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NATIONAL TRANSPORTATION COMMUNICATIONS FOR ITS PROTOCOL  
CASE STUDY REPORT

**NTCIP 9002-Amendment 1 v07**

**Virginia DOT Statewide VMS Project**

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## **PREFACE**

When early adopters began using the NTCIP in their deployment activities, there was limited guidance available. Since then, *The NTCIP Guide* (NTCIP 9001) has been developed to help users understand, specify, and deploy the family of standards. NTCIP 9001 version 03 was completed in 2002 and is available.

Early NTCIP deployments and the initial NTCIP case studies identified issues due to content ambiguities and shortfalls in the first version of several standards. Subsequent amendments addressed many of these issues.

Case study reports revealed that functional requirements within user specifications could be improved. As a result, a systems engineering approach to standards development has been adopted to help users better specify NTCIP-based systems. New versions of ITS standards will add sections on concepts of operation, functional requirements, traceability to the data dictionary, and dialogs and sequences.

Early adopters also revealed that testing was an issue in many of their deployments. An NTCIP working group on testing and conformity assessment was created in 2002 to further assess and define testing issues.

The case studies also revealed a general need for continued outreach, education and training. These needs are being addressed through a variety of ongoing Standards Development Organization activities.

These NTCIP case studies have proved valuable to the ITS community and have facilitated the continued improvement of the standards. As a result of lessons learned from the case studies, and improvements in the standards development process, future deployments are expected to face fewer challenges.

## **1. CASE STUDY UPDATE**

The initial deployment of NTCIP-conformant equipment by the Virginia Department of Transportation (VDOT) was documented in a case study of their Variable Message Sign (VMS) implementation in NTCIP-9002 Version 01.04, dated September 03, 1999. Now that some time has elapsed since that

initial effort, AASHTO, FHWA, ITE and NEMA is sponsoring this case study update. This effort, presented as a case study amendment, focuses on insights gained over the three years of deployment since the initial case study was performed. Specifically, this amendment will address Agency issues concerning current implementation efforts and their needs based upon experience gained through NTCIP deployment experience.

## 2. RECENT NTCIP IMPLEMENTATION EFFORTS

The original VDOT Statewide DMS Project called for Seventy-seven (77) LED variable message signs to be installed to provide traveler information to motorists throughout Virginia’s transportation network. In addition to the NTCIP, VDOT specified LED displays and walk-in cabinets to minimize operations and maintenance burdens and to allow greater flexibility in using the signs. Dial-up communications over the public telephone network was used to communicate with signs on the initial project. Seventeen of the 77 signs were to be installed during Phase I. The remaining signs were to be installed during Phase II, after demonstrating successful implementation of Phase I.

Now that it is the summer of 2002, the Agency is in the process of finalizing the Phase I implementation. However, the remaining phase of the project has been changed. Instead of a statewide implementation effort, the Agency has opted for localized projects that meet the needs of individual districts. There are two projects that have been awarded, with one progressing through the implementation stage. A third project is being advertised. Table 1 represents the location and status of these subsequent projects.

**Table 1: Current VDOT VMS Deployment Projects**

<i>District</i>	<i>Number of Signs</i>	<i>Status</i>
Richmond and Fredericksburg Districts	11 – overhead signs	Deployment
Salem District	45 – small signs (on butterfly mounts)	Contract Awarded
Stanton District	7 – shoulder mounted	Advertisement

As of May 2002, the new projects are envisioned to continue the use of Dial-up communications over the public telephone network as their primary means of communication. At the time of this writing, the Agency is also investigating the suitability of direct fiber optic links for future projects as an alternative communications media.

### 2-1 CURRENT PROCUREMENT PRACTICES

In most cases, the Agency ensures that products used on contracts comply with specifications by requiring the prime contractor to select products from a “Qualified Products List.” However, the Agency was concerned that the construction contractor could select a vendor with limited qualifications for producing NTCIP-compliant variable message signs. Through May 2002, the Agency continued to use a typical low-bid process for selecting their general contractors, who must select their VMS vendor from a list of pre-qualified vendors. VMS vendors were required to participate in a pre-qualification to be eligible to submit a bid.

At the time of this writing, the Agency continues to use the process of pre-qualifying vendors for VMS deployments described in the original case study. In May 2002, the VDOT pre-qualification list had three vendors eligible to provide signs on VDOT VMS projects.

## 2-2 CURRENT SPECIFICATION CHANGES

The Agency has changed its NTCIP specifications from the initial statewide procurement to reflect updates to NTCIP 1203 – Object Definitions for DMS and other NTCIP standards. Two examples of current VDOT specifications are provided in Annex A.

## 3. FUTURE NEEDS

Based upon their experience gained since the original procurement, the Agency believes that NTCIP provides the best opportunity for achieving VMS interoperability within VDOT implementations. VDOT is committed to the goals of interoperability and interchangeability. It believes that NTCIP will keep them from getting “locked in” to a single vendor and provide competition for their VMS procurements. Unfortunately, the Agency has not had an opportunity to put their interoperability and interchangeability requirements to the test, as the sum of the projects awarded by VDOT have gone to the same VMS vendor. The Agency remains hopeful that issues will not arise when other vendors are selected.

