

The cabinet shall include one (1) earth ground lug that is electrically bonded to the

cabinet. The lug shall be installed near the power entrance. The installation contractor shall provide the balance of materials and services needed to properly connect to earth ground. All earth grounding shall conform to the National Electrical Code.

b) UPS Power Panel

The cabinet shall contain a UPS power panel board and circuit breakers for connection of electronic equipment within the SCC and other equipment outside of the cabinet, such as a CCTV camera. The UPS Power Panel shall meet the following minimum requirements:

- 50 Amps, main lugs input
- Minimum of 4 branch circuits
- Short circuit ratings of 10,000 Amps for the branch circuits
- UL listed
- Printed branch circuit label

c) Circuit Breakers

The utility and UPS power panels shall be equipped with snap-in single-pole and double-pole thermal-magnetic circuit breakers of the appropriate current and voltage ratings for the intended loads and in accordance with the National Electric Code. The circuit breakers shall have a color-coded visual indication of when the breaker is tripped. Tandem circuit breakers may be provided in the UPS Power Panel to provide a minimum of 4 circuits.

(2) Uninterruptible Power Supply (UPS)

The SCC shall be furnished with a UPS to maintain and provide conditioned power to key electronic devices as specified herein. The UPS shall be a rack mounted, environmentally hardened, line-interactive type. The UPS shall be supplied with extended temperature range batteries, an external automatic bypass switch, and a generator transfer switch as specified herein.

The UPS and batteries shall be sized and wired to supply the following loads for a minimum of four (4) hours in the event of a power failure:

- All Contractor furnished and installed VMS or HCMS controllers and associated electronic devices.
- For HCMS installations, a minimum of two message changes for each drum sign portion of the HCMS.
- One PTZ video camera supplied by others (100 Watt max. load)
- Two Traffic monitoring devices supplied by others (50 Watt max. load)
- Communications device(s) (i.e. router, modem, radio, network switch, etc. supplied by others (200 Watt max. load)

The LED portion of a VMS or HCMS shall not be powered by the UPS or included in the UPS and battery sizing requirement. The LED portion of a VSLS or Lane Control Sign shall be powered by the UPS and included in the UPS and battery sizing requirement.

The output of the UPS shall be connected to all protected equipment inside the SCC through a properly rated flexible line cord to a vertical power strip with a minimum of ten (10) NEMA 5-15R 120v surge protected outlets.

All AC line cords in the SCC, whether for UPS power or unprotected utility power, shall be neatly labeled near the plug using flexible wire ID tape, machine printed with permanent ink, identifying the connected load.

a) Operating Specifications

The UPS shall meet or exceed the following operating specifications:

- Output Power Rating: 2,000VA, 1500W
- Input Voltage Range: 90VAC to 150VAC
- Input Frequency: 60Hz ±5%
- Input Configuration: 3-wire (hot, neutral, and ground)
- Output Voltage: 120VAC ±10% over full input voltage range
- Output Frequency: 60Hz ±.05%
- Output Waveform: True sine wave
- Typical Transfer Time: <5ms
- Overload Capability: 110% for 10 minutes, 200% for 0.5 seconds
- Efficiency: 98% (resistive)
- Line Transient Protection: ANSI/IEEE C.62.41/C.62.45 Cat A&B
- Operating Temperature Range: -35 to +74°C
- Humidity Range: 0% to 95% non-condensing
- Size (maximum): 17"W x 10"D x 5.25"H (3RU)
- Weight (maximum): 35 pounds
- UPS Protection: Input and output short circuit; input and output overload; excessive battery discharge
- Communications: Serial Interface (monitor, control and calibrate), DB-9 or USB connector and Ethernet interface with SNMP support
- Front panel display indicators: Fault, Test, Low Battery, On Battery, Online
- Battery recharge time: 2-8 hours; must be temperature-compensated

b) UPS Communications and Alarms

The UPS shall include RS-232 serial, open-collector signal, and 10Base-T Ethernet ports for remote monitoring and control of the UPS and battery system.

The UPS RS-232 serial port shall be connected directly to the VMS or HCMS controller to allow the controller to notify the central control server that local power has been lost. Additionally, the UPS Ethernet port shall be connected to the SCC network switch to allow remote access to extended UPS status information.

c) Batteries

The UPS shall be provided with a bank of 12 VDC Valve Regulated Lead Acid batteries with Absorbent Glass Mat (AGM) plate separators, connected in a series or series/parallel configuration to provide the required UPS input voltage and specified maximum load battery runtime. The batteries shall be rated for -40° F to 122° F operating temperature range and designed for a 10-year minimum life expectancy in float service at 77° F. The batteries shall be arranged in the SCC for easy access to the battery terminals for voltage measurement and battery replacement. The terminals shall be coated with an appropriate dielectric grease to minimize oxidation and corrosion. The batteries shall be securely mounted near the bottom of the SCC or, if required due to space constraints, in a separate battery compartment mounted to one side of the SCC. UPS batteries may be crated and shipped separately from the SCC to prevent shipping damage.

d) Automatic Bypass Switch (ABS)

The UPS system shall include an external ABS made by the same manufacturer and fully compatible with the supplied UPS. The ABS shall be wired to the utility power and the UPS so that UPS power is supplied to the UPS loads while on utility power or battery power. In the event of a UPS failure or battery discharge, the ABS shall automatically bypass the UPS inverter and switch utility power to the UPS loads. The ABS shall also allow the UPS load to be manually transferred to utility power to allow the UPS to be serviced or replaced without interrupting power to the load.

e) Generator Connection

The SCC shall include a single external generator plug, fully compatible with the supplied UPS(s). Where two UPS's are being powered from one generator plug, each UPS shall be connected to a different phase. The generator plug shall be a 30Amp, 120VAC, 4-wire twist-lock receptacle with male connectors and a water-tight cover for operation of the UPS(s) during an extended power outage. One mating twist-lock plug shall also be provided with each SCC for connection by others to a backup generator. The generator input receptacle shall be mounted through one side of the SCC to allow connection to a generator without opening the cabinet doors. The SCC and receptacle orientation shall be coordinated on a site-by-site basis to assure clearances for access and NEC code compliance. The UPS shall perform automatic transfer to generator input when both utility power is lost and 120VAC is applied to the UPS through the generator plug.

(3) Convenience Outlets

The SCC shall contain a utility outlet circuit consisting of a minimum of one (1) 15-A NEMA 15-R, 120 VAC duplex receptacle, with a ground-fault circuit interrupter located for optimum access and convenience. The convenience outlets shall not be connected to the UPS output.

(4) Ground Bar

A copper ground bar, such as Square-D model PK12GTA, shall be mounted near the bottom of the cabinet to provide a convenient grounding point for surge protectors, shielded cables and other devices within the cabinet. The ground bar shall have a minimum of 12 grounding screw terminals and shall be bonded to the cabinet's main power grounding point by way of a #6 AWG green insulated copper wire secured along one side of the cabinet.

(5) Transient Protection

The SCC signal and power inputs shall be protected from electrical spikes and transients as follows:

a) AC Mains 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. The surge suppressor shall be connected to the load center through an appropriately rated branch circuit breaker and shall include auxiliary contacts to provide an alarm indication to the VMS or HCMS controller in the event of a surge suppressor fault condition.

b) Control Equipment AC Power

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

- Withstand a peak 50,000 Ampere surge current for an 8x20 microsecond

waveform

- Maximum continuous operating current of 15 Amps at 120 VAC, 60 Hz
- Series inductance of 200 micro Henrys (nominal)
- Temperature range as specified in NEMA Standards Publication TS 4
- The device shall be UL-1449 recognized
- UL 1449 surge rating of 400 V or less

c) Communication Signals

Multi-stage transient voltage surge suppressors shall protect all communication signals connecting the control equipment from off-site sources using copper cables. Transient voltage surge suppressors shall protect all copper communication lines used to pass data between the sign controller and sign.

## (C) Environmental Systems

### (1) Exhaust Fan

One (1) thermostatically controlled 100 CFM exhaust fan shall be mounted near the top of the SCC. The fan shall be removable and replaceable from inside the cabinet. The exhaust fan shall not be powered by the cabinet UPS. The fan thermostat shall include a manual adjustment and a nonadjustable high temperature limit switch.

### (2) Air Filters

Filtered air intake ports shall be located on the bottom third of each access door. The air filters shall be of a standard size and shall be removable and replaceable from inside the cabinet. The air intake ports shall be protected by louvered vents and tight mesh insect screens.

## (D) Communications Equipment

The Contractor shall furnish and install a Fiber Termination Panel (FTP) and all required interconnecting copper and fiber optic patch cords in each SCC. The Authority will furnish, install and configure a rack mounted network switch and provide a functional communications link between each SCC and the Traffic Management Center.

### (1) Network Switch

The Authority will furnish, configure, and install a rack mounted Network Switch in the SCC. The Contractor shall furnish and install communications equipment indicated on the plans and all fiber optic and copper cable patch cords necessary for connection of all contractor furnished equipment to the network switch. The Authority will furnish and install all fiber optic and copper cable patch cords necessary for connection of the network switch to equipment not furnished under this contract. The Authority provided network switch requires duplex LC connectors for fiber connections and RJ45 connectors for copper connections.

### (2) Fiber Termination Panel

The Contractor or a third-party communications contractor indicated on the plans shall furnish and install a Fiber Termination Panel (FTP) within the SCC. The FTP shall be a compact 19" rack mounted unit for interconnectivity and termination of optical fibers with a slide out master panel and removable top cover for accessing terminations and splicing.

The panel shall be provided with 19″ rack mounting hardware and meet the following general requirements:

General Requirements:

- Dimensions (max.): 1.87″H x 17.0″W x 9.75″D
- Capacity: Three (3) fiber optic adapter panels
- Material: 16 Gauge Steel
- Finish: Black electrostatically applied powder coat

The SCC FTP shall be as manufactured by Multilink, Inc. model FRM-1RU-3X-TS-S, or approved equal.

Each SCC FTP shall be provided with two (2)12-port fiber adapter panels with beige duplex multi-mode SC connectors for internal and external communications and one (1) 12-port panel with blue duplex SC connectors for single mode remote communications or one (1) 12-port panel with aqua duplex SC connectors for 50-micron fiber multi-mode remote communications. Each connector shall be provided with a plastic dust cap for protection when not in use. The SCC FTP is intended for termination and interconnection of all fiber optic cables entering the SCC, except for cables provided by the DMS contractor for connection of the SCC to the DMS.

## 918.52 Variable Message Signs (VMS).

Delete the Subsection and replace it with the following:

In the context of these specifications, a VMS is a type of Dynamic Message Sign with changeable message content that is only restricted by the sign display size and density.

Pixel arrays, which dictate the size of the sign, shall be as follows, or as per Contract Drawings:

| Application | Pixel Array | Sign Dimensions |
|---|---|---|
| General Traffic Advisory | 96x336 | 6′-9″ x 22-′-4″ x 1′-0″ |
| Express E-ZPass | 48x192 | 4′-8″ x 13′-0″ |
| Variable Speed Limit Sign, LED portion, Subsection 918.53 | 32x48 | 2′-1″ x 3′-2″ |
| Fixed Panel Sign Variable Insert (FPSVI) | 64 rows, columns as per Contract Drawings | As per Contract Drawings |
| Other applications | As per Contract Drawings | As per Contract Drawings |

### (A) VMS General Requirements

This Paragraph describes the minimum construction and operational functionality requirements for the Variable Message Sign (VMS). The VMS shall be furnished with all the materials, software licenses, and services necessary for the VMS and associated equipment that fully comply with the functional requirements specified herein, including incidental items that may have been inadvertently omitted.

The VMS shall be designed and constructed to utilize the latest available techniques with a minimum number of different parts, subassemblies, circuits, and modules to maximize standardization and commonalty. The sign shall be designed and constructed so as to present a clean neat appearance. Poor workmanship shall be cause for rejection of the sign. The performance of the sign shall not be impaired due to continuous vibration caused by wind, temperature, vibration or other factors. This includes the visibility and legibility of the display.

| | |
|---|---|
| **Display Technology** | **High-intensity LED** |
| **Cabinet Access** | **Front or rear access, minimum, as per Contract Documents** |
| **Cabinet Enclosure** | **NEMA 3R, or NEMA 3 with all components within rated IP65, minimum. Shallow depth with front or rear accessibility for maintenance.** |
| **Face Panel** | **Exposed face modular LED boards (no mask) removable from the front or rear of the sign.** |
| **Face Panel Finish** | **Semi-Gloss Black automotive body finish** |
| **Housing finish** | **Mill Finish Aluminum** |
| **Weight** | **Per Contract Drawings** |
| **Dimensions** | **Per Contract Drawings** |
| **Operating Temp. Range** | **-30˚ F to +165˚ F (-34˚ C to +74˚ C)** |
| **Humidity Range** | **0 to 99%, non-condensing** |
| **Controller Location** | **System Controller Cabinet** |

| | |
|---|---|
| **Display Type** | **Full-matrix (variable text and graphics)** |
| **VMS Display Modules:** | **Exposed face modular LED boards (no mask) removable from the front or rear of the sign.** |
| **VMS Pixels:** | **RGB pixels, 20mm pitch (distance between pixels). 60 Deg nominal viewing cone with a half power angle of 30 Deg.** |
| **Pixel Matrix** | **Per Contract Drawings** |
| **Pixel Pitch** | **20mm (.81")** |
| **Viewing Distance** | **1100' using 18" characters** |
| **Viewing Cone** | **60° nominal viewing cone with a half power angle of 30°** |
| **Sign Intensity** | **12,400 candelas/m2 minimum (white)** |
| **LED Color** | **Full color (32,000 distinct colors using red, green and blue LEDs)** |
| **Site Power Requirements** | **120/240 VAC, single-phase power (3-wires plus ground)** |
| **Sign Power Requirements** | **120/240 VAC, single-phase power (from System Controller Cabinet)** |
| **Communications Protocol** | **NTCIP 1203 (latest NJTA accepted version)** |
| **Communications Options** | **Cellular, fiber optic, direct Ethernet and radio Ethernet** |
| **Structural Design Standard** | **AASHTO** |
| **NEMA Standards** | **NEMA TS 4 Section 2 Environmental Requirements** |

### (1) General Materials and Construction

Maximum overall VMS sign housing and overall sign weights shall be as per this Specification Section. The maximum criteria shall not be exceeded in order to conform to the design of the VMS sign structure.

The VMS housing shall provide access for all LED display modules, electronics, environmental control equipment, air filters, wiring, and other internal components. At a minimum, access shall be via the front or rear of the VMS as specified in the Contract Documents.

The VMS size shall be as specified in the Contract Documents

The matrix shall have a 20mm pixel pitch display capable of displaying full color messages that are continuous, uniform, and unbroken in appearance to motorists and travelers.

Each display pixel shall be composed of red, green, and blue LED's. The pixel matrix shall be capable of displaying alphanumeric character fonts from a minimum of twelve (12) font sets with which messages can be formatted and displayed. Each font shall support up to 255 characters.