Users often cite the need for improved functionality and feature sets in NTCIP standards. VDOT is no different in this regard. The Agency is looking forward to incorporating the new version of NTCIP 1203 into their project specifications as soon as the standard is available. Further, VDOT will strive to update existing signs to newer standards, as practical, under newer projects.

The Agency also expressed a concern that additional testing tools are needed to judge conformance to the NTCIP standards. VDOT currently has to rely on consultants for its verification and validation testing since it lacks the resources to do this testing in-house. There is a strong desire to have conformance testing tools, beyond that of the NTCIP Exerciser, available for their use in performing in-house testing.

## ANNEX A-1: VMS SPECIFICATIONS – RICHMOND AND FREDERICKSBURG DISTRICTS 2001

The following contains complete versions of two Special Provisions and specifications for Dynamic Message Signs used in recent VDOT projects. The first set of specifications was used in the Richmond and Fredericksburg Districts and the second set was used in the Salem District. Parties interested in additional information should contact Mr. Michael L. Winn with VDOT at (804) 692-0308.

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VIRGINIA DEPARTMENT OF TRANSPORTATION  
SPECIAL PROVISION FOR  
**VARIABLE MESSAGE SIGN SYSTEM**

**Editor’s Note: (For Overhead Structures Used in Richmond and Fredericksburg Districts 2001)**

October 2, 2000

### I. DESCRIPTION

This work shall consist of furnishing and installing LED variable message signs (VMS)/ dynamic message signs (DMS), associated control, operation, 120/240VAC power, telephone and monitoring equipment in accordance with these Specifications and as directed by the Engineer.

### II. MATERIALS

**A. Aluminum** for fabricated items shall conform to the requirements of Section 229 of the Specifications and shall be fabricated, welded and inspected in accordance with the requirements of Section 407 of the Specifications.

**B. Steel** for fabricated items shall conform to the requirements of Section 226 of the Specifications and shall be fabricated, welded and inspected in accordance with the requirements of Section 407 of the Specifications.

**C. Electrical Items** shall conform to the requirements of Section 238 of the Specifications.

**D. Galvanizing** shall conform to the requirements of Section 233 of the Specifications.

- E. **Hydraulic Cement Concrete** shall conform to the requirements of Section 217 of the Specifications.
- F. **Paint** for the sign front and mask shall be a fluoropolymer based coating system containing KYNAR 500 resin or equivalent.

### III. VARIABLE MESSAGE SIGN

A. **Displays**—The sign displays shall conform to the following requirements:

- The sign display shall only consist of LED's as specified in III.B.
- Displays shall be full matrix. The matrix shall measure 27 pixels in height and 105 pixels in length. Pixels shall be evenly spaced.
- Sign displays shall have sufficient borders on all four sides for display clarity and background contrast.
- Sign displays shall be legible from a distance of 1000 feet when displaying 18" characters. Legibility of displays shall include daylight hours with direct sunlight on the face and behind the VMS.
- The sign displays shall be capable of graphic displays upon upgrade of software.
- The time required to clear any display and post any new display shall not exceed 500 milliseconds.

B. **LED's**—All LED's provided for the manufacture of VMS shall conform to the following minimum requirements:

- LEDs shall be untinted, non-diffused, high-output, solid state lamps utilizing aluminum indium gallium phosphide (AlInGaP) LED technology.
- LEDs shall emit a true amber color at a wavelength of 592 nm ( $\pm 4$ nm).
- Size of the LED shall be T-1 $\frac{3}{4}$  (5mm).
- LEDs shall be nominally rated for 100,000 hours of operation under field conditions, which shall include operating temperatures between -22° and +185°F (-30° and +85°C).
- LEDs shall have either a 15° or 17° viewing angle.
- LEDs shall be of the same degree viewing angle and of the same manufacturer for all signs.

- LEDs shall have no less than 50% of the normalized intensity at their respective 15° or 17° viewing angles.
  - LEDs shall be soldered to circuit boards with through-hole type of circuit board mounting. Surface mounting of LEDs will not be allowed.
- C. Pixels**—Each light emitting pixel of an LED display shall consist of a cluster of closely spaced LEDs. LED pixels shall conform to the following requirements:
- Pixels shall be constructed with two strings of LEDs. The number of LEDs in each string shall be determined by the manufacturer as required to produce the candela requirement as stated herein.
  - LED pixels shall produce the luminous intensity levels required herein at a drive current of 20 mA per string with a forward voltage drop not to exceed 24 VDC. The LED drive current shall be adjustable up to and shall not be allowed to exceed 30 mA per string.
  - Each pixel shall produce a luminous intensity of 40 Cd when driven with a LED drive current of 20 mA per string.
  - LED pixels shall be driven with direct-drive pulse width modulation. Maximum pulse amplitude shall not exceed 30 mA.
  - Materials used in the fabrication of LED clusters shall contain UV light inhibitor and shall be designed for direct exposure to sunlight.
  - Each LED pixel shall be rated for outdoor use over the environmental range expected for the sign locations (including heat absorption due to sunlight).
  - LED pixels shall be attached to the display panel with a secure fastening system.
  - LED pixels shall be mounted perpendicular to the display panel.
  - LED pixels shall be replaceable either individually or in groupings. Groupings with three or more pixels shall be permitted only if bench level repairs and replacements to individual pixels are possible.
  - Pixels shall be replaceable from the inside rear of the walk-in display. Clusters shall be interchangeable between signs employing the same display technology.

- Characters formed by the VMS displays shall have a minimum of seven (7) pixels in height. The number of pixels making up the character width shall vary by character and shall be in accordance with the characters described herein.
- The pixel pitch, or center to center spacing, shall be such that seven (7) pixels in height shall produce a character 18" in height ( $\pm 0.5\%$ ) measured from the top of the top pixel to the bottom of the bottom pixel.

**D. Power Supplies**—Power supplies shall operate from 120 VAC power. The LED displays shall be operated at low internal DC voltage not exceeding 24 VDC. Power supplies shall be solid state electronic switching regulated output. Signs shall be powered with two supplies for each 1/3 of the display. Power supplies shall be wired in redundant parallel configuration for each section and shall provide equal amounts of current to each section. Power supplies shall be rated such that if one supply fails, the other can operate the entire LED section under full load conditions. Power supplies shall operate from  $-22^{\circ}$  to  $+140^{\circ}$  F ( $-30^{\circ}$  to  $+60^{\circ}$  C).

Power supplies shall be short circuit protected by DC power off and shall reset automatically after 5 seconds of AC power off. Power supplies shall also be protected by a minimum overload allowance of 105% and have an efficiency rating of at least 75%. Power supply shall be UL listed if the power supply is manufactured by specific power supply manufacturer. Power supplies shall be installed with the terminals/connectors facing the rear of the sign and shall be unobstructed by hardware or mounting brackets. The operator shall be able to read the terminal designations and measure voltages without removing the power supply or obstructions.

**E. Sign Housings, Faces, Framing and Mounting Members**—VMS housings shall be "walk-in" type. VMS housing and all of its equipment and materials shall be designed and constructed so that all maintenance and repair is performed from within the VMS housing, with the exception of structural members and components thereof. Sign housings shall be constructed of aluminum, alloy 5052 H34, and shall not be less than 1/8-in. thick. Seams shall be continuously welded except for the KYNAR 500 coated sign face. Framing structural shapes shall be constructed of aluminum, alloy 6061-T6. Non-corrosive materials shall be used where possible and corrosion protection shall be provided between dissimilar metals. Sign cases shall be cleaned and de-oxidized after welding. The front of the cases shall be finished matte black.

Signs shall have polycarbonate sign face coverings. Coverings shall be weather tight, ultraviolet protected, non-diffusing, polycarbonate 1/8-in. thick. Polycarbonate sign face shall be covered with a .090 in. minimum thickness aluminum mask. Aluminum mask shall provide openings directly in front of each pixel. Pixel openings shall be of sufficient size as to not interfere with LED light output. Sign face shall be designed to minimize bowing.

Sign housing, windows, framing and mounting members shall be designed to conform to the requirements of Draft 3 of the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* including amendments from the May 1999 AASHTO Subcommittee on Bridges and Structures meeting and the following clarifications:

- Basic wind speed shall be used in the designs. Alternate method for wind pressures (Appendix C) shall not be used.
- When the installation location of the structures being designed lie between isotachs, the basic wind speed shall be determined by using the higher adjacent isotach.
- Any optional design parameters indicated in the AASHTO specification that are allowed when acceptable to the owner shall not be used for the designs.

For copies of the draft and the amendments, please contact Mr. Patrick Collins, Chairman of the Technical Committee for Structural Supports for Signs, Luminaires and Traffic Signals at (307) 777-4427.

Signs shall be constructed to present a clean, neat appearance; and the equipment located therein shall be protected from moisture, dust, dirt and corrosion. Sign enclosures shall contain small weep holes for draining moisture that accumulates in the signs from condensation. Weep holes shall be designed to prevent the entrance of insects.

Signs shall be attached to the vertical truss of the overhead sign structure with I-beams. VMS signs shall be furnished with all required attachments and hardware for attachment to the I - beams on overhead sign structures. Number of I-beams needed and the method of attaching the I-beams to the sign housing and the vertical truss of the overhead sign structure shall conform to the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* including amendments from the May 1999 AASHTO Subcommittee on Bridges and Structures meeting and the following clarifications:

- Basic wind speed shall be used in the designs. Alternate method for wind pressures (Appendix C) shall not be used.
- When the installation location of the structures being designed lie between isotachs, the basic wind speed shall be determined by using the higher adjacent isotach.
- Any optional design parameters indicated in the AASHTO specification that are allowed when acceptable to the owner shall not be used for the designs.
- Lifting eyes or the equivalent shall be provided for moving and mounting signs. VMS housings shall be designed such that the VMS can be shipped and temporarily stored without damage or undue stresses prior to installation on the overhead support structure. VMS shall be shipped with a temporary wood support frame that will permit the shipping/storage of the VMS in an above-ground vertical position without damage to the sign housing. The Contractor shall remove the lifting eyes from the VMS after installation. Holes shall be sealed with a bolt and nylon washer and secured in place with nut and lock washer. The holes shall then be sealed with clear silicone sealant on both the outside and inside. The Lifting eyes shall be stored in the VMS cabinet for future use.