The VMS shall be able to display messages composed of any combination of alphanumeric text, punctuation symbols, and graphic images across multiple frames.

### (2) Origin

The VMS shall be final-assembled in the USA. To ensure proper service, support and logistics, US-based VMS service and support personnel are required. The bidder shall certify that it will comply with the requirements of Section 1048 of the Intermodal Surface Transportation Efficiency Act of 1991 and Regulations in 49 CFR 661.

(3) Legibility

VMS messages shall be legible within a distance range of 80 feet (24.38 m) to 1,100 feet (335.28 m) from the VMS display face under the following conditions:

- When the VMS is mounted so its bottom side is positioned between five feet and twenty feet above a level 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 such as snow, rain, sun.
- 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 the motorist eye level is 3 feet to 12 feet above the roadway surface.

(4) Dimensions

The approximate VMS housing dimensions shall be as specified in the Contract Documents. The housing dimensions shall not exceed values shown in the NJTA Standard Drawings.

Where indicated in the Contract Drawings, the VMS shall be capable of being mounted in walk-through sign structures as shown in the NJTA Standard Drawings.

(5) Power Requirements

The VMS shall operate from a 120/240 VAC, 60Hz, single-phase power source. Total required demand current for a single VMS and Controller Cabinet shall not exceed 50 Amps.

(6) Sign Construction

Each 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 (Latest Edition), Enclosures for Electrical Equipment (1000 Volts Maximum). Alternatively, a housing meeting NEMA 3 enclosure criteria shall be acceptable where all internal components conform to a minimum IP65 rating, or a more stringent rating where required elsewhere in these Specifications. All internal and external components shall be manufactured from corrosion resistant materials.

The VMS shall be a single piece assembly consisting of all display modules, internal components, housing frame, mounting brackets, structural members, lifting provisions, and top, bottom, and side borders. The VMS shall be designed and constructed to require no field assembly prior to installation.

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.

The VMS and sign controller components shall be capable of storage and operation without any decrease in performance over the environmental and temperature range specified in NEMA Standards Publication TS-4.

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

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

dielectric material.

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 applicable NEC code requirements.

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 as specified in NEMA Standards Publication TS 4. The VMS 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.

Fiber optic cable communications shall be used to the extent practical between the sign and the ground mounted control cabinet in order to isolate the equipment from voltage transients and reduce the need for copper cabling.

No company logos, model numbers or text of any kind will be permitted on the outside of the sign housing.

The rear access housing dimensions and total weight of each section shall be as shown in this Specification or in the Plans. All electronic and electrical equipment compartments shall be designed and manufactured to be rain and weather tight.

All sides of the VMS housing exterior, except the front of the LED modules, shall be covered with 5052-H32 aluminum alloy sheets with a minimum thickness of 0.090" (2.286 mm). This external aluminum skin may be attached to the structural framework using a proven chemically bonding structural adhesive. The VMS housing structural frame shall be constructed of 5052-H32 aluminum alloy members. The structural framework members may be permanently attached to each other using a proven chemically bonding structural adhesive.

The sign housing shall be engineered and Professional Engineer certified to 2001 AASHTO and NCHRP Report 411 specifications for AASHTO basic wind speeds. The sign housing shall also be engineered and Professional Engineer certified to withstand loading combinations as outlined in 2001 AASHTO including: sign weight, ice and wind loads, and shall also meet strength requirements for truck-induced gusts as specified in NCHRP Report 412. The sign housing shall be engineered and Professional Engineer certified to withstand snow loading (40 PSF) for applicable geographical regions.

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

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

Exterior mounting assemblies shall be stainless steel or galvanized ASTM A 709, Grade 50 structural angles.

The VMS housing for each type of VMS shall be designed and fabricated to fit within the appropriate VMS structure as depicted in the NJTA Standard Drawings

### (7) Chemical Bonding

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

To ensure that appropriate procedures are followed to bond the aluminum sheet and

cabinet frame members, the structural adhesive manufacturer shall certify the VMS manufacturer's adhesive application process. The VMS Manufacturer is responsible for performing all necessary testing of the adhesive to meet all requirements of the contract specifications.

### (8) Welding

If welding is selected by the manufacturer over chemical bonding, the minimum sheet thickness of the exterior panels shall be 0.1 inches.

The aluminum skin shall be welded to the VMS cabinet frame. All exterior sheet seams shall be continuously seam welded to the VMS frame to form a single structure. Stitch welding shall be used on the interior of the cabinet to attach the aluminum skin sheets to the aluminum extrusion frame.

All welding shall be by an inert gas process in accordance with the American Welding Society (AWS) Standards, 2008 ANSI/AWS D1.2/D1.2M Structural Welding Code for Aluminum. The VMS manufacturer's welders and welding procedures shall be certified by an ANSI/AWS Certified Welding Inspector to the 2003 ANSI/AWS D1.2/D1.2M Structural Welding Code for Aluminum.

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

The VMS manufacturer shall submit documentary evidence and complete reference data for the above requirements. Reference data shall include the name and address of the welding organization, and the name and telephone number of an individual from the organization who can be contacted to verify the above requirements and all the details required to support the above requirements.

The Authority reserves the right to contact additional references. Any poor or unsatisfactory reference, as determined by the Authority in its sole and absolute discretion, will cause the manufacturer to be rejected.

### (9) Mounting Brackets and Miscellaneous Materials

Multiple mounting brackets in the form of steel angles, as shown on the NJTA Standard Drawings, shall be bolted to the VMS housing exterior to facilitate attachment of the VMS to the support structure. Mounting brackets shall be:

- Stainless steel or galvanized ASTM A 709, Grade 50 structural steel
- 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 mechanically galvanized A325 high-strength stainless steel bolts, washers, and lock washers
- 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, if required, without penetrating the VMS housing or compromising the housing's ability to shed water

The VMS Manufacturer shall supply neoprene pads, of the dimensions shown on the Plans, used to support the bottom of the sign. The pads shall be either virgin neoprene (polychloroprene) or virgin natural rubber (polyisoprene). The elastomer compound shall be temperature grade 3 and 60 durometers.

The VMS Manufacturer shall design the bolted connection used on the steel angle mounting brackets to support the VMS sign and connect to the plates on the VMS support structure. The VMS Manufacturer shall drill the holes in the mounting brackets per his design. The VMS Manufacturer shall supply the required galvanized A325 high strength bolts, nuts and

washers needed to make these connections.

### (10) Lifting Hardware

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

The lifting eyebolts shall be easily removed by one individual without opening or entering the display and without any risk of compromising water-tightness. Special tools shall not be required. Removal of the eyebolts shall not create holes and no replacement bolts or other hardware shall be necessary to seal the cabinet. In addition, it shall not be required to remove the eyebolts or alternate lifting hardware, should this material fit within and be useful for future removal of the VMS from the support structure.

The hardware used to attach the mounting brackets (nuts, bolts, washers, and direct tension indicators) to the VMS cabinet shall be stainless steel and shall be appropriately sized for the application.

### (11) Exterior Finish

The VMS sign portion front face panels and front face border pieces shall be coated with semi-gloss black automotive body grade fluoropolymer coating, with an expected outdoor service life of 20 years.

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

### (12) Service Access

The VMS housing shall provide, at a minimum, front or rear access for all maintenance operations as indicated in the Contract Documents. The VMS housing shall provide safe and convenient access to all modular assemblies, components, wiring, and subsystems located within the VMS housing. All of those internal components shall be removable and replaceable by a single technician.

Access doors shall be provided for each section of a rear or dual access sign housing. One door shall also be provided for accessing the load center and sign control electronics. It shall be possible to remove and replace all components in a rear or dual access sign from the rear access doors without first having to remove multiple interfering components. All cable assemblies, ventilation ducts, and door partitions shall be assembled and placed to minimize interference with the removal and replacement of internal components.

The doors shall be restrained to prevent them from falling off or blowing around in the wind when in the open position. The doors shall not interfere with the mounting when in the open or closed position.

When in the open position, the doors shall not obstruct any portion of the opening. Ventilation hoods and closed doors shall not obstruct the opening of any door. The doors shall not interfere with the flow of air through the ventilation hoods.

Each door shall contain screw-type quarter-turn latches. A tamper resistant key shall be used for activating the latches. All latches shall be keyed alike. Two keys shall be provided with each sign delivered. The latches shall pull the door tight and compress a gasket located around the perimeter of each door. The gasket shall prevent water from entering the cabinet.

### (13) Environmental Behavior

The VMS shall be capable of operating without any decrease in performance over a temperature range as required under NEMA Standards Publication TS 4 (with a relative humidity of up to 100% condensing) unless otherwise noted in this specification.

### (14) Wiring and Power Distribution

a) Power and Signal Entrances

The sign and its sign controller shall be capable of operating from 120/240 VAC, with a maximum of 50 Ampere service, 60 Hertz, single-phase power. 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.

b) Panel Board

The VMS shall contain a power panel board or DIN rail mounted circuit breakers that meet the following minimum requirements:

- Service entrance-rated
- Short circuit ratings of 22,000 Amps and 10,000 Amps for the main and branch circuits, respectively
- UL listed panel boards and circuit breakers

c) Internal Wiring

All wiring and electrical equipment shall be in accordance with the requirements of the National Electrical Code. Wiring shall be neatly arranged, bundled, and mechanically supported. 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. The use of adhesive-backed, surface-mount wiring clamps shall not be permitted.

All internal wire terminations shall be made at appropriately rated terminal blocks or connectors. Crimp type terminals shall be affixed with a cycle-controlled crimp tool that will not permit a crimp to be made without the proper degree of compression. All terminal blocks shall be clearly labeled with terminal numbers. All wires shall be individually labeled at terminal points with a machine printed flexible tape or another professional means designed specifically for wire labeling.

d) Earth Grounding

The VMS manufacturer shall provide one earth ground lug that is electrically bonded to each section of 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. All earth grounding shall conform to the National Electrical Code.

### (15) Transient Protection

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

a) Sign AC Power

The AC power feed for all equipment in the sign cabinet shall be protected at the panel board by a parallel-connection surge suppresser rated for a minimum surge of 40 KA. This device shall conform to the following requirements:

- Withstand a peak 80,000-Ampere surge current, 40kA L-N, 40kA L-G
- Designed, manufactured, & tested consistent with: IEEE C6.41.1-2002,

C62.41.2-2002, C2.45-2002, ANSI/IEEE C62.41-1991, C62.45-1992, NEMA LS-1, and NEC 285.6

- Less than 0.5 nanosecond response time
- Temperature range as specified in NEMA Standards Publication TS 4
- 5000 Category (C3 High) impulses with <10% drift, short circuit current rating of 200,000 rms symmetrical Amperes (UL Listed)
- UL listed to: UL 1449 200kA SCCR, UL 1283 4th Edition, and Canadian safety standards

b) Communication Lines

All copper cable communication lines shall be protected by transient suppression devices as appropriate for the type and operating voltage of the communication line. Communication line transient suppression devices shall be equipped with modular connectors for ease of replacement and shall electrically bonded to ground with a heavy gauge ground wire kept as short and straight as practical.

### (16) LED Display Modules

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

- Each LED display module shall have a cam latch(es) that fasten it to the VMS housing. Latching mechanisms shall be actuated by a quarter-turn latching points on the front face of each LED display module. It shall be possible to activate the latches from both the front and back of each module. The module latches shall be actuated by a standard hex key wrench.
- The LED display modules shall be sealed to a minimum of IP67 standards.
- LED display modules shall not be welded to the VMS housing.
- Front face LED display modules shall provide a high-contrast background for the VMS display matrix. The front of each LED display module shall be black and contain high-contrast plastic masking for the LED pixels.
- Removal of the LED modules shall be from the interior of a rear access or dual access VMS housing. All LED display modules and internal components shall be removable and replaceable by a single technician. For a rear or dual access VMS, the LED module shall be unlatched, removed and pulled back through the opening in which it covered. All VMS modules shall be secured to the sign housing with a quick release lanyard or tether to prevent the modules from becoming dislodged from the VMS during the removal and replacement process.
- In the presence of wind, rain and snow, the VMS front face shall not distort in a manner that adversely affects LED message legibility.
- Each LED display module shall contain no more than one circuit board to minimize electrical connections. All LED modules shall be manufactured using laminated fiberglass printed circuit boards with conformal coating to minimize environmental corrosion.
- The LED pixels in the module shall be protected by a black contrast-enhancing silicone elastomer that surrounds the base of the LEDs and seals the entire front face of the module to prevent water penetration and corrosion, while not obstructing the viewing angles of the LEDs.
- LED display module electrical connections shall use a quick-disconnect locking connector. Removal of an LED display module from the VMS 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 LED display modules shall be identical and interchangeable throughout the VMS.
- Removal or failure of any LED module shall not affect the operation of any other LED module or sign component. Removal of one or more LED modules shall not affect the structural integrity of any part of the sign.
- Each LED display module shall contain a minimum of 256 LED pixels configured in a two-dimensional array. The pixel array shall be a minimum of 16 pixels high by 16 pixels wide.
- The distance from the center of a pixel to the center of each adjacent pixels, both horizontally and vertically, shall be 0.78 inches (20mm).
- All pixels shall contain an equal quantity of LED strings.
- The failure of an LED string or pixel shall not cause the failure of any other LED string or pixel in the VMS.
- Each pixel shall contain the quantity of discrete LEDs needed to output white colored light at a minimum luminous intensity of 12,400 candelas per square meter when operated within the forward current limits defined in these specifications.
- The circular base of the discrete LEDs shall be soldered so that they are parallel to the surface of the printed circuit board. The longitudinal axis of the LEDs shall be perpendicular to the circuit board.

### (17) Discrete LEDs

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

- All LED's shall have a minimum unimpeded viewing cone of 60 degrees with a half-power angle of 30 degrees measured from the longitudinal axis of the LED.
- Red, green and blue LEDs shall be able to produce colors that will meet NEMA Standards Publication TS 4 Section 5.5.1 requirements for chromaticity.
- The LED manufacturer shall perform color sorting of the bins. Each color of LEDs shall be obtained from no more than two (2) consecutive color "bins" as defined by the LED manufacturer.
- The LED manufacturer shall perform intensity sorting of the bins. Each color of LEDs shall be obtained from no more than two (2) consecutive luminous intensity "bins" as defined by the LED manufacturer.
- The various LED color and intensity bins shall be distributed evenly throughout the sign and shall be consistent from pixel to pixel. Random distribution of the LED bins shall not be accepted.
- The LED package styles shall be through-hole with standoffs.
- All LEDs used in all VMS provided for this contract shall be from the same manufacturer and of the same part number, except for the variations in the part number due to the intensity and color bins.
- The LEDs shall be rated by the LED manufacturer to have a minimum lifetime of 100,000 hours of continuous operation while maintaining a minimum of 70% of the original brightness.