**F. Design of Walk-In Housings—**The minimum height of the interior from the top of the walkway to the lowest framing member or other obstruction shall be 72 in. The minimum distance from the interior rear wall of the VMS housing to the closest display components shall be 36 in. This free space shall be maintained across the entire interior of the sign housing. Structural members shall be designed and positioned so as to not be an obstruction to free movement of maintenance technicians throughout the 72 in. height of the interior of the housing.

A level walkway shall be installed in the bottom of the VMS housing on which maintenance personnel can walk. This walkway shall be a minimum of 24 in. wide, and shall run the entire length of the sign. The walkway's top surface shall be non-slip and free of obstructions that would present a tripping hazard to maintenance personnel.

All VMS equipment, components, modular assemblies, and other materials located in the VMS housing shall be removable, transportable, and capable of being installed by a single technician utilizing a one-person aerial lift truck. Structural members and components thereof are not included in this requirement.

Housings shall have interior non-corrosive, metal cage support frames to mount the display clusters. The cage support frame shall be designed to withstand and minimize vibrational effects to the display and/or electronics.

Doors shall be installed on each side of the housing and shall open to the outside rear of the VMS housing. VMS housing doors shall be rain-tight/dust-tight doors with minimum doorway opening dimensions of 6 feet high by 2 feet wide. Doors shall be provided with continuous stainless steel hinges. A four inch kickplate shall be provided at the base of both VMS door openings above the internal walkway. VMS housing doors shall have a stop to retain the door open at the full open position. The door stop shall be located at the top of the door opening/cabinet housing and shall be designed to remain in place and not obstruct the entrance/exit of the cabinet. The doors shall be designed with reinforcements to prevent bowing, twisting and excessive flexing. The VMS housing doors shall be furnished with a door lock that is keyed to the Department's standard tumbler lock number 9R48773. The latching/locking mechanism shall include a handle on the interior of the housing such that a person with no key and no tools cannot become entrapped inside the housing. One of the doors will require removable rails on the inside of the housing. Rails shall be installed horizontally and spaced vertically every twelve inches to a height of 48 inches above the internal walkway. Size of rails shall be as required to conform to OSHA and all other applicable regulations. Rails shall be attached to the sign housing with stainless steel hardware and designed for removal with simple hand tools. The Department will advise the Contractor prior to installation which side the rails will be required on.

Doors shall be provided with door switch(s) and control wiring for office monitoring of door(s) when open.

Fans or other forced air devices for maintenance personnel shall be provided in accordance with the requirements of the *VIRGINIA UNIFORM STATEWIDE BUILDING CODE* and the *INTERNATIONAL MECHANICAL CODE* Section 400. The Contractor shall provide copies of applicable regulations dealing with personnel ventilation systems, and proof of compliance with each requirement.

The maintenance personnel ventilation system shall be controlled by an adjustable timer that will turn off the fans after the set time has expired. The adjustable timer shall be adjustable to at least four (4) hours and shall be located just inside the VMS housing door, within easy reach of a maintenance technician, without having to enter the VMS housing.

- G. Internal Lighting for Walk-In Housings**—Walk-in VMS housings shall include an internal fluorescent lighting system to provide maintenance personnel with a minimum of 240 watts of evenly distributed lighting within each sign housing. Ballast shall be rated for operation in zero degree temperatures. Fluorescent lighting shall include protective cover over the fluorescent lamps. Two three-way switches shall control the interior lighting system and shall be located just inside the VMS housing within easy reach from outside the VMS housing through each housing door.

The sign housing and display panel shall be designed to minimize any visible internal light from the outside of the VMS when the internal VMS lighting is on during nighttime maintenance activities.

- H. Circuit Breaker Panel Box**—The VMS housing shall include a circuit breaker panel box installed inside the cabinet for power to circuits inside the cabinet. Main power to the circuit breaker panel box shall be from the main service disconnect. Circuit breakers and wiring shall be rated and in accordance with the NEC.
- I. Duplex Outlets for Walk-In Housings**—The VMS housing shall include a minimum of two 15 AMP, 120 VAC duplex electrical outlets, with ground fault circuit interrupters, for use by maintenance personnel. The two duplex outlets, one at each end, shall be located within the VMS housing
- J. Heaters and Fans**—Signs shall contain a minimum of three thermostatically controlled fans and electric heating elements to prevent condensation on the inside of the display windows. Thermostats for the control of the fans and electric heaters for the display window shall activate at 40° ±5°F (4° ±3°C) ambient temperature. Fans shall be designed to provide the CFM required to properly remove condensation on the inside of the display window. Vented thermostatically controlled fans with filters shall be used to circulate the air inside the enclosures for cooling. Cooling fans shall be located behind the display modules and shall blow air directly on the back of the LED pixels once the internal VMS air temperature reaches 100° F. Fans shall be designed to provide the CFM required to properly cool the enclosure and display modules. Heaters shall operate from a 240-volt, 60-Hz, single phase, AC power. Fans shall operate from 120-volt, 60-Hz, single phase, AC power. Vents for fan intake and exhaust shall be weatherproof in design.
- K. Temperature Sensor**—Cabinet shall be provided with an adjustable temperature sensor to monitor the interior temperature of the VMS. Sensor shall be selectable from 90° to 150° F (±10°). Sensor shall be wired to VMS field controller for control as required in Section IV. F. 4.
- L. Serviceable Parts**—LED driver boards shall be in the VMS housings for all signs. Plug-in locking connectors shall be provided on each driver board for all connections. Connectors shall be held in place with screws. Driver boards shall be easily removable for service/replacement with simple hand tools. Driver boards and all electronic circuit boards installed in the VMS housing shall be thoroughly coated with an acrylic conformal coating for moisture-resistance.

- M. Transient Protection**—Variable message sign control cables shall be protected at their point of connection in the sign by grounded metal oxide varistors or approved equivalent devices. The metal case of each sign shall be electrically bonded to the support structure at all mounting bolt locations. The bonding shall consist of an electrical bond wire or properly prepared electrical contact points. The structure, in turn, shall be electrically bonded to earth ground.
- N. Other**—The Contractor shall provide any other equipment required in order to monitor and control the VMS/DMS and associated equipment per these specifications.

#### IV. VARIABLE MESSAGE SIGN FIELD CONTROLLER

- A. General**—Each sign shall include an associated controller, which shall be installed in a cabinet near the sign. Laptop computer and necessary equipment to program sign controllers shall be provided by the Contractor and remain property of the Contractor.

Controllers shall be installed to operate over dial-up telephone lines.

Controllers shall be a microprocessor based intelligent unit, capable of controlling and monitoring all of the variable message sign and associated functions as described within these specifications. Controllers shall be integral units with their own power supplies. Controllers shall be housed in durably fabricated aluminum enclosures. Controller's volume, and power supplies, shall not exceed five cubic feet and shall fit inside the controller cabinet.

- B. Memory**—Controllers shall have both permanent and changeable memory. Permanent memory shall be in the form of plug-in PROM integrated circuits and shall contain the software. Changeable memory shall be in the form of RAM integrated circuits with a lithium battery backup (or other approved backup) that retains the data in memory for a minimum of one year following a power failure. Changeable memory shall contain all of the changeable operating parameters including the set-able data defined by the NTCIP requirements of Section IV.F.
- C. Data Transmission Requirements**—Each controller shall have a EIA/TIA-232E communication port. This port shall be capable of operation at all industry standard speeds up to 19,200 bits per second. Controllers shall be initially installed to operate over dial-up telephone lines. The Contractor shall install the required modem conforming to the Specifications herein and shall connect the modem to the EIA/TIA-232E port and telephone interface box.

Installation of telephone service will be coordinated by VDOT District offices for each VMS. The Contractor shall install all cable and connections between the telephone interface box and the VMS/DMS modem(s). The Contractor shall provide 8 weeks notice to the Engineer prior to telephone service installation. The VMS/DMS control cabinet shall be installed prior to requesting telephone service.

- D. Clock**—Controller shall contain a computer-readable time-of-year clock with a lithium battery or other equivalent backup. Back up shall keep the clock operating properly for at least 10 years without external power. Clock shall automatically adjust for daylight saving time and leap year through hardware or software or a combination of both. It shall be set by the sign controller's microprocessor. Clock shall be accurate to within 1 minute per month. Clock shall be Y2K compliant.
- E. Local Interface**—The controller shall support a local user interface in addition to the laptop interface. At a minimum, the local user interface shall allow the user to display a test message on the sign. If the local interface allows the user to display any other messages, the user shall be prompted to enter a password, which shall be stored and verified by the sign controller. Password shall not be echoed on the operator interface when entered by the user. Controllers shall be initially shipped with the password VMSSIM. The sign controller shall store a minimum of three (3) passwords that are user configurable.
- F. Controller Software**
- 1. Display Presentation**—VMS controller shall control the driver modules in such a way as to create the desired display on the sign. At a minimum, the signs shall be able to display the characters as described in Section V.C.4.(e). Space allocated to each character shall be proportional to the character's true width.
  - 2. Display Selection**—The controller shall implement the display per the logic defined in the NTCIP documentation referenced in V. Per the recent NTCIP DMS WG interpretation, the schedule shall control the sign display when the current buffer is set to reference the scheduled message.
  - 3. Dimming System**—With each VMS display and controller, the Contractor shall furnish and install a system which shall sense the background ambient light level and provide a minimum of sixteen field adjustable intensities (dimming). Dimming shall be implemented with high frequency variation of the display duty cycle (pulse width modulation). The frequency shall be selected to minimize any detrimental flickering.

The dimming system shall conform to the following minimum requirements:

- a. Photo-Electric Sensors**—The dimming system shall contain three photo-electric sensors installed in water-tight metal enclosures on the VMS housing. The photo-electric sensors shall have a 0.25 in. (minimum) photo-sensitive area. The photo-electric sensors shall be capable of being continually exposed to direct sunlight without impairment of performance. The water-tight metal enclosure shall have a 1.00 square inch (minimum) glass window area. The photo-electric sensors shall be placed so that they sense the ambient light levels striking the front, and rear of each sign. Sensors shall be located on the cabinet to allow replacement by workers from the walkway.