### (18) Pixel Drive Circuitry

Each LED display module shall contain electronic driver circuitry that shall individually control all pixels on that module. The driver circuitry shall conform to the following specifications:

- LED driver boards shall be manufactured using a printed circuit board.
- Each LED driver board shall be microprocessor-controlled and shall communicate with the sign controller on a wire or fiber optic communication network using an addressable

network protocol. The microprocessor shall process commands from the sign controller to display data, perform diagnostic tests, and report pixel and diagnostic status.

- Constant current LED driver ICs or another method that provides at least the same level of control (such as PWM) shall be used to prevent LED forward current from exceeding the LED manufacturer's recommended forward current whenever a forward voltage is applied. To maximize LED service life, LED drive currents will not be allowed that exceed the manufacturer's recommendations for the 100,000-hour lifetime requirement.
- The LED pixels shall be directly driven using pulse width modulation (PWM) of the drive current to control the display intensity. This LED driver circuitry shall vary the current pulse width to achieve the proper display intensity levels for all ambient light conditions. The drive current pulse shall be modulated at a frequency high enough to provide flicker-free operation and a minimum of 200 brightness levels.
- The LED driver circuitry shall receive updated display data at a minimum rate of two (2) frames per second from the sign controller.
- Each LED driver circuit shall be powered by 24 VDC from external regulated DC power supplies. This input voltage shall be fused. Each driver board shall receive power from a minimum of two (2) independent power supplies. Indicator LEDs shall be provided to indicate the status of various voltage levels on the board.
- The voltage of each power input shall be measured to the nearest tenth of a volt and reported to the sign controller upon request. Each driver circuit shall also contain one status LED for each power source that indicates if the power source is present or not.
- The LED driver circuitry shall be able to detect that individual LED strings or pixels are stuck on or off and shall report the pixel status to the sign controller upon request.
- The LED driver circuit shall contain a LED display that indicates the functional status of the driver and pixel boards. At a minimum, it shall indicate error states of the LED pixels and communication network. The indicator shall be positioned such that a maintenance technician can easily view the status code for diagnostic purposes. The status codes shall also be reported to the sign controller upon request.
- Removal or failure of a single driver circuit board shall not affect the performance of any other LED display module in the VMS.
- Individual addressing of each driver circuit shall be configured via the communication wiring harness or module position. No on-board addressing jumpers or switches shall be allowed.

### (19) Regulated DC Power Supplies

The LED pixel display modules shall be powered with auto-ranging regulated switching power supplies that convert the incoming AC to DC at a nominal voltage of 12, 24, or 48 Volts DC. Power supplies shall be wired in a redundant parallel configuration that uses multiple supplies for the VMS display matrix.

Power supplies shall be designed to provide redundancy within the display to ensure continued operation under a failure of a single power supply. Power supplies shall be redundant and rated such that if one supply fails, the display shall be able to operate 100% of the pixels in that display region at 100% brightness when the internal VMS air temperature is +140°F (60°C) or less.

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

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

The output of each power supply shall be connected to multiple circuits that provide power

to the LED modules. Each output circuit shall not exceed 15 Amperes.

Each power supply shall be monitored by a microprocessor-controlled circuit. This circuit shall monitor the voltage of each power supply and the status of each output circuit's fuse. The power supply voltages and fuse states shall be reported via a communication network to the sign controller and reported to Central by the sign controller.

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

Regulated DC power supplies shall conform to the following specifications:

- Nominal output voltage of 12, 24, or 48 VDC +/- 10% unless otherwise approved
- Operating input voltage range shall be a minimum of 90 to 260 VAC
- Operating temperature range shall be as specified in NEMA Standards Publication TS 4
- Maximum output power rating shall be maintained over a minimum temperature range as specified in NEMA Standards Publication TS 4.
- Power supply efficiency shall be a minimum of 80%
- Power factor rating shall be a minimum of 0.95
- Power supply input circuit shall be fused
- Automatic output shut down if the power supply overheats or one of the following output faults occurs: over-voltage, short circuit, or over-current
- Maximum allowable power supply weight shall be 15 pounds.
- Power supplies shall be UL listed
- Printed circuit boards shall be protected by a silicone conformal coating

### (20) Control Systems

The VMS shall be controlled from primary and auxiliary locations in compliance with Subparagraph 918.52(B)(18) of these specifications.

### (21) Environmental Monitoring Systems

The VMS shall include sensors that monitor and report ambient (external) light level and temperature, as well as the internal temperature.

#### a) Ambient Light Measurement

Sensors that measure the outdoor ambient light level at the VMS site shall be mounted in-line with the VMS housing walls. This ambient light measurement system shall consist of two (2) electronic light sensors. The light sensors shall be placed such that they measure the ambient light levels striking the front and rear of the VMS. The VMS sign controller shall continuously monitor the light sensors and adjust the LED display matrix intensity to a level that creates a legible message on the VMS face. The VMS shall allow for remote adjustment of the light sensor measurement to display intensity table from the central server software.

#### b) Ambient Temperature Measurement

A minimum of one (1) ambient temperature sensor shall be mounted to either the rear wall or bottom side of the VMS housing. An ambient outdoor temperature sensor shall be placed such that it is never in direct contact with sunlight. The external temperature sensor reading shall be continuously monitored by the VMS sign controller and shall be reported to the VMS control software upon request.

#### c) Internal Temperature Measurement

The VMS shall contain a minimum of two (2) temperature sensors that are mounted near the top of the VMS interior. The temperature sensor(s) shall measure the temperature of air in the cabinet over a minimum range from -40°F to

+ 176°F (-40°C to 80°C). The temperatures from the sensors shall be continuously measured and monitored by the sign controller. A temperature reading greater than a user selectable critical temperature shall cause the sign to go to blank and the sign controller shall report this action to the central controller. This user selectable critical temperature shall be capable of being changed by the central controller or laptop computer. The central controller and laptop computers shall have the ability to read temperature measurements from the sign controller. The internal temperature sensor's outputs shall be continuously monitored by the VMS sign controller and shall be reported to the VMS control software upon request.

### (22) Interior VMS Environmental Control

The VMS shall contain systems for cabinet ventilation and safe over-temperature shutdown.

a) Housing Ventilation System

The VMS housing shall contain a thermostatically controlled ventilation system 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.

Cooling fans shall be the ball-bearing type and shall be mounted in a line across the rear of the VMS housing wall. One fan at a minimum shall be installed per each exhaust port. Intake ports shall be located in a line across the rear VMS wall.

Each ventilation fan shall contain a sensor to monitor its rotational speed, measured in revolutions per minute. The fan speed shall be reported via a communication network to the sign controller upon request. Alternatively, the ventilation system status may be monitored by airflow sensors in-line with the ventilation air stream. The airflow sensors shall be sufficiently dampened to prevent oscillations and false indications.

An aluminum hood or louvers 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 intake and exhaust ports shall be designed to prevent blowing rain from entering the VMS.

b) Over Temperature Safety Shutdown

The VMS controller shall automatically shut down the LED modules to prevent damaging the LED's if the measured internal cabinet air temperature exceeds a maximum threshold temperature. The threshold temperature shall be configurable and shall have a default factory setting of 140°F (+60°C).

### (23) Sign Controller Signal Interface

Communication signals from the sign controller in a ground-mounted controller cabinet to the VMS shall use redundant fiber optic cables. Each VMS shall have two (2) duplex fiber optic communication ports for connection to the sign controller. A failure of either communications port or fiber optic cable shall not interrupt communications through the other communications port. It shall also be possible to connect multiple VMS to a single controller in a ring configuration using the redundant communication ports.

The VMS fiber optic cable shall comply with the following specifications:

- 62.5/125 or 50/125 µm diameter multi-mode fibers
- ST, SC, or LC style connectors to match style of controller connector
- Rated for indoor/outdoor use
- UL-rated
- PVC outer jacket

- Tight buffer inner jacket
- Operating temperature range: as specified for the sign and outdoor equipment.

The Contractor shall furnish and install fiber optic cable for connection to the ground-level control cabinet. A minimum of six (6) fibers shall be provided with one (1) for controller to sign commands, one (1) for sign to controller responses, and four (4) spares. All fiber strands, whether used or spare, shall be terminated at both ends by the installer. The fibers shall terminate in a mounted termination panel or connectorized block at both ends and shall be connected to the sign controller and sign interface by way of flexible and durable fiber optic patch cords.

## **(B)** VMS Controller

This Paragraph describes the minimum specifications for the VMS controller. Each VMS shall include a sign controller, and associated equipment. The VMS Manufacturer shall provide all the materials, software, and services necessary to install VMS controllers and associated equipment that fully comply with the functional requirements specified herein, including incidental items that may have been inadvertently omitted.

### (1) General Requirements

The sign controller shall meet the following operational requirements:

- Communicate using the NTCIP v2 protocol or later.
- Contain memory for storing changeable and permanent messages, schedules, and other necessary files for controller operation.
- Include a front panel user interface with an LCD display, or equivalent, and a keypad for direct operation and diagnostics as described herein.
- Contain a minimum of two (2) NTCIP–compliant RS232 communication ports with DB9 connectors.
- Contain a minimum of two (2) NTCIP-compliant Ethernet ports with RJ45 connectors
- Contain firmware (embedded software) that shall monitor all external and internal sensors and communication inputs and control the display modules as directed by external control software and the front panel interface. NTCIP shall be natively supported in the VMS controller. External protocol converter or translator devices are not allowed.
- All control capability required for each VMS site shall fit within the space available within the System Control Cabinet (SCC) specified in Specification Subsection 918.19.

### (2) Controller Location

The primary sign controller and associated communication equipment may be installed inside the SCC. Auxiliary control capability shall be installed as needed to provide local access to the controller from both the SCC and sign enclosure. Auxiliary control capability shall be included as specified in Subparagraph 918.52(B)(17).

### (3) Environmental

The sign controller shall meet the environmental requirements defined in NEMA Standards Publication TS 4, Hardware Standards for Dynamic Message Signs (DMS), with NTCIP Requirements.

### (4) Sign Controller Functions

The sign controller shall be controlled from the Authority's existing Central Controller or a laptop computer, which shall specify the appropriate display. The sign controller shall be capable of controlling multiple LED VMS signs. The sign controller and its software shall perform the following functions:

- Display a message

- Report errors and failures, including:
  (1) Data Transmission error
  (2) Receipt of invalid data
  (3) Communications failure recovery
  (4) VMS component failure (VMS pixel error, power supply failure, etc.)
  (5) Power recovery
- Message and status monitoring:
  The sign controller shall transmit a return message to the Central Controller whenever it receives a valid transmission requesting sign status. The return message shall contain the following:
  (1) Address or ID of the sign
  (2) Message that is actually displayed.
  (3) Message source information (Central, Local, etc.)
  (4) Device error codes
  (5) Uninterruptible power supply status
- Severe error condition response:
  The sign controller shall report severe error conditions to the central controller. The severe error conditions are:
  (1) AC power failure.
  (2) AC power recovery.
  (3) Surge protection has been tripped
- Communication Failure
  In the event the central controller fails to communicate within a programmable time limit with the sign controller, the sign shall respond per the requirements of NTCIP. This function shall apply only when the sign controller is in central control mode.
- Sign Failure
  Failure of any sign shall not affect the operation of any other sign in the system.
- Power Failure
  The sign controller shall maintain its internal time clock during power outages less than 255 minutes and display the proper message when power is restored.
- Remote Reset
  The sign controller shall be capable of being remotely reset from the central controller.

### (5) Operational Requirements

#### a) 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 VMS, including the status of all sensors and a what-you-see-is-what-you-get (WYSIWYG) representation of the message visible on the LED VMS display face.
- Perform diagnostics testing and monitoring of various system components, including pixels, power systems, sensors, and more.
- Activate LED VMS messages stored in memory.

- Configure display parameters, including display size and colors.
- Configure communications port settings and NTCIP options.

The front panel interface shall also include:

- Power switch to turn the controller on and off.
- "Local/remote" switch that places the controller in local mode such that it can be controlled from the front panel interface, instead of via the primary NTCIP communication channel.
- Reset switch to quickly restart the controller.

b) Memory

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

c) Internal Clock

The VMS sign controller shall contain a computer-readable clock that has a battery backup circuit. The controller shall allow for connection to a Network Time Protocol (NTP) sever for synchronization of the internal clock.

## (6) Communications

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

a) Communication Mode

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, fiber, or wireless communications with a remotely located computer. The system communications backbone, as well as all field modems or signal converters, will provide the VMS sign controller with an Ethernet signal.
- Locally via direct connection with a laptop computer that is connected directly to the sign controller using any of the following connections: RS232, USB, or Ethernet.

b) Serial Communication Port

The VMS controller shall contain a minimum of one (1) serial communication port. This port shall support a direct communication interface for local laptop control using either a DB9 or USB connector.

The baud rate, connection type, and NTCIP communication protocol shall be configurable. The port must support all typical serial baud ranging from 1200 to 115,200 baud. The port shall be capable of supporting the NTCIP 2103 (PPP), NTCIP 2201 (Null), and NTCIP 2202 (Internet) transport profiles. Only one of each of the transport and sub network profiles shall be active at any time on the port.

c) Ethernet Port

The VMS controller shall contain a minimum of one (1) 10/100Base-T Ethernet communication port for communicating from the central control system to the VMS sign controller. The Ethernet port shall have a standard RJ45 connector.

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

d) Controller Addressing

The VMS controller shall use the NTCIP 2104 (Ethernet) network protocol with a static v4 IP address. Both the IP address and subnet shall be configurable. The controller addressing shall be configurable through the front panel user interface.

e) Transient Protection

The serial and Ethernet communication ports in the VMS controller shall be protected with surge protection between each signal line and ground. This surge protection shall be integrated internally within the controller.

### (7) VMS Control Outputs

VMS sign controller(s) located in the ground level SCC shall transmit and receive data packets to and from the VMS via redundant dedicated fiber optic cables. The controller shall communicate with all sensors, drivers, and other devices utilizing a bus network running throughout the VMS.

Data transferred shall include pixel control and monitoring, 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.

Adequate surge protection shall be installed to mitigate the effects of spikes that result from motor operation and all other sources.

### (8) Messaging

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

a) Message Presentation on the VMS Display Matrix

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

- Display of alpha numeric characters, including letters, numbers, and punctuation.
- Selection of particular character font's style.
- Horizontal alignment of text on the display, including left, center, and right justification.
- Vertical alignment of text on the display, including top, middle, and bottom justification.
- Adjusting the spacing horizontally between characters or vertically between lines of text.
- Alternating between pages of a multiple-page message.
- Display of graphic bitmaps of various sizes ranging from very small to the size of the entire VMS matrix.
- Simultaneous display of character fonts over graphic images.

b) VMS 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 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 direction of travel is user selectable as either left-to-right or right-to-left.
- Multiple-Page Message – A message contains up to six different pages of information, with each page filling the entire pixel matrix. Each page's display time is user programmable from 0.1 seconds to 25.5 seconds, and adjustable in increments of 0.1 seconds.