- b. **Dimming Levels**—Manual and automatic dimming modes shall be provided enabling the user to select the desired mode of operation.

The dimming system shall select one of sixteen levels from the sensed ambient light. The set points for each of the sixteen ambient light levels shall be set within user adjustable software.

- c. **Interference**—The dimming circuit and VMS power system shall have electrical devices installed to minimize RFI noise generated by the VMS both on the power line and radiated by sign circuitry.

#### 4. Exception Reporting -

The sign controller shall issue an SNMP trap under the following conditions:

- **Power Supply Failure**—The sign controller shall be capable of sensing the failure of each individual power supply. When one of the power supplies in a group has failed, the sign controller shall issue an SNMP trap.
- **Power Restoration**—Whenever it detects restoration of AC power at the sign controller.
- **Temperature Limit**—Whenever internal VMS temperature initially exceeds programmed safety limit a new trap, will not be issued until the temperature once again falls below the safety limit and then exceeds it.
- **Door Open**—Whenever the door of the VMS housing or the door of the controller cabinet is opened.

The format of the traps will be provided to the contractor after award of the contract.

If the connection is dial-up, the controller shall additionally initiate a phone call to the central computer as necessary. If the central computer's line is busy, the sign controller shall keep trying at intervals selectable by the operator until it gets through. When it does connect with the central computer, it shall transmit the appropriate SNMP trap. Sign controller shall automatically disconnect dial-up communications within one (1) minute if communications is not sensed by the sign controller.

The controller shall have a minimum of two serial ports: one for the central computer and one easily accessible for the maintenance technician. Each serial port shall support all of the Subnet Profiles defined in Section V. C. 1. It shall be possible for a maintenance technician to connect a laptop computer to the remote control port, and carry out all operations that could be carried out by the central computer.

All other communication requirements such as checksum and parities are specified by NTCIP per Section V.

5. **Controller ID**—A 4 byte IP Network Address shall be assignable to each controller so that SNMP Trap messages are able to identify the originating sign.
6. **Diagnostic Test**—Upon command from a remote computer, the controller shall test the electrical operation of all drivers and the over current, under current and normal current of the pixels. Field controller shall analyze the pixel current and determine whether the pixel is operating with “normal”, “under”, or “over”, current and shall communicate the result using a Department specified NTCIP compatible message. The format of these objects will be provided to the contractor after award of the contract.
7. **Power Interruptions**—The contents of the controller's memory shall be preserved by battery power during power interruptions and the controller shall resume operation automatically when power is restored. Upon recovering from a power interruption, the controller shall report to the central computer that it has just recovered from a power interruption per Section IV. F. 4.
8. **Software Duplication Rights**—The Department shall have the right to duplicate the sign controller software as needed for use in controlling signs under its jurisdiction. VDOT and its agents, shall have the right to reverse engineer the communications interface to the sign as necessary, in order to debug the system and perform systems integration activities in the future.

### 3-3 COMMUNICATION REQUIREMENTS

This portion of the specification defines the detailed Communication requirements for the Dynamic Message Signs covered by the procurement package.

#### A. Definitions

The following terms shall apply within the scope of this procurement specification:

**DMS** - A Dynamic Message Sign, includes the sign display, controller, cabinet, and other associated field equipment. The specific type of dynamic message sign (i.e., blank-out sign, changeable message sign, character matrix sign, full-matrix sign, etc.) for this procurement is specified elsewhere within this procurement specification.

**FSORS** - Full, Standardized Object Range Support

Full, Standardized Object Range Support – Support for, and proper implementation of, all valid values of an object as defined within the object's OBJECT-TYPE macro in the subject NTCIP standard; this is further defined in two distinct sub-requirements. (1) If the ACCESS of the object is read-write, a Management System shall be able to set the object to any valid value as defined by the SYNTAX and DESCRIPTION fields (except that the value of 'other' need not be supported when such a value is defined) and the indicated functionality shall be provided. (2) The value indicated by the object (e.g., in response to a 'get'), regardless of the ACCESS, shall reflect the current condition per the rules specified in the object's DESCRIPTION.

Management System – A computer system used to control an NTCIP component. This includes any laptop software used for field control as well as the central control software.

NTCIP – National Transportation Communication for ITS Protocol

NTCIP Component – A DMS or a Management System.

NTCIP System – A Management System plus the various ASCs and DMSs controlled by the Management System.

Response Time – The time to prepare and begin transmission of a complete response containing the requested Application Layer information. This is measured as the time from receipt of the closing flag of the request to the transmission of the opening flag of the response when the device has immediate access to transmit.

**B. References**

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

Each NTCIP Component covered by these project specifications shall implement the most recent version of the standard that is at the stage of Recommended or higher as of February 15, 2001, including any and all Approved or Recommended Amendments to these standards as of the same date with exceptions as noted herein to reflect the recent interpretations of the NTCIP DMS WG. It is the ultimate responsibility of the Contractor to monitor NTCIP activities to discover any more recent documents.