### (9) Message Activation

Messages shall be activated on the VMS in three ways:

- Manual – An operator using the controller front panel LCD/keypad interface or NTCIP-compatible control software manually instructs a particular message to be activated.
- Schedule – The internal time-based scheduler in the controller 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. (Alternatively, schedules may be stored and managed in the central controller).
- Events – Certain events, such as a communication or power loss, shall trigger an event response when they occur. These events shall be configured using the control software. Configurable event responses shall include the ability to blank the sign, post a pre-configured default message, or retain the existing message display.

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

- The message's duration timeout expires.
- The controller receives a command to change the message.
- The controller receives a command to blank the sign.
- The schedule stored in the controller's memory (or stored and managed in the Central controller) indicates that it is time to activate a different message.
- A special event, such as a loss of communication, occurs that is linked to message activation.

It shall be possible to confer a "priority" status onto any message, and a command to display a higher priority message shall cause any lower priority message to be overridden.

### (10) Schedule Activation

The VMS sign controller shall support the activation of messages based on a time/date-based schedule, stored either in the sign controller, or in the Central controller). The format and operation of the message scheduler shall be per the NTCIP 1201 and NTCIP 1203 standards.

### (11) Display of Alphanumeric Text

The VMS sign controller shall support the storage and use of a minimum of twenty (20) font sets with which messages can be formatted and displayed. Each font shall support up to 255 characters. All text font files shall include the following characters:

- 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: # & * + / ( ) [ ] < > @
- The VMS Manufacturer shall provide the VMS controller with the following fonts preinstalled. The controller shall support changing or replacing these fonts from the central software using NTCIP. All font characters are variable width except where indicated otherwise.

| Pixel Array | Character Height (approx.) | Character Width (avg.) | Stroke Width (pixels) | Comments |
|---|---|---|---|---|
| 20x12 | 16″ | 9.5″ | 3 | Small |
| 20x16 | 16″ | 12.5″ | 4 | Small – MUTCD * |
| 23x15 | 18″ | 12″ | 3 | Standard |
| 23x15 | 18″ | 12″ | 3 | Standard, fixed width |
| 23x17 | 18″ | 13.5 | 3 | Standard, wide |
| 23x19 | 18″ | 14″ | 4 | Standard – MUTCD * |
| 24x15 | 19″ | 12″ | 3 | Tall |
| 24x15 | 19″ | 12″ | 3 | Tall, fixed width |
| 24x19 | 19″ | 15″ | 4 | Tall – MUTCD * |

* Note: Fonts commented as "MUTCD" in the table above shall be made to simulate the appearance and size requirements of the Manual on Uniform Traffic Control Devices (MUTCD) and the "Standard Highway Signs and Markings" (SHSM) Book for Series E-Modified text characters.

### (12) Display of Graphic Images

The VMS control software shall support the inclusion of graphics in messages in accordance with NTCIP 1203 v2. The VMS may support graphics that exceed current NTCIP limitations by using manufacturer-specific MIB objects and MULTI tags.

### (13) VMS Intensity Control

The VMS controller shall provide a means to change the brightness of the display matrix manually or automatically. The manual control will allow the user to select one of at least 100 intensity levels, which will be communicated to the LED drivers in the VMS. The brightness shall remain at that level until the user changes the level or sets the controller to automatic mode.

The automatic intensity control mode shall monitor the ambient light sensors of the VMS and use a mathematical algorithm to automatically select one of 100 or more intensity levels. The intensity level shall then be transmitted to the LED drivers in the VMS. The controller shall allow the adjustment of display intensity settings under various lighting conditions remotely from the central control software.

The intensity control mode, manual or automatic, shall be settable via NTCIP using the control software and via the front panel interface. The manual brightness level shall be

settable via the software and front panel. The mode and brightness level shall be monitored from both the software and front panel interfaces.

### (14) Permanent Messages

VMS controller(s) shall have the ability to store and activate NTCIP compliant permanent messages. A software utility or other means shall be provided to remotely download permanent message and support files to the VMS controller. It shall also be possible to download changeable messages from the central server, store them in the VMS controller, and display them on the sign.

### (15) System Status Monitoring and Diagnostic Testing

The VMS controller shall be capable of monitoring the status of many of the VMS components and subsystems in real-time and/or manual modes, depending on the component or system. The following sections detail the status and diagnostic information that shall be provided by the controller. All of this status and diagnostic data shall be available via the front panel LCD screen and shall be transmitted via NTCIP to control software upon request.

a) Message Display Status

The VMS controller shall be capable of monitoring and displaying the currently active VMS message (if any) on the controller's front panel LCD display. This display shall be in a WYSIWYG (What You See Is What You Get) format. What is viewed on the VMS control computer monitor shall be a scaled representation of how a message will appear when it is being displayed on the VMS. Similarly, after a pixel diagnostic test routine has been run, what you see on the control computer monitor shall be a scaled representation of the functional status of each pixel in the VMS display matrix. This term does not refer to methodologies called "WYSIWYG" (or similar), that simply simulate what is being displayed on a VMS (such as, for example, by not directly monitoring the electrical current flowing through each string of LED's in all LED pixels).

b) LED Pixel Testing

Upon command from either the front panel control interface or via NTCIP from remote control software, the sign controller shall direct all of the LED modules to perform diagnostic tests of all their pixels. The controller shall then collect and report the results of the pixel testing.

The controller shall also be capable of automatically detecting in real-time the status of each of the display's pixels and reporting their on/off status. This monitoring shall take place without interfering with the display of data on the VMS face.

c) Power Supply Operation

The sign controller shall monitor and report the functional status of all regulated DC power supplies located in the VMS by monitoring diagnostic outputs located on the supplies. The controller shall monitor the output voltage of each power supply and the status of each output fuse. The power supply voltages shall be measured to the nearest tenth of a volt and the fuse status shall be indicated as pass or fail.

d) Fan or Ventilation Operation

The controller shall monitor the status of the fans using a tachometer integrated into each fan and report the status back to the central controller. Alternatively, the controller shall monitor the airflow in the ventilation system and report the status back to the central controller.

e) Door Status

The VMS controller shall monitor the status of all System Control Cabinet and VMS doors. The sign controller shall report the open or closed door status back to the central controller.

f) Environmental Conditions

The VMS controller shall monitor and report the readings of all light, temperature, and humidity sensors installed in the VMS housing. The VMS controller shall also monitor and report the internal temperature of the sign controller.

## (16) Error Notification

The VMS sign controller shall be capable of automatically informing a maintenance operator (via the local LCD panel) and the central control system (via NTCIP communication) of the occurrence of important events and subsystem failures.

All major component and subsystem errors shall be indicated on the controller's LCD front panel.

The controller shall be capable of sending event notifications to the central controller in response to regular status polling, a manually initiated status update command, or via SNMP "traps" as allowed by NTCIP. When one of these events occurs, the sign controller shall create a data packet for transmission to the central controller that shall contain details about the event. The transmission of traps shall be governed by the NTCIP standards. The controller shall be configurable to enable or disable the transmission of traps for each event or error type. This configuration shall include the automatic initiation of these traps, including establishing modem connections if appropriate, when the NTCIP network permits transmission initiation by the sign controller.

The following sections list errors and events that the controller shall report as defined above.

a) Over Temperature Shutdown

The VMS controller shall continuously monitor the VMS housing's temperature sensors and shall automatically shut down the VMS if the internal cabinet temperature exceeds a safety threshold. This threshold shall have a default value of +140ºF (60ºC) and shall be configurable at the controller.

If the temperature approaches the threshold, the controller shall reduce the brightness of the VMS sign face. If the temperature continues to increase and exceeds that threshold, the controller shall trigger a warning notification event and blank the face of the sign. The sign face shall remain blank until the temperature begins to drop. As the temperature drops, the controller shall gradually increase the brightness of the display face, eventually returning to normal brightness.

The sign controller shall employ an algorithm to control the above brightness reductions and increases utilizing hysteresis to ensure that the display face does not visibly flicker as the temperature changes.

The event notifications sent for over temperature situations shall include visual indication on the controller's front panel LCD, as well as a trap notification sent to the central control system.

b) Controller Restart

When the VMS controller detects that it has been restarted due to a manual reset or error condition, it shall send a trap notification to the central controller. It shall also automatically activate the NTCIP reset message if it is configured to do so.

c) Power Loss

When the VMS controller detects that it has lost power, it shall automatically indicate that on the front panel LCD. It shall also send a trap notification to the central controller and activate the NTCIP power loss message if configured to do

so.

d) Power System Failure

The VMS controller shall automatically monitor the major power systems in the sign and detect when one of them has failed. These failures shall be reported on the front panel LCD and transmitted to the central controller if configured to do so.

e) Door Open

When the sign controller detects that one of the sign cabinet or control cabinet doors has been opened, it shall transmit a trap to the central controller indicating which door has opened.

f) Communication Loss

The VMS controller shall monitor the frequency of communication packets from the central controller. If the controller detects that communication has not occurred between the sign controller and central controller for longer than a configurable timeout, then the sign controller shall automatically activate a communication loss message as defined by NTCIP. This communication loss message shall be configurable and may be disabled as allowed by NTCIP.

## (17) Auxiliary Control

The VMS shall include auxiliary control capability that will provide a secondary user interface for VMS control, configuration, and maintenance from the System Controller Cabinet and the sign housing. The auxiliary control interface shall meet the same electrical, mechanical, and environmental specifications as the VMS controller except that it shall communicate with the primary sign controller, not with the central controller.

a) Interface

The auxiliary controller shall be located in the VMS and shall offer identical functionality as is available at the primary controller in the SCC. The auxiliary controller shall include an LCD panel and keypad, a local/remote switch, a reset switch, status LEDs, and one NTCIP compatible serial communication port that meets the same specifications as the VMS controller.

b) VMS Control Interface

The auxiliary control user interface shall include an identical menu system to the VMS controller with all of its features and functionality.

c) Controller Signal Interface

The auxiliary controller shall interface to the VMS controller using either outdoor rated fiber optic cable, outdoor rated and surge protected twisted pair cable, or a secure wireless connection. It shall be capable of operating up to 1000 feet from the VMS controller.

d) Virtual Auxiliary Control

As an acceptable alternative to the physical auxiliary controller specified above, a Virtual Auxiliary Control (VAC) application may be furnished and shall be capable of locally communicating and controlling the VMS controller from a laptop computer or an Android OS smart phone. The VMS controller shall communicate with the application over encrypted Wi-Fi using AES-256 encryption. The VAC application shall include a graphical user interface with all of the configuration, operation, and diagnostic functions and features available from the VMS controller interface.

The VAC Wi-Fi access point shall be located in the SCC. It shall have an operating

temperature range meeting or exceeding that of the sign controller and it shall have an internal antenna capable of communicating with a device located on or near the VMS structure. The Wi-Fi access point shall be fully compatible with the Authority's Cisco network management software.

(18) Local Manual Control

It shall be possible to locally operate the VMS through the keypad and display of the primary VMS controller or auxiliary VMS control interface. It shall be possible to select and display preconfigured messages on the VMS or enter simple text messages through the local controller user interface. This level of control is mainly intended for diagnostic purposes.

## 918.54 Hybrid Changeable Message Sign (HCMS).

Delete the Subsection and replace it with the following:

HCMS signs are the combination of rotating drum panels and embedded Variable Message Sign modules. Following are general characteristics of the HCMS.

| | |
|---|---|
| **Enclosure:** | **Sign enclosure is non-walk-in with rear accessibility for maintenance.** |
| **Front Panel Height (max):** | **Type 1 (Ramp HCMS): 8 ft – 3 in**<br>**Type 2 (Mainline with Split Drum HCMS): 13 ft – 6 in**<br>**Type 3 (Mainline HCMS): 11 ft – 0 in** |
| **Panel Width(max):** | **Type 1 (Ramps): 19 ft – 6 in**<br>**Type 2 (Mainline with Split Drum HCMS): 24 ft – 0 in**<br>**Type 3 (Mainline HCMS): 33 ft – 0 in** |
| **Panel Depth(max):** | **2 ft – 6 in** |
| **Weight (max):** | **Mainline HCMS: 9,000 lbs**<br>**Ramp HCMS: 4,000 lbs** |
| **VMS Display Modules:** | **Exposed face modular LED boards (no mask) removable from the front or rear of the sign.** |
| **VMS Pixels:** | **RGB pixels, 20mm pitch (distance between pixels). 60 Deg nominal viewing cone with a half power angle of 30 Deg.** |
| **Communications:** | **NTCIP 1203 (latest NJTA accepted version)** |
| **Power Source:** | **120/240VAC, Single Phase** |
| **Max. Power:** | **6400 Watts** |

### **(A)** HCMS General Requirements

This Paragraph describes the minimum construction and operational functionality requirements for the rear access HCMS. The HCMS shall be furnished with all the materials, software licenses, and services necessary for the HCMS and associated equipment that fully comply with the functional requirements specified herein, including incidental items that may have been inadvertently omitted.

The complete HCMS housing, including rotary drums, VMS display modules, and system control cabinet, shall be designed and manufactured in-house by the HCMS Manufacturer. The HCMS shall be designed and constructed to utilize the latest available techniques with a minimum number of different parts, subassemblies, circuits, and modules to maximize standardization and commonalty. The sign shall be designed and constructed so as to present a clean neat appearance. Poor workmanship shall be cause for rejection of the sign. The performance of the sign shall not be impaired due to continuous vibration caused by wind, temperature, vibration or other factors. This includes the visibility and legibility of the display.

#### (1) General Materials and Construction

All materials furnished, assembled, fabricated or installed under this item shall be new,

corrosion resistant and in strict accordance with the details shown in the plans and as detailed in this specification. All details and functionality listed in this specification will be thoroughly inspected and tested by the Authority or its designated representative during the Factory Acceptance Testing. Failure to meet all details and functionality detailed in this specification shall be grounds for rejection of the equipment. All materials and components are to be submitted for technical review as part of the shop drawing review process. No material or item shall be ordered, procured, fabricated or installed until final approval is granted by means of stamped "Approved" shop drawing from the Authority or its designated design engineer.

Maximum overall HCMS sign housing and overall sign weights shall be as per this Specification section. The maximum criteria shall not be exceeded in order to conform to the design of the HCMS sign structure.

a) VMS Section

The VMS housing shall provide rear access for all LED display modules, electronics, environmental control equipment, air filters, wiring, and other internal HCMS components.

The VMS size shall be as specified in the Contract Documents. The VMS shall contain a full display matrix measuring as follows for each HCMS Type:

- Type 1: 64 pixel rows x 288 pixel columns
- Type 2: 64 pixel rows x 352 pixel columns
- Type 3: 64 pixel rows x 480 pixel columns

The matrix shall have a 20mm pixel pitch display capable of displaying full color messages that are continuous, uniform, and unbroken in appearance to motorists and travelers.

Each display pixel shall be composed of red, green, and blue LED's. The pixel matrix shall be capable of displaying alphanumeric character fonts from a minimum of twelve (12) font sets with which messages can be formatted and displayed. Each font shall support up to 255 characters.

The VMS portion of the HCMS shall be able to display messages composed of any combination of alphanumeric text, punctuation symbols, and graphic images across multiple frames.

b) Drum Section

Each drum sign housing shall be composed of a separate module that shall provide rear access for all drum control modules, electronics, environmental control equipment, air filters, wiring, and other internal HCMS components.