**Table 1: NTCIP Standards**

<i>Abbreviated Number</i>	Full Number	Title	Known Amendments
NTCIP 1101	<b>NTCIP 1101:1997</b> (NEMA TS 3.2-1996)	Simple Transportation Management Framework	Amendment #1 dated November 2, 1998.
NTCIP 1201	<b>NTCIP 1201:1997</b> (NEMA TS 3.4-1996)	Global Object Definitions	Amendment #1 dated November 2, 1998.
NTCIP1203	<b>NTCIP 1203:1997</b> (NEMA TS 3.6-1997)	Object Definitions for Dynamic Message Signs	
NTCIP 2000	<b>NTCIP 2000:1997</b>  (NEMA TS 3.3-1996)	Class B Profile	Amendment #1 dated November 2, 1998.
NTCIP 2101	<b>NTCIP 2101v01.17</b> <b>(Recommended)</b>	Subnet Profile for PMPP over RS-232	
NTCIP 2103	<b>NTCIP 2103v01.05 (User Comment)</b>	Subnet Profile for Point-to-Point Protocol over RS-232	
NTCIP 2202	<b>NTCIP 2202v01.04</b> <b>(Recommended)</b>	Internet Transport Profile	

	(NEMA TS 3.Internet		
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**C. General Requirements**

1. Subnet Level

Each serial port on each NTCIP Component shall support NTCIP 2103 over a dial-up connection with a contractor provided external modem with data rates of 28.8 kbps, 19.2 kbps, 14.4 kbps, 9600 bps, 4800 bps, 2400 bps, 1200 bps, 600 bps, and 300 bps. The NTCIP Component shall be able to make outgoing and receive incoming calls as necessary and support the following modem command sets:

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

Each serial port on each NTCIP Component shall support NTCIP 2103 over a null-modem connection with data rates of 19.2 kbps, 14.4 kbps, 9600 bps, 4800 bps, 2400 bps, 1200 bps, 600 bps, and 300 bps.

Each serial port on each NTCIP Component shall support NTCIP 2101 with data rates of 9600 bps, 4800 bps, 2400 bps, 1200 bps, 600 bps, and 300 bps.

All “CHAP” secrets shall be user configurable.

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

2. Transport Level

Each NTCIP Component shall comply with NTCIP 2000 when using the NTCIP 2101 Subnet Profile.

Each NTCIP Component shall comply with NTCIP 2202 when using the NTCIP 2103 Subnet Profile.

NTCIP Components may support additional Transport Profiles at the manufacturer's option. Response datagrams shall use the same Transport Profile used in the request.

3. Application Level

Each NTCIP Component shall comply with NTCIP 1101 and shall meet the requirements for Conformance Level 1 (NOTE - See Amendment to standard).

Each NTCIP Component shall support the standard SNMP traps as well as those traps as defined in IV.F.

An NTCIP Component may support additional Application Profiles at the manufacturer's option. Responses shall use the same Application Profile used by the request. Each

NTCIP Component shall support the receipt of Application data packets at any time allowed by the subject standards.

4. Information Level

Each NTCIP Component shall provide Full, Standardized Object Range Support of all objects required by these procurement specifications unless otherwise indicated below. The maximum Response Time for any object or group of objects shall be 200 milliseconds.

The DMS shall support all mandatory objects of all mandatory Conformance Groups as defined in NTCIP 1201 and NTCIP 1203. Table 2 indicates the modified object requirements for these mandatory objects.

**Table 2: Modified Object Ranges for Mandatory Objects**

Object	Reference	Project Requirement
moduleTableEntry	NTCIP 1201 Clause 2.2.3	Shall contain at least one row with moduleType equal to 3 (software). The moduleMake shall specify the name of the manufacturer, the moduleModel shall specify the manufacturer's name of the component and the modelVersion shall indicate the model version number of the component.
maxGroupAddresses	NTCIP 1201 Clause 2.7.1	shall be at least 1
communityNamesMax	NTCIP 1201 Clause 2.8.2	Shall be at least 3
dmsNumPermanentMsg	NTCIP 1203 Clause 2.6.1.1.1.1	Shall be at least 1*
dmsMaxChangeableMsg	NTCIP 1203 Clause 2.6.1.1.1.3	Shall be at least 21
dmsFreeChangeableMemory	NTCIP 1203 Clause 2.6.1.1.1.4	Shall be at least 20 when no messages are stored.
dmsMessageMemoryType	NTCIP 1203 Clause 2.6.1.1.1.8.1	In addition to the FSORS, the component shall support a seventh memory type (i.e., dmsMessageMemoryType = 7), which shall indicate a blank message. The sign shall support 255 messages of this type, dmsMessageNumber = 1 to 255, and the dmsMessageRunTimePriority shall be equal to the dmsMessageNumber for each message. The dmsMessageMultiString shall be a zero-length octet string. The dmsMessageCRC shall be zero (0x0000) for all 255 of
		<b>NOTE: This is a variation from the standard that reflects recent DMS WG consensus on how to resolve an ambiguity in the standard.</b>

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		these messages and the normal CRC algorithm shall be ignored for the blank messages.
dmsMessageMultiString	NTCIP 1203 Clause 2.6.1.1.1.8.3	The DMS shall support any valid MULTI string containing any subset of those MULTI tags listed in Table 4
dmsControlMode	NTCIP 1203 Clause 2.7.1.1.1.1	Shall support at least the following modes: local external central centralOverride

\* The Permanent Messages shall display the content shown in Table 3.