The drum size and graphics shall be as specified in the Contract Documents. Each drum section shall be housed in a cabinet with measurements capable of meeting the text size, line spacing, character spacing and border requirements as shown in the NJTA Standard Drawings.

(2) Origin

The HCMS shall be final-assembled in the USA. To ensure proper service, support and logistics, US-based HCMS service and support personnel are required. The bidder shall certify that it will comply with the requirements of Section 1048 of the Intermodal Surface Transportation Efficiency Act of 1991 and Regulations in 49 CFR 661. Furthermore, the VMS section and Drum section of the HCMS shall individually be final-assembled in the USA, with US-based service and support personnel, to ensure proper service, support, and logistics of these individual sections.

### (3) Legibility

VMS messages shall be legible within a distance range of 80 feet (24.38 m) to 1,100 feet (335.28 m) from the HCMS display face under the following conditions:

- When the VMS is mounted so its bottom side is positioned between five feet and twenty feet above a level 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 such as snow, rain, sun.
- 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 the motorist eye level is 3 feet to 12 feet above the roadway surface.

### (4) Dimensions

The approximate HCMS housing dimensions shall be specified for the type of VMS and drum sections specified in the Contract Documents. The housing dimensions shall not exceed values shown in the NJTA Standard Drawings.

The HCMS shall be capable of being mounted in walk-through sign structures as shown in the NJTA Standard Drawings.

### (5) Power Requirements

The HCMS shall operate from a 120/240 VAC, 60Hz, single-phase power source. Total required demand current for a single HCMS and Controller Cabinet shall not exceed 50 Amps.

### (6) Sign Construction

Each HCMS housing shall be constructed to have a neat, professional appearance. All internal and external components shall be manufactured from corrosion resistant materials.

The HCMS 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.

The HCMS and sign controller components shall be capable of storage and operation without any decrease in performance over the environmental and temperature range specified in NEMA Standards Publication TS 4.

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

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

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 applicable NEC code requirements.

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

All workmanship shall comply with ANSI/IPC-A-610B Class 2 titled "Acceptability of Electronic Assemblies", ANSI/IPC-7711 titled "Rework of Electronic Assemblies" and ANSI/IPC-7721 titled "Rework and Modification of Printed Boards and Electronic Assemblies."

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 HCMS as specified in NEMA Standards Publication TS 4. The HCMS shall not radiate electromagnetic signals that adversely affect any other electronic device, including those located in vehicles passing underneath or otherwise near the HCMS and its sign controller.

Fiber optic cable communications shall be used to the extent practical between the sign and the ground mounted control cabinet in order to isolate the equipment from voltage transients and reduce the need for copper cabling.

### (7) HCMS Face

The materials used on the sign face, other than the VMS display, shall be highly reflective to aid in nighttime visibility. All materials and paints shall be colorfast and designed to retain their true colors and reflectivity for a minimum of seven years under direct sunlight. The entire sign face shall be finished with high intensity micro-prism retroreflective sheeting, ASTM D4956-04 Type XI or better, such as 3M™ Diamond Grade™ VIP. A topcoat shall be utilized to provide improved scuff, scratch and gouge resistance and increased durability.

### (8) HCMS Housing

The HCMS shall be constructed as two separate enclosed sections, one for the LED VMS section of the sign and the other for the rotary drum section of the sign. Each section of the sign may have different depths as it is understood the drum section inherently requires more depth than a variable message sign due to the drum rotors. The two sections of the HCMS may be combined either before shipment or at the site prior to erection. Separate sealed sign housings shall allow for future partial sign replacements by section to facilitate partial upgrades of any one section of the sign.

No company logos, model numbers or text of any kind will be permitted on the outside of the sign housing.

The rear access housing dimensions and total weight of each section shall be as shown in this Specification or in the Plans. All electronic and electrical equipment compartments shall be designed and manufactured to be rain and weather tight.

#### a) VMS Housing

All sides of the HCMS housing exterior, except the front of the LED modules and the drum openings, shall be covered with 5052-H32 aluminum alloy sheets with a minimum thickness of 0.090" (2.286 mm). This external aluminum skin may be attached to the structural framework using a proven chemically bonding structural adhesive. The HCMS housing structural frame shall be constructed of 5052-H32 aluminum alloy members. The structural framework members may be permanently attached to each other using a proven chemically bonding structural adhesive.

The equipment within the sign housing shall be protected from moisture, dust, dirt and corrosion. The rear access housing shall meet NEMA 3R enclosure criteria as defined in NEMA Standards Publication 250-1997, "Enclosures for Electrical Equipment (1000 Volts Maximum)." Alternatively, a housing meeting NEMA 3 enclosure criteria shall be acceptable where all internal components conform to a minimum IP65 rating, or a more stringent rating where required elsewhere in these Specifications.

The sign housing shall be engineered and Professional Engineer certified to 2001 AASHTO and NCHRP Report 411 specifications for AASHTO basic wind speeds. The sign housing shall also be engineered and Professional Engineer certified to withstand loading combinations as outlined in 2001 AASHTO including: sign weight, ice and wind loads, and shall also meet strength requirements for truck-induced gusts as specified in NCHRP Report 412. The sign housing shall be engineered and Professional Engineer certified to withstand snow loading (40 PSF) for applicable geographical regions.

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

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

Exterior mounting assemblies shall be stainless steel or galvanized ASTM A 709, Grade 50 structural angles.

The HCMS housing for each type of HCMS shall be designed and fabricated to fit within the appropriate HCMS structure as depicted in the NJTA Standard Drawings

b) CMS Housing

The CMS portion housing shall be constructed as one integral box housing. Where possible, all external seams and joints shall be continuous MIG welded.

The sign housing shall be engineered and P.E. certified to 2001 AASHTO and NCHRP Report 411 specifications for AASHTO basic wind speeds. The sign housing, including the rotors, shall also be engineered and P.E. certified to withstand group loading combinations as outlined in 2001 AASHTO including: sign weight, ice and wind loads, and shall also meet strength requirements for truck-induced gusts as specified in NCHRP Report 412. The sign housing shall be engineered to withstand snow loading (40 PSF) for applicable geographical regions.

The portion of the CMS sign housing containing controller and power components shall meet NEMA 3R enclosure criteria as defined in NEMA Standards Publication 250-1997, "Enclosures for Electrical Equipment (1000 Volts Maximum)."

All fasteners and miscellaneous hardware shall be stainless steel.

If cable attachments are used in the sign housing, the cables shall be securely clamped as approved by the Engineer. No adhesive cable attachments will be allowed.

The housing, except for the face, shall be natural aluminum finish. The entire sign face shall be finished with high intensity micro-prism retroreflective sheeting conforming to Section 1.6, above.

The sign housing shall incorporate rain-tight enclosures at both ends to house control and rotor drive components and shall be accessible from the rear of the sign housing. The enclosure containing electrical and/or electromechanical components shall be equipped with a ventilation fan controlled by a thermostat to inhibit condensation within the enclosure. The fan and intake port shall be located at the bottom of the enclosure. The enclosure shall be vented at the top into the rotor area through screened exhaust ports. Hinged panels with neoprene gaskets shall be provided at both ends of the sign housing to allow rear access to control and drive mechanisms and to facilitate rotor removal if necessary.

The sign face shall incorporate self-regulating heat tape with a stainless steel

braided jacket around the entire perimeter of each rotor aperture. The heat tape shall be encased in a metal tube that shall be formed to the perimeter of the aperture and shall be designed to prevent "icing" of the rotors. An adjustable thermostat shall regulate power to the heat tape. The heated portion of the sign face shall be isolated as much as possible from the rest of the sign face and housing.

The sign housing shall enclose all sides of the rotary drum except for the face to protect the control and rotor drive components from roadway containments, snow buildup, debris, and moisture. The equipment housed within the sign housing shall be protected from moisture, dust, dirt and corrosion. All seams and overlaps shall be designed to prevent the entrance of moisture. The sign housing shall be partitioned in a manner to divert any water entering the housing away from the top of the rotors and the mechanical and electrical equipment.

Provision for drainage by means of adequate screened weep holes in the bottom of the sign housing shall be provided. An extended rain lip shall be incorporated at the top of each rotor aperture to protect from rain entering the sign interior.

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

### (9) Chemical Bonding

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

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

### (10) Welding

If welding is selected by the manufacturer over chemical bonding, the minimum sheet thickness of the exterior panels shall be 0.1 inches.

The aluminum skin shall be welded to the HCMS cabinet frame. All exterior sheet seams shall be continuously seam welded to the HCMS frame to form a single structure. Stitch welding shall be used on the interior of the cabinet to attach the aluminum skin sheets to the aluminum extrusion frame.

All welding shall be by an inert gas process in accordance with the American Welding Society (AWS) Standards, 2008 ANSI/AWS D1.2/D1.2M Structural Welding Code for Aluminum. The HCMS manufacturer's welders and welding procedures shall be certified by an ANSI/AWS Certified Welding Inspector to the 2003 ANSI/AWS D1.2/D1.2M Structural Welding Code for Aluminum.

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

The HCMS manufacturer shall submit documentary evidence and complete reference data for the above requirements. Reference data shall include the name and address of the welding organization, and the name and telephone number of an individual from the organization who can be contacted to verify the above requirements and all the details

required to support the above requirements.

The Authority reserves the right to contact additional references. Any poor or unsatisfactory reference, as determined by the Authority in its sole and absolute discretion, will cause the manufacturer to be rejected.

### (11) Mounting Brackets and Miscellaneous Materials

Multiple mounting brackets in the form of steel angles, as shown on the NJTA Standard Drawings, shall be bolted to the HCMS housing exterior to facilitate attachment of the HCMS to the support structure. Mounting brackets shall be:

- Stainless steel or galvanized ASTM A 709, Grade 50 structural steel
- Attached to the HCMS structural frame members, not just the exterior sheet metal
- Installed at the HCMS Manufacturer's factory
- Attached to the HCMS using mechanically galvanized A325 high-strength stainless steel bolts, washers, and lock washers
- Attached to the HCMS using direct tension indicators to verify that mounting hardware is tightened with the proper amount of force
- Installed such that all bracket-to-HCMS attachment points are sealed and water-tight
- Designed and fabricated such that the installing contractor can drill into them, if required, without penetrating the HCMS housing or compromising the housing's ability to shed water

The HCMS Manufacturer shall supply neoprene pads, of the dimensions shown on the Plans, used to support the bottom of the sign. The pads shall be either virgin neoprene (polychloroprene) or virgin natural rubber (polyisoprene). The elastomer compound shall be temperature grade 3 and 60 durometers.

The HCMS Manufacturer shall design the bolted connection used on the steel angle mounting brackets to support the HCMS sign and connect to the plates on the HCMS support structure. The HCMS Manufacturer shall drill the holes in the mounting brackets per his design. The HCMS Manufacturer shall supply the required galvanized A325 high strength bolts, nuts and washers needed to make these connections.

### (12) Lifting Hardware

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

The lifting eyebolts shall be easily removed by one individual without opening or entering the display and without any risk of compromising water-tightness. Special tools shall not be required. Removal of the eyebolts shall not create holes and no replacement bolts or other hardware shall be necessary to seal the cabinet. In addition, it shall not be required to remove the eyebolts or alternate lifting hardware, should this material fit within and be useful for future removal of the HCMS from the support structure.

The hardware used to attach the mounting brackets (nuts, bolts, washers, and direct tension indicators) to the HCMS cabinet shall be stainless steel and shall be appropriately sized for the application.

### (13) Exterior Finish

A reflective green sign panel shall border the entire message portion of the rotary drum section and VMS section of the HCMS front face with reflective sheeting as defined in

Subsection 918.54(A)(7). All other HCMS housing surfaces, including the access doors, shall be natural mill-finish aluminum.

No sign manufacturer text or graphics other than what is specifically shown on the Plans shall be applied to the front face on any part of the HCMS.

### (14) Service Access

The HCMS housing shall provide rear access for all maintenance operations. The HCMS housing shall provide safe and convenient access to all modular assemblies, components, wiring, and subsystems located within the HCMS housing. All of those internal components shall be removable and replaceable by a single technician.

Access doors shall be provided for each section of the housing. One door shall also be provided for accessing the load center and sign control electronics.

The doors shall be restrained to prevent them from falling off or blowing around in the wind when in the open position. The doors shall not interfere with the mounting when in the open or closed position. Cleaning of the drum faces shall be possible from the rear of the sign without causing damage to the sign components.

When in the open position, the doors shall not obstruct any portion of the opening. Ventilation hoods and closed doors shall not obstruct the opening of any door. The doors shall not interfere with the flow of air through the ventilation hoods.

Each door shall contain screw-type quarter-turn latches. A tamper resistant key shall be used for activating the latches. All latches shall be keyed alike, with the same key used for the VMS and drum sections of the sign. Two keys shall be provided with each sign delivered. The latches shall pull the door tight and compress a gasket located around the perimeter of each door. The gasket shall prevent water from entering the cabinet.

### (15) Environmental Behavior

The HCMS shall be capable of operating without any decrease in performance over a temperature range as required under NEMA Standards Publication TS 4 (with a relative humidity of up to 100% condensing) unless otherwise noted in this specification.

### (16) Wiring and Power Distribution

#### a) Power and Signal Entrances

The sign and its sign controller shall be capable of operating from 120/240 VAC, with a maximum of 50 Ampere service, 60 Hertz, single-phase power. Two threaded conduit hubs shall be located on the rear wall of the HCMS housing. One hub shall be for incoming AC power and the other shall be for incoming signal cabling or a communications line.

#### b) Panel Board

The HCMS shall contain a power panel board or DIN rail mounted circuit breakers that meet the following minimum requirements:

- Service entrance-rated
- Short circuit ratings of 22,000 Amps and 10,000 Amps for the main and branch circuits, respectively
- UL listed panel boards and circuit breakers

#### c) Internal Wiring

All wiring and electrical equipment shall be in accordance with the requirements of the National Electrical Code. Wiring shall be neatly arranged, bundled, and mechanically supported. Wiring shall not impede the removal of display modules, power supplies, environmental control equipment, and other sign components

and shall not impede the ability to clean drum faces or change drum message panels. Wires shall not make contact with or bend around sharp metal edges. The use of adhesive-backed, surface-mount wiring clamps shall not be permitted.

All internal wire terminations shall be made at appropriately rated terminal blocks or connectors. Crimp type terminals shall be affixed with a cycle-controlled crimp tool that will not permit a crimp to be made without the proper degree of compression. All terminal blocks shall be clearly labeled with terminal numbers. All wires shall be individually labeled at terminal points with a machine printed flexible tape or another professional means designed specifically for wire labeling.

d) Earth Grounding

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

(17) Transient Protection

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

a) Sign AC Power

The AC power feed for all equipment in the sign cabinet shall be protected at the panel board by a parallel-connection surge suppresser rated for a minimum surge of 40 KA. This device shall conform to the following requirements:

- Withstand a peak 80,000-Ampere surge current, 40kA L-N, 40kA L-G
- Designed, manufactured, & tested consistent with: IEEE C6.41.1-2002, C62.41.2-2002, C2.45-2002, ANSI/IEEE C62.41-1991, C62.45-1992, NEMA LS-1, and NEC 285.6
- Less than 0.5 nanosecond response time
- Temperature range as specified in NEMA Standards Publication TS 4
- 5000 Category (C3 High) impulses with <10% drift, short circuit current rating of 200,000 rms symmetrical Amperes (UL Listed)
- UL listed to: UL 1449 200kA SCCR, UL 1283 4th Edition, and Canadian safety standards

b) Communication Lines

All copper cable communication lines shall be protected by transient suppression devices as appropriate for the type and operating voltage of the communication line. Communication line transient suppression devices shall be equipped with modular connectors for ease of replacement and shall electrically bonded to ground with a heavy gauge ground wire kept as short and straight as practical.

**(B)** Variable Message Sign (VMS) Section.

(1) General Requirements

The Variable Message Sign (VMS) Assembly shall be a full matrix, full color LED display designed to work in conjunction with the rotary drum portion of the Hybrid Changeable Message Sign and shall conform to the requirements of these Specifications and as shown

on the Plans. The VMS assembly may be constructed as an independent module, with a separate enclosure containing all required electronic assemblies, wiring, and environmental systems; but when combined with the rotary drum section and surrounding border, it shall operate and appear as one cohesive changeable message sign.

(2) LED Display Modules

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

- Each LED display module shall have a cam latch(es) that fasten it to the VMS housing. Latching mechanisms shall be actuated by a quarter-turn latching points on the front face of each LED display module. It shall be possible to activate the latches from both the front and back of each module. The module latches shall be actuated by a standard hex key wrench.
- The LED display modules shall be sealed to a minimum of IP67 standards.
- LED display modules shall not be welded to the VMS housing.
- Front face LED display modules shall provide a high-contrast background for the VMS display matrix. The front of each LED display module shall be black and contain high-contrast plastic masking for the LED pixels.
- Removal of the LED modules shall be from the interior of the HCMS cabinet. All LED display modules and internal components shall be removable and replaceable from the rear by a single technician through the rear of the HCMS. The LED module shall be unlatched, removed and pulled back through the opening in which it covered. All modules shall be secured to the sign housing with a quick release lanyard or tether to prevent the modules from becoming dislodged from the VMS while transitioning through the opening during the removal and replacement process.
- In the presence of wind, rain and snow, the VMS front face shall not distort in a manner that adversely affects LED message legibility.
- Each LED display module shall contain no more than one circuit board to minimize electrical connections. All LED modules shall be manufactured using laminated fiberglass printed circuit boards with conformal coating to minimize environmental corrosion.
- The LED pixels in the module shall be protected by a black contrast-enhancing silicone elastomer that surrounds the base of the LEDs and seals the entire front face of the module to prevent water penetration and corrosion, while not obstructing the viewing angles of the LEDs.
- LED display module electrical connections shall use a quick-disconnect locking connector. Removal of an LED display module from the VMS 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 LED display modules shall be identical and interchangeable throughout the VMS.
- Removal or failure of any LED module shall not affect the operation of any other LED module or sign component. Removal of one or more LED modules shall not affect the structural integrity of any part of the sign.
- Each LED display module shall contain a minimum of 256 LED pixels configured in a two-dimensional array. The pixel array shall be a minimum of 16 pixels high by 16 pixels wide.
- The distance from the center of a pixel to the center of each adjacent pixels, both horizontally and vertically, shall be 0.78 inches (20mm).
- All pixels shall contain an equal quantity of LED strings.
- The failure of an LED string or pixel shall not cause the failure of any other LED string or pixel in the VMS.

- Each pixel shall contain the quantity of discrete LEDs needed to output white colored light at a minimum luminous intensity of 12,400 candelas per square meter when operated within the forward current limits defined in these specifications.
- The circular base of the discrete LEDs shall be soldered so that they are parallel to the surface of the printed circuit board. The longitudinal axis of the LEDs shall be perpendicular to the circuit board.

(3) Discrete LEDs

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

- All LEDs shall have a minimum unimpeded viewing cone of 60 degrees with a half-power angle of 30 degrees measured from the longitudinal axis of the LED.
- Red, green and blue LEDs shall be able to produce colors that will meet NEMA Standards Publication TS 4 Section 5.5.1 requirements for chromaticity.
- The LED manufacturer shall perform color sorting of the bins. Each color of LEDs shall be obtained from no more than two (2) consecutive color "bins" as defined by the LED manufacturer.
- The LED manufacturer shall perform intensity sorting of the bins. Each color of LEDs shall be obtained from no more than two (2) consecutive luminous intensity "bins" as defined by the LED manufacturer.
- The various LED color and intensity bins shall be distributed evenly throughout the sign and shall be consistent from pixel to pixel. Random distribution of the LED bins shall not be accepted.
- The LED package styles shall be through-hole with standoffs.
- All LEDs used in all VMS provided for this contract shall be from the same manufacturer and of the same part number, except for the variations in the part number due to the intensity and color bins.
- The LEDs shall be rated by the LED manufacturer to have a minimum lifetime of 100,000 hours of continuous operation while maintaining a minimum of 70% of the original brightness.

(4) Pixel Drive Circuitry

Each LED display module shall contain electronic driver circuitry that shall individually control all pixels on that module. The driver circuitry shall conform to the following specifications:

- LED driver boards shall be manufactured using a printed circuit board.
- Each LED driver board shall be microprocessor-controlled and shall communicate with the sign controller on a wire or fiber optic communication network using an addressable network protocol. The microprocessor shall process commands from the sign controller to display data, perform diagnostic tests, and report pixel and diagnostic status.
- Constant current LED driver ICs or another method that provides at least the same level of control (such as PWM) shall be used to prevent LED forward current from exceeding the LED manufacturer's recommended forward current whenever a forward voltage is applied. To maximize LED service life, LED drive currents will not be allowed that exceed the manufacturer's recommendations for the 100,000-hour lifetime requirement.
- The LED pixels shall be directly driven using pulse width modulation (PWM) of the drive current to control the display intensity. This LED driver circuitry shall vary the current pulse width to achieve the proper display intensity levels for all ambient light conditions. The drive current pulse shall be modulated at a frequency high enough to provide flicker-free operation and a minimum of 200 brightness levels.

- The LED driver circuitry shall receive updated display data at a minimum rate of two (2) frames per second from the sign controller.
- Each LED driver circuit shall be powered by 24 VDC from external regulated DC power supplies. This input voltage shall be fused. Each driver board shall receive power from a minimum of two (2) independent power supplies. Indicator LEDs shall be provided to indicate the status of various voltage levels on the board.
- The voltage of each power input shall be measured to the nearest tenth of a volt and reported to the sign controller upon request. Each driver circuit shall also contain one status LED for each power source that indicates if the power source is present or not.
- The LED driver circuitry shall be able to detect that individual LED strings or pixels are stuck on or off and shall report the pixel status to the sign controller upon request.
- The LED driver circuit shall contain a LED display that indicates the functional status of the driver and pixel boards. At a minimum, it shall indicate error states of the LED pixels and communication network. The indicator shall be positioned such that a maintenance technician can easily view the status code for diagnostic purposes. The status codes shall also be reported to the sign controller upon request.
- Removal or failure of a single driver circuit board shall not affect the performance of any other LED display module in the VMS.
- Individual addressing of each driver circuit shall be configured via the communication wiring harness or module position. No on-board addressing jumpers or switches shall be allowed.

### (5) Regulated DC Power Supplies

The LED pixel display modules shall be powered with auto-ranging regulated switching power supplies that convert the incoming AC to DC at a nominal voltage of 12, 24, or 48 Volts DC. Power supplies shall be wired in a redundant parallel configuration that uses multiple supplies for the VMS display matrix.

Power supplies shall be designed to provide redundancy within the display to ensure continued operation under a failure of a single power supply. Power supplies shall be redundant and rated such that if one supply fails, the display shall be able to operate 100% of the pixels in that display region at 100% brightness when the internal VMS air temperature is +140°F (60°C) or less.

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

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

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

Each power supply shall be monitored by a microprocessor-controlled circuit. This circuit shall monitor the voltage of each power supply and the status of each output circuit's fuse. The power supply voltages and fuse states shall be reported via a communication network to the sign controller and reported to Central by the sign controller.

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

Each power supply shall be protected by an independent surge protector.

Regulated DC power supplies shall conform to the following specifications:

- Nominal output voltage of 12, 24, or 48 VDC +/- 10% unless otherwise approved

- Operating input voltage range shall be a minimum of 90 to 260 VAC
- Operating temperature range shall be as specified in NEMA Standards Publication TS 4
- Maximum output power rating shall be maintained over a minimum temperature range as specified in NEMA Standards Publication TS 4.
- Power supply efficiency shall be a minimum of 80%
- Power factor rating shall be a minimum of 0.95
- Power supply input circuit shall be fused
- Automatic output shut down if the power supply overheats or one of the following output faults occurs: over-voltage, short circuit, or over-current
- Maximum allowable power supply weight shall be 15 pounds.
- Power supplies shall be UL listed
- Printed circuit boards shall be protected by a silicone conformal coating

(6) Control Systems

The VMS shall be controlled by primary and auxiliary locations in compliance with Subection 918.54(D) of these specifications.

(7) Environmental Monitoring Systems

The VMS shall include sensors that monitor and report ambient (external) light level and temperature, as well as the internal temperature.

a) Ambient Light Measurement

Sensors that measure the outdoor ambient light level at the HCMS site shall be mounted in-line with the HCMS housing walls. This ambient light measurement system shall consist of two (2) electronic light sensors. The light sensors shall be placed such that they measure the ambient light levels striking the front and rear of the HCMS. The HCMS sign controller shall continuously monitor the light sensors and adjust the LED display matrix intensity to a level that creates a legible message on the VMS face. The VMS shall allow for remote adjustment of the light sensor measurement to display intensity table from the central server software.

b) Ambient Temperature Measurement

A minimum of one (1) ambient temperature sensor shall be mounted to either the rear wall or bottom side of the HCMS housing. An ambient outdoor temperature sensor shall be placed such that it is never in direct contact with sunlight. The external temperature sensor reading shall be continuously monitored by the HCMS sign controller and shall be reported to the HCMS control software upon request.

c) Internal Temperature Measurement

The VMS shall contain a minimum of two (2) temperature sensors that are mounted near the top of the VMS interior. The temperature sensor(s) shall measure the temperature of air in the cabinet over a minimum range from -40°F to + 176°F (-40°C to 80°C). The temperatures from the sensors shall be continuously measured and monitored by the sign controller. A temperature reading greater than a user selectable critical temperature shall cause the sign to go to blank and the sign controller shall report this action to the central controller. This user selectable critical temperature shall be capable of being changed by the central controller or laptop computer. The central controller and laptop computers shall have the ability to read temperature measurements from the sign controller. The internal temperature sensor's outputs shall be continuously monitored by the HCMS sign controller and shall be reported to the VMS control software upon request.

### (8) Interior VMS Environmental Control

The VMS shall contain systems for cabinet ventilation and safe over-temperature shutdown.

#### a) Housing Ventilation System

The VMS housing shall contain a thermostatically controlled ventilation system 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.

Cooling fans shall be the ball-bearing type and shall be mounted in a line across the rear of the VMS housing wall. One fan at a minimum shall be installed per each exhaust port. Intake ports shall be located in a line across the rear VMS wall.

Each ventilation fan shall contain a sensor to monitor its rotational speed, measured in revolutions per minute. The fan speed shall be reported via a communication network to the sign controller upon request. Alternatively, the ventilation system status may be monitored by airflow sensors in-line with the ventilation air stream. The airflow sensors shall be sufficiently dampened to prevent oscillations and false indications.

An aluminum hood or louvers 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 intake and exhaust ports shall be designed to prevent blowing rain from entering the VMS.

#### b) Over Temperature Safety Shutdown

The HCMS controller shall automatically shut down the LED modules to prevent damaging the LED's if the measured internal cabinet air temperature exceeds a maximum threshold temperature. The threshold temperature shall be configurable and shall have a default factory setting of 140°F (+60°C).

### (9) Sign Controller Signal Interface

Communication signals from the sign controller in a ground-mounted controller cabinet to the VMS shall use redundant fiber optic cables. Each VMS shall have two (2) duplex fiber optic communication ports for connection to the sign controller. A failure of either communications port or fiber optic cable shall not interrupt communications through the other communications port. It shall also be possible to connect multiple VMS to a single controller in a ring configuration using the redundant communication ports.

The VMS fiber optic cable shall comply with the following specifications:

- 62.5/125 or 50/125 µm diameter multi-mode fibers
- ST, SC, or LC style connectors to match style of controller connector
- Rated for indoor/outdoor use
- UL-rated
- PVC outer jacket
- Tight buffer inner jacket
- Operating temperature range: as specified for the sign and outdoor equipment.

The Contractor shall furnish and install fiber optic cable for connection to the ground-level control cabinet. A minimum of six (6) fibers shall be provided with one (1) for controller to sign commands, one (1) for sign to controller responses, and four (4) spares. All fiber strands, whether used or spare, shall be terminated at both ends by the installer. The fibers shall terminate in a mounted termination panel or connectorized block at both ends and shall be connected to the sign controller and sign interface by way of flexible and durable

fiber optic patch cords.

**(C)** Changeable Message Sign (CMS) Section

(1) General Requirements

This Subparagraph describes the minimum construction and operational functionality requirements for the rotary drum portion of the rear access HCMS. The HCMS Manufacturer shall provide all the materials and services necessary for the HCMS and associated equipment that fully comply with the functional requirements specified herein, including incidental items that may have been inadvertently omitted.

The rotary drum CMS, the sign messages and sign types by location, sample letter size, and letter style shall be as shown in the Contract Drawings. Each drum shall be able to display three or four discrete messages, as shown in the report. Corrosion resistance shall be provided for all internal sign components. The CMS shall include a minimum number of moving parts, sub-assemblies and points of failure.

(2) Sign Controller

The sign controller shall be as specified in Section 918.54(D) of these specifications.

(3) Rotating Drums

The drums shall provide the capability of displaying three or four message selections per drum, as shown in the plans. Each drum frame shall be constructed as a rigid truss or tube and shall be designed to AASHTO standards with minimal deflection due to the rotors own weight, wind load forces, and the weight of the attached sign panels, and to allow for proper operation. The drums shall rotate on concentric shafts supported by self-aligning end bearing assemblies. The drum message face shall not constitute structural members of the drum assembly.

Drums shall be designed to drain any precipitated or condensed moisture that may accumulate internally. An external rain lip shall be included at the top of each drum aperture. Sign face openings shall have Teflon coated polyester fabric dust wipers to protect the sign interior from moisture, dust and contaminants.

Each drum shall accommodate either three or four removable, flat, distortion free sign panels, as shown in the plans. The end bearings shall be sealed and permanently lubricated to eliminate the need for periodic service.

It shall be possible to change the message copy on each drum face from the back of the sign by replacing the face panels. Replaceable message panels shall consist of single-piece aluminum sheets with shop applied reflective sheeting, graphics and text. The message panels shall be securely fastened to the drums with removable corrosion-resistant colored hardware to match the panel sheeting.

Each drum rotor shall have one motor and drive mechanism. Multiple rotors as part of the same sign shall all move together as a group, but operated and monitored individually by the sign controller. Split drum rotors, for Type 2 HCMS, shall be coupled via a stainless steel roller chain. Fabric belt coupling is not acceptable.

a) Drive Motors

The entire drive mechanism shall be installed in a weather-tight enclosure in the sign housing. All components of the mechanism shall be sealed and permanently lubricated to eliminate the need for periodic service requirements. The gear box shall be lubricated with synthetic lubricant to prevent congealing at extreme low temperatures.

All major components of the drum drive assembly shall be readily available, over-the-counter parts requiring no modification. The motor shall be low voltage (less than 120V), wash-down rated (extreme environment), with a stainless steel

housing. The Proposer is responsible for selecting the specific motor voltage and power supply location to ensure operation of the sign in accordance with the stated requirements. Minimum rotation speed shall be 6 RPM.

Drum rotation shall be bi-directional. The direction of drum rotation, as determined by the sign controller, shall be based on the shortest rotational distance to the selected message face.

Each drum drive assembly shall incorporate a magnetic-disk brake to stop and maintain drum position. The brake assembly shall be engaged when de-energized to stop and maintain drum position in the event of power or control system failure. A local, mechanical release for the brakes shall be provided such that each motor assembly may be manually rotated by a hand crank.

Each sign shall be equipped with a removable hand crank for manual drum rotation. One hand crank shall be secured in each sign enclosure in an easily accessible location. It shall also be possible to operate the hand crank control from a standard cordless drill. If an adaptor is required for drill operation of the hand crank control, the adaptor shall be supplied and secured in each sign enclosure.

Each sign shall incorporate in the drive component enclosure a maintenance/test panel. Each maintenance panel shall have a Safety Test Switch located in close proximity to the drive motor. This switch shall include an ON/OFF/MOMENTARY-ON configuration. The purpose of this switch is to provide a safety disconnect while performing maintenance on the rotor drive system and to provide a functional test of drive system components exclusive of all automatic control components.

Each rotor shall be actuated by solid state load switches located in close proximity to its respective drive motor (One for the motor and one for the brake). Electro-mechanical relays shall not be used.

Each rotating drum compartment shall incorporate a door safety switch to prevent inadvertent rotor actuation during maintenance. If multiple switches are required, the switches shall be wired such that rotor activation shall be prevented if any one drum compartment door is opened. The sign controller shall initiate a "door open" error indication when any of the drum compartment doors are open. Opening the motor drive compartment or AC power compartment doors shall cause the controller to initiate a door open error indication, but not stop drum rotation.

a) Rotor Position Requirements

Each revolving rotor assembly shall be designed such that the rotor stops in parallel alignment with the face of the sign, with a tolerance of 1 degree over rotation or under rotation. The sign face positioning shall not be affected by wind loads, vibration, etc. It shall be possible to individually adjust and store the final stop point of each drum face by way of the sign controller software.

The position of each drum shall be monitored with a solid-state absolute position encoder. The encoder shall be an integral part of the drive system located within a weather tight enclosure in the sign housing. The encoder output shall be used to enable the controller to set the drum position and to report the exact drum position to the control software.

b) Drum Illumination

While illumination of the reflective sheeting is typically achieved by vehicle headlights at night, many of the HCMS will be positioned in areas where there are tight geometric curves in the roadway. Under these circumstances, headlights do not illuminate the signs with sufficient time for motorists to read and distinguish the message. As such, it is necessary provide illumination of the CMS portion of

the HCMS. Each rotary drum shall be illuminated using LED "strip" lighting. This LED light strip may be incorporated into the rain-lip as a part of each drum line section, or as otherwise recommended by the HCMS Manufacturer. The Manufacturer shall demonstrate that this lighting, its distribution and uniformity is factory tested prior to final fabrication. The lighting shall not bleed onto the VMS portion of the HCMS sign display. Ideally, the lighting should be balanced with the VMS intensity to provide a uniform appearance at night.

Drum face lighting shall be controlled by the sign controller. The sign controller shall monitor ambient light conditions and, based on configurable thresholds, activate a solid state relay to turn the lighting on or off. For installations where more than one HCMS is installed on one sign structure, the lighting control shall be interlocked so that all sign lighting turns on or off at the same time.

## **(D)** HCMS Controller

This Paragraph describes the minimum specifications for the HCMS controller to be provided with the contract. Each HCMS shall include a sign controller, and associated equipment. The HCMS Manufacturer shall provide all the materials, software, and services necessary to install HCMS controllers and associated equipment that fully comply with the functional requirements specified herein, including incidental items that may have been inadvertently omitted.

### (1) General Requirements

Ideally, the HCMS shall contain a single HCMS controller that controls both the LED VMS and the rotary drum CMS segments included in the HCMS. Additionally, an auxiliary control capability shall be included as specified in Subparagraph 918.54(D)(18). Both the VMS and CMS portions of the sign should be treated as one single display by the HCMS controller. This is to ensure that the sign is operated and monitored as a single Hybrid Changeable Message Sign and there are no conflicting messages between the VMS and CMS sections. If a single controller for the CMS and VMS sections of the HCMS cannot be provided, the HCMS manufacturer must provide software to link the independent controllers for unified operation and to prevent conflicting messages.

The sign controller shall meet the following operational requirements:

- Communicate using the NTCIP v2 protocol or later.
- Contain memory for storing changeable and permanent messages, schedules, and other necessary files for controller operation.
- Include a front panel user interface with an LCD display, or equivalent, and a keypad for direct operation and diagnostics as described herein.
- Contain a minimum of two (2) NTCIP–compliant RS232 communication ports with DB9 connectors.
- Contain a minimum of two (2) NTCIP-compliant Ethernet ports with RJ45 connectors
- Contain firmware (embedded software) that shall monitor all external and internal sensors and communication inputs and control the display modules as directed by external control software and the front panel interface. NTCIP shall be natively supported in the HCMS controller. External protocol converter or translator devices are not allowed.
- Contain sufficient inputs and outputs to provide control and feedback for the drum sign segments contained in the HCMS.
- All control capability required for each HCMS site shall fit within the space available within the System Control Cabinet (SCC) specified in Specification Section 918.19.
- HCMS installations may be composed of two separate Hybrid Signs mounted on a single structure. Both HCMS in this configuration shall be controlled by equipment contained in a single SCC.

### (2) Controller Location

The primary sign controller and associated communication equipment may be installed either inside the SCC or sign enclosure. Auxiliary control capability shall be installed as needed to provide keypad and display access to the controller from both the SCC and sign enclosure.

(3) Environmental

The sign controller shall meet the environmental requirements defined in NEMA Standards Publication TS 4, Hardware Standards for Dynamic Message Signs (DMS), with NTCIP Requirements.

(4) Sign Controller Functions

The sign controller shall be controlled from the Authority's existing Central Controller or a laptop computer, which shall specify the appropriate display. The sign controller shall be capable of controlling at least one LED VMS sign section and two drum sign rotors, each rotor having three or four faces. This sign controller and its software shall perform the following functions:

- Display a message
- Report errors and failures, including:
  - (1) Data Transmission error
  - (2) Receipt of invalid data
  - (3) Communications failure recovery
  - (4) HCMS component failure (failure of any rotary drum to reach its required position, VMS pixel error, power supply failure, etc.)
  - (5) Power recovery
- Message and status monitoring:

  The sign controller shall transmit a return message to the Central Controller whenever it receives a valid transmission requesting sign status. The return message shall contain the following:
  - (1) Address or ID of the sign
  - (2) Message that is actually displayed, to include position verification feedback of each rotor based on the output of the encoder position using NTCIP standards.
  - (3) Message source information (Central, Local, etc.)
  - (4) Device error codes
  - (5) Uninterruptible power supply status
- Severe error condition response:

  The sign controller shall report severe error conditions to the central controller. The severe error conditions are:
  - (1) AC power failure.
  - (2) AC power recovery.
  - (3) Surge protection has been tripped
- Communication Failure

  In the event the central controller fails to communicate within a programmable time limit with the sign controller, the sign shall respond per the requirements of NTCIP. This function shall apply only when the sign controller is in central control mode.
- Sign Failure

Failure of any sign section shall not affect the operation of any other sign section in the system.

- Power Failure

  The sign controller shall maintain its internal time clock during power outages less than 255 minutes and display the proper message when power is restored.

- Remote Reset

  The sign controller shall be capable of being remotely reset from the central controller.

### (5) Operational Requirements

#### a) 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 HCMS:

- Monitor the current status of the HCMS, including the status of all sensors, a what-you-see-is-what-you-get (WYSIWYG) representation of the message visible on the LED VMS display face, and an indication of the rotational position and displayed face text of each CMS drum
- Perform diagnostics testing and monitoring of various system components, including pixels, power systems, sensors, drum rotation, and more
- Activate LED VMS messages stored in memory and activate associated drum displays
- Configure display parameters, including display size and colors
- Configure communications port settings and NTCIP options

The front panel interface shall also include:

- Power switch to turn the controller on and off
- "Local/remote" switch that places the controller in local mode such that it can be controlled from the front panel interface, instead of via the primary NTCIP communication channel
- Reset switch to quickly restart the controller

#### b) Memory

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

#### c) Internal Clock

The HCMS sign controller shall contain a computer-readable clock that has a battery backup circuit. The controller shall allow for connection to a Network Time Protocol (NTP) sever for synchronization of the internal clock.

### (6) Communications

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

#### a) Communication Mode

The HCMS sign controller shall be able to receive instructions from and provide

information to a computer containing HCMS control software using the following communication modes:

- Remotely via direct, fiber, or wireless communications with a remotely located computer. The system communications backbone, as well as all field modems or signal converters, will provide the HCMS sign controller with an Ethernet signal.

- Locally via direct connection with a laptop computer that is connected directly to the sign controller using any of the following connections: RS232, USB, or Ethernet.

b) Serial Communication Port

The HCMS controller shall contain a minimum of one (1) serial communication port. This port shall support a direct communication interface for local laptop control using either a DB9 or USB connector.

The baud rate, connection type, and NTCIP communication protocol shall be configurable. The port must support all typical serial baud ranging from 1200 to 115,200 baud. The port shall be capable of supporting the NTCIP 2103 (PPP), NTCIP 2201 (Null), and NTCIP 2202 (Internet) transport profiles. Only one of each of the transport and sub network profiles shall be active at any time on the port.

c) Ethernet Port

The HCMS controller shall contain a minimum of one (1) 10/100Base-T Ethernet communication port for communicating from the central control system to the HCMS sign controller. The Ethernet port shall have a standard RJ45 connector.

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

d) Controller Addressing

The HCMS controller shall use the NTCIP 2104 (Ethernet) network protocol with a static v4 IP address. Both the IP address and subnet shall be configurable. The controller addressing shall be configurable through the front panel user interface.

e) Transient Protection

The serial and Ethernet communication ports in the HCMS controller shall be protected with surge protection between each signal line and ground. This surge protection shall be integrated internally within the controller.

### (7) HCMS Control Outputs

HCMS sign controller(s) located in the ground level SCC shall transmit and receive data packets to and from the HCMS via dedicated fiber optic cables. The controller shall communicate with all sensors, drivers, and other devices utilizing a bus network running throughout the HCMS.

Data transferred shall include pixel control and monitoring, drum control and monitoring, 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.

An absolute encoder shall be utilized to monitor the position of each drum. Adequate surge protection shall be installed to mitigate the effects of spikes that result from motor operation and all other sources.

### (8) Messaging

The HCMS controller shall have the ability to display messages on the VMS display face and drum sign segments as required herein.

a) Message Presentation on the VMS Display Matrix

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

- Display of alpha numeric characters, including letters, numbers, and punctuation
- Selection of particular character font's style
- Horizontal alignment of text on the display, including left, center, and right justification
- Vertical alignment of text on the display, including top, middle, and bottom justification
- Adjusting the spacing horizontally between characters or vertically between lines of text
- Alternating between pages of a multiple-page message
- Display of graphic bitmaps of various sizes ranging from very small to the size of the entire VMS matrix
- Simultaneous display of character fonts over graphic images

b) Message Presentation on the CMS

The sign controller shall control the CMS rotary drums to display the preconfigured arrangement of drum faces for the selected message. The controller display shall present a menu of message choices showing a text representation of each message. It shall be possible to select and display a desired message from the controller keypad.

c) VMS 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 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 direction of travel is user selectable as either left-to-right or right-to-left.
- Multiple-Page Message – A message contains up to six different pages of information, with each page filling the entire pixel matrix. Each page's display time is user programmable from 0.1 seconds to 25.5 seconds, and adjustable in increments of 0.1 seconds.

(9) Message Change Sequence

HCMS message activation shall operate in the following sequence of events:

- Blank all LED VMS sections
- Verify that all VMS are blank
- Roll CMS drums to selected message display

- Verify that all CMS drums are in the correct position to display the selected message
- Post selected message on VMS
- Verify that all VMS are displaying the selected message

Failure of any sequential step shall cause the sequence to stop and the controller to report to the central server an error message along with the currently displayed message information. Local control of the specified message change sequence is preferred, but if this not possible, the sequence may be controlled by the central server. At locations where two HCMS are installed on the same structure as a functional pair, the message change sequence of the two signs shall occur simultaneously to prevent a temporary message mismatch.

### (10) Message Activation

Messages shall be activated on the HCMS in three ways:

- Manual – An operator using the front panel LCD/keypad interface, local control panel switches, or NTCIP-compatible control software manually instructs a particular message to be activated.
- Schedule – The internal time-based scheduler in the controller 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. (Alternatively, schedules may be stored and managed in the Central controller).
- Events – Certain events, such as a communication or power loss, shall trigger an event response when they occur. These events shall be configured using the control software. Configurable event responses shall include the ability to blank the sign, post a pre-configured default message, or retain the existing message display.

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

- The message's duration timeout expires.
- The controller receives a command to change the message.
- The controller receives a command to blank the sign.
- The schedule stored in the controller's memory (or stored and managed in the Central controller) indicates that it is time to activate a different message.
- A special event, such as a loss of communication, occurs that is linked to message activation.

It shall be possible to confer a "priority" status onto any message, and a command to display a higher priority message shall cause any lower priority message to be overridden.

### (11) Schedule Activation

The HCMS sign controller shall support the activation of messages based on a time/date-based schedule, stored either in the sign controller, or in the Central controller). The format and operation of the message scheduler shall be per the NTCIP 1201 and NTCIP 1203 standards.

### (12) Display of Alphanumeric Text

The HCMS sign controller shall support the storage and use of a minimum of twenty (20) font sets with which messages can be formatted and displayed. Each font shall support up to 255 characters. All text font files shall include the following characters:

- 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: # & * + / ( ) [ ] < > @
- The HCMS Manufacturer shall provide the HCMS controller with the following fonts preinstalled. The controller shall support changing or replacing these fonts from the central software using NTCIP. All font characters are variable width except where indicated otherwise.

| Pixel Array | Character Height (approx.) | Character Width (avg.) | Stroke Width (pixels) | Comments |
|---|---|---|---|---|
| 20x12 | 16” | 9.5” | 3 | Small |
| 20x16 | 16” | 12.5” | 4 | Small – MUTCD * |
| 23x15 | 18” | 12” | 3 | Standard |
| 23x15 | 18” | 12” | 3 | Standard, fixed width |
| 23x17 | 18” | 13.5 | 3 | Standard, wide |
| 23x19 | 18” | 14” | 4 | Standard – MUTCD * |
| 24x15 | 19” | 12” | 3 | Tall |
| 24x15 | 19” | 12” | 3 | Tall, fixed width |
| 24x19 | 19” | 15” | 4 | Tall – MUTCD * |

* Note: Fonts commented as “MUTCD” in the table above shall be made to simulate the appearance and size requirements of the Manual on Uniform Traffic Control Devices (MUTCD) and the “Standard Highway Signs and Markings” (SHSM) Book for Series E-Modified text characters.

### (13) Display of Graphic Images

The VMS control software shall support the inclusion of graphics in messages in accordance with NTCIP 1203 v2. The VMS may support graphics that exceed current NTCIP limitations by using manufacturer-specific MIB objects and MULTI tags.

### (14) VMS Intensity Control

The HCMS controller shall provide a means to change the brightness of the display matrix manually or automatically. The manual control will allow the user to select one of at least 100 intensity levels, which will be communicated to the LED drivers in the VMS. The brightness shall remain at that level until the user changes the level or sets the controller to automatic mode.

The automatic intensity control mode shall monitor the ambient light sensors of the VMS and use a mathematical algorithm to automatically select one of 100 or more intensity levels. The intensity level shall then be transmitted to the LED drivers in the VMS. The controller shall allow the adjustment of display intensity settings under various lighting conditions remotely from the central control software.

The intensity control mode, manual or automatic, shall be settable via NTCIP using the control software and via the front panel interface. The manual brightness level shall be settable via the software and front panel. The mode and brightness level shall be monitored from both the software and front panel interfaces.

### (15) Permanent Messages

HCMS controller(s) shall have the ability to store and activate NTCIP compliant permanent messages. A software utility or other means shall be provided to remotely download permanent message and support files to the HCMS controller. It shall also be possible to download changeable messages from the central server, store them in the HCMS controller, and display them on the sign.

### (16) System Status Monitoring and Diagnostic Testing

The HCMS controller shall be capable of monitoring the status of many of the HCMS components and subsystems in real-time and/or manual modes, depending on the component or system. The following sections detail the status and diagnostic information that shall be provided by the controller. All of this status and diagnostic data shall be available via the front panel LCD screen and shall be transmitted via NTCIP to control software upon request.

#### a) Message Display Status

The HCMS controller shall be capable of monitoring and displaying the currently active VMS message (if any) on the controller's front panel LCD display. This display shall be in a WYSIWYG (What You See Is What You Get) format. What is viewed on the HCMS control computer monitor shall be a scaled representation of how a message will appear when it is being displayed on the HCMS. Similarly, after a pixel diagnostic test routine has been run, what you see on the control computer monitor shall be a scaled representation of the functional status of each pixel in the VMS display matrix. This term does not refer to methodologies called "WYSIWYG" (or similar), that simply simulate what is being displayed on a VMS (such as, for example, by not directly monitoring the electrical current flowing through each string of LED's in all LED pixels). With regards to the rotary drum portion of the display, the HCMS controller shall be capable of monitoring and displaying the current rotational position and displayed face of each drum in the rotating drum portion of the sign.

#### b) LED Pixel Testing

Upon command from either the front panel control interface or via NTCIP from remote control software, the sign controller shall direct all of the LED modules to perform diagnostic tests of all their pixels. The controller shall then collect and report the results of the pixel testing.

The controller shall also be capable of automatically detecting in real-time the status of each of the display's pixels and reporting their on/off status. This monitoring shall take place without interfering with the display of data on the VMS face.

#### c) Rotary Drum Testing

The controller shall be capable of automatically rolling the message drums to each drum face or preset message position, stopping briefly at each position or preset message, and measure the rotational speed, stop point, and angular position for each message change. The drums shall revert back to their original position after completion of the test and the controller shall report the measured test results.

#### d) Power Supply Operation

The sign controller shall monitor and report the functional status of all regulated DC power supplies located in the HCMS by monitoring diagnostic outputs located on the supplies. The controller shall monitor the output voltage of each power supply and the status of each output fuse. The power supply voltages shall be measured to the nearest tenth of a volt and the fuse status shall be indicated as pass or fail.

#### e) Fan or Ventilation Operation

The controller shall monitor the status of the fans using a tachometer integrated into each fan and report the status back to the central controller. Alternatively, the controller shall monitor the airflow in the ventilation system and report the status back to the central controller.

f) Door Status

The HCMS controller shall monitor the status of all System Control Cabinet and HCMS doors. The sign controller shall report the open or closed door status back to the central controller.

g) Environmental Conditions

The HCMS controller shall monitor and report the readings of all light, temperature, and humidity sensors installed in the HCMS housing. The HCMS controller shall also monitor and report the internal temperature of the sign controller.

(17) Error Notification

The HCMS sign controller shall be capable of automatically informing a maintenance operator (via the local LCD panel) and the central control system (via NTCIP communication) of the occurrence of important events and subsystem failures.

All major component and subsystem errors shall be indicated on the controller's LCD front panel.

The controller shall be capable of sending event notifications to the central controller in response to regular status polling, a manually initiated status update command, or via SNMP "traps" as allowed by NTCIP. When one of these events occurs, the sign controller shall create a data packet for transmission to the central controller that shall contain details about the event. The transmission of traps shall be governed by the NTCIP standards. The controller shall be configurable to enable or disable the transmission of traps for each event or error type. This configuration shall include the automatic initiation of these traps, including establishing modem connections if appropriate, when the NTCIP network permits transmission initiation by the sign controller.

The following sections list errors and events that the controller shall report as defined above.

a) Over Temperature Shutdown

The HCMS controller shall continuously monitor the VMS housing's temperature sensors and shall automatically shut down the VMS if the internal cabinet temperature exceeds a safety threshold. This threshold shall have a default value of +140ºF (60ºC) and shall be configurable at the controller.

If the temperature approaches the threshold, the controller shall reduce the brightness of the VMS sign face. If the temperature continues to increase and exceeds that threshold, the controller shall trigger a warning notification event and blank the face of the sign. The sign face shall remain blank until the temperature begins to drop. As the temperature drops, the controller shall gradually increase the brightness of the display face, eventually returning to normal brightness.

The sign controller shall employ an algorithm to control the above brightness reductions and increases utilizing hysteresis to ensure that the display face does not visibly flicker as the temperature changes.

The event notifications sent for over temperature situations shall include visual indication on the controller's front panel LCD, as well as a trap notification sent to the central control system.

b) Controller Restart

When the HCMS controller detects that it has been restarted due to a manual reset

or error condition, it shall send a trap notification to the central controller. It shall also automatically activate the NTCIP reset message if it is configured to do so.

c) Power Loss

When the HCMS controller detects that it has lost power, it shall automatically indicate that on the front panel LCD. It shall also send a trap notification to the central controller and activate the NTCIP power loss message if configured to do so.

d) Power System Failure

The HCMS controller shall automatically monitor the major power systems in the sign and detect when one of them has failed. These failures shall be reported on the front panel LCD and transmitted to the central controller if configured to do so.

e) Door Open

When the sign controller detects that one of the sign cabinet or control cabinet doors has been opened, it shall transmit a trap to the central controller indicating which door has opened.

f) Communication Loss

The HCMS controller shall monitor the frequency of communication packets from the central controller. If the controller detects that communication has not occurred between the sign controller and central controller for longer than a configurable timeout, then the sign controller shall automatically activate a communication loss message as defined by NTCIP. This communication loss message shall be configurable and may be disabled as allowed by NTCIP.

## (18) Auxiliary Control

The HCMS shall include auxiliary control capability that will provide a secondary user interface for HCMS control, configuration, and maintenance from the System Controller Cabinet and the sign housing. The auxiliary control interface shall meet the same electrical, mechanical, and environmental specifications as the HCMS controller except that it shall communicate with the primary sign controller, not with the central controller.

a) Interface

The auxiliary control location shall offer identical functionality as is available at the primary controller. Regardless of placement of the primary controller, the local SCC cabinet shall include an LCD panel and keypad. It shall also contain a local/remote switch, a reset switch, status LEDs, and one NTCIP compatible serial communication port that meet the same specifications as the HCMS controller. The interface from a location other than the SCC may use a software interface via a secure connection from a technician's laptop computer in lieu if a matching keypad and LCD display.

b) HCMS Control Interface

The auxiliary control interface shall include an identical menu system to the HCMS controller with all of its features and functionality.

c) Location

If the primary sign controller is located in the SCC, the auxiliary control location shall be located inside the HCMS cabinet to facilitate operation by maintenance workers while working on the HCMS. If the primary sign controller is located in the sign cabinet, the auxiliary control location shall be located in the SCC to facilitate sign operation while working in the SCC.

d) Controller Signal Interface

The auxiliary control location shall interface to the HCMS controller using either outdoor rated fiber optic cable, outdoor rated and surge protected twisted pair cable, or a secure wireless connection. It shall be capable of operating up to 1000 feet from the HCMS controller.

e) Virtual Auxiliary Control

As an acceptable alternative to the physical auxiliary controller specified above, a Virtual Auxiliary Control (VAC) application may be furnished and shall be capable of locally communicating and controlling the VMS controller from a laptop computer or an Android OS smart phone. The VMS controller shall communicate with the application over encrypted Wi-Fi using AES-256 encryption. The VAC application shall include a graphical user interface with all of the configuration, operation, and diagnostic functions and features available from the VMS controller interface.

The VAC Wi-Fi access point shall be located in the SCC. It shall have an operating temperature range meeting or exceeding that of the sign controller and it shall have an internal antenna capable of communicating with a device located on or near the VMS structure. The Wi-Fi access point shall be fully compatible with the Authority's Cisco network management software.

## (19) Coordinated Operation of Double Signs

The sign controller shall be capable of being controlled from the central controller or a laptop computer. Each sign controller shall be capable of controlling one entire HCMS consisting of one LED VMS and one or two drum rotors. Where there are two HCMS to be installed on a single structure (2 signs per location), it is essential that the two HCMS controllers be electronically interconnected such that one single message command can control both signs, since these sign messages are typically coordinated at ramp or mainline splits, for traffic operations. This electronic interlocking may be done locally as designed by the HCMS Manufacturer, or through the use of a single controller capable of controlling a combined total of 2 LED VMS and 4 drum rotors.

## (20) Local Manual Control

Local manual control is essential for HCMS operation with respect to maintaining critical messages under either emergency operations or maintenance of the HCMS.

Local manual/emergency operation shall be based on four required levels of local control as follows:

a) Level 1 Drum Control

The lowest level of local manual/emergency control shall be to turn the drums through the use of a handcrank. Handcrank operation shall be capable by mechanically, and simply releasing the drum brake at the rear of the sign and inserting the provided handcrank into the gear assembly for manual rotation. This should only be accomplished with power removed to the drum motor. VMS operation should still be possible without disruption.

a) Level 2 Drum Control:

The next level of local manual control shall be to electrically control each individual drum through a series of switches within the drum control compartment of the sign. Drum switch control shall include the ability to select a specific drum and continuously rotate it to any position. It shall also be possible to select a specific drum face and have the drum rotate and stop at the selected face. This level of control is mainly intended for maintenance and calibration purposes. Level 2 control is only intended to operate the CMS portion (rotary drums) of the

HCMS and should not affect VMS operation in any way, even if a VMS message is currently displayed.

b) Level 3 Drum and VMS Control

The next level of local manual/emergency control shall be to turn the drums and operate the VMS through the keypad and display of the primary or auxiliary control interface. It shall be possible to select and display preconfigured messages on the CMS and VMS portions of the HCMS through the local controller user interface. This level of control is mainly intended for diagnostic purposes.

c) Level 4 Drum and VMS Control

The highest level of local control is through local message selection switches for complete and simple local operation of the HCMS for various roadway closures or emergency conditions without relying on access or knowledge of the master controller. The local control switches shall be accessible through a small switch compartment door installed in the front door of the SCC. The local control compartment shall include a master activation pushbutton switch and six (6) pushbutton message selection switches. The drums should turn and stop in the correct position and the VMS display should change to the correct message after the master switch and a single message selection switch are simultaneously depressed for several seconds. A laminated graphic representation of the programmed messages and associated selection switches shall be attached inside the manual control compartment for reference. This level of control is intended for when there is a communications failure between the sign and central controller.

**Normal HCMS Operation**

| Means | User Interface | Controls | Position Control |
|---|---|---|---|
| Remote Control | Central Control Software | CMS/VMS combined | Yes |
| Local Control (at SCC) | n/a | n/a | n/a |
| Local Control (at Rear of Sign) | n/a | n/a | n/a |
| Handcrank | n/a | n/a | n/a |

**Local Operation (Level 1) - Manual Drum Control**

| Means | Interface | *Controls | Position Control |
|---|---|---|---|
| Remote Control | n/a | n/a | n/a |
| Local Control (at SCC) | n/a | n/a | n/a |
| Local Control (at Rear of Sign) | n/a | n/a | No |
| Handcrank | n/a | CMS Single Drum | No |

*VMS continues to operate normally

**Local Operation (Level 2) - Manual Motor Control**

| Means | Interface | *Controls | Position Control |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Remote Control | n/a | n/a | n/a |
| Local Control (at SCC) | n/a | n/a | n/a |
| Local Control (at Rear of Sign) | Internal Switches | CMS Single Drum | Yes and No |
| Handcrank | n/a | n/a | n/a |

*VMS continues to operate normally

**Local Operation (Level 3) – Local HCMS Message Control**

| **Means** | **Interface** | ***Controls** | **Position Control** |
|---|---|---|---|
| Remote Control | n/a | n/a | n/a |
| Local Control (at SCC) | Controller Keypad | CMS/VMS Combined | Yes |
| Local Control (at Rear of Sign) | Controller Keypad | CMS/VMS Combined | Yes |
| Handcrank | n/a | n/a | n/a |

**Local Operation (Level 4) – Local HCMS Message Control**

| **Means** | **Interface** | ***Controls** | **Position Control** |
|---|---|---|---|
| Remote Control | n/a | n/a | n/a |
| Local Control (at SCC) | Switch Compartment | CMS/VMS Combined | Yes |
| Local Control (at Rear of Sign) | n/a | n/a | n/a |
| Handcrank | n/a | n/a | n/a |