If the sign processes a command for an invalid display, the display should not be affected; any previous message should continue displaying as if no such command had been received. Objects of syntax MessageActivationCode or MessageIDCode shall accept values with Message Type = 6, Message Number = 1, and CRC = 0x00 00 as a valid call to activate the schedule. Objects of syntax MessageActivationCode or MessageIDCode shall accept values with Message Type = 7, Message Number = 1 through 255, and CRC = 0x00 00 as a valid call to blank the sign with a run-time priority equal to the indicated message number. **These requirements are per recent DMS WG consensus on how to solve ambiguities within the standard.**

**Table 3: Content of Permanent Messages**

Perm. Msg. Num.	4. DESCRIPTION
1	Shall be a test message that allows the user to determine if all pixels are working properly and configured for their actual locations in the display

**Table 4: Required MULTI Tags**

Code	Feature
f1	field 1 - time (12hr)
f2	field 2 - time (24hr)
f8	field 8 - day of month
f9	field 9 – month
f10	field 10 - 2 digit year
f11	field 11 - 4 digit year
fl (and /fl)	flashing text on a line by line basis with flash

	rates controllable in 0.5 second increments.
fo	Font
jl2	justification – line - left
jl3	justification – line - center
jl4	justification – line - right
jl5	justification – line - full
jp2	justification – page - top
jp3	justification – page - middle
jp4	justification – page - bottom
mv	moving text
nl	new line
np	new page, up to 2 instances in a message (i.e., up to 3 pages/frames in a message counting first page)
pt	page times controllable in 0.5 second increments.

The NTCIP Component shall also implement all mandatory objects of the following optional conformance groups.

- (a) Time Management, as defined in NTCIP 1201

- (b) Timebase Event Schedule, as defined in NTCIP 1201. The following list indicates the modified object requirements for this conformance group.

**Table 5: Modified Object Ranges for the Timebase Event Schedule Conformance Group**

Object	Reference	Project Requirement
maxTimeBaseScheduleEntries	NTCIP 1201 Clause 2.4.3.1	Shall be at least 28
maxDayPlans	NTCIP 1201 Clause 2.4.4.1	Shall be at least 14
maxDayPlanEvents	NTCIP 1201 Clause 2.4.4.2	Shall be at least 10

- (c) Report, as defined in NTCIP 1201. The following list indicates the modified object requirements for this conformance group.

- (d) PMPP

**Table 6: Modified Object Ranges for the Report Conformance Group**

Object	Reference	Project Requirement
maxEventLogConfigs	NTCIP 1201 Clause 2.5.1	Shall be at least 50

eventConfigurationMode	NTCIP 1201 Clause 2.4.3.1	The NTCIP Component shall support the following Event Configuration Modes: onChange greaterThanValue smallerThanValue
maxEventLogSize	NTCIP 1201 Clause 2.5.3	Shall be at least 200
maxEventClasses	NTCIP 1201 Clause 2.5.5	Shall be at least 16

(e) Font Configuration, as defined in NTCIP 1203. The following list indicates the modified object requirements for this conformance group.

**Table 7: Modified Object Ranges for the Font Configuration Conformance Group**

Object	Reference	Project Requirement
numFonts	NTCIP 1203 Clause 2.4.1.1.1.1	Shall be at least 4*
maxFontCharacters	NTCIP 1203 Clause 2.4.1.1.1.3	Shall be at least 127**

\*Upon delivery, the first font shall be a standard 18” font. The second font shall be a double-stroke 18” font. The third font shall be a 28” font. The fourth font shall be empty.

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

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

(f) VMS Configuration, as defined in NTCIP 1203.

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

**Table 8: Modified Object Ranges for the MULTI Configuration Conformance Group**

Object	Reference	Project Requirement
defaultBackgroundColor	NTCIP 1203 Clause 2.5.1.1.1.1	The DMS shall support the following background colors: black
defaultForegroundColor	NTCIP 1203 Clause 2.5.1.1.1.2	The DMS shall support the

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		following foreground colors: amber
defaultJustificationLine	NTCIP 1203 Clause 2.5.1.1.1.6	The DMS shall support the following forms of line justification: left center right full
defaultJustificationPage	NTCIP 1203 Clause 2.5.1.1.1.7	The DMS shall support the following forms of page justification: top middle bottom
defaultPageOnTime	NTCIP 1203 Clause 2.5.1.1.1.8	The DMS shall support the full range of these objects with step sizes no larger than 0.5 seconds
defaultPageOffTime	NTCIP 1203 Clause 2.5.1.1.1.9	The DMS shall support the full range of these objects with step sizes no larger than 0.5 seconds
defaultCharacterSet	NTCIP 1203 Clause 2.5.1.1.1.10	TheDMS shall support the following character sets: eightBit

(h) Multi Error Configuration, as defined in NTCIP 1203

(i) Illumination/Brightness Control, as defined in NTCIP 1203. The following list indicates the modified object requirements for this conformance group.

**Table 9: Modified Object Ranges for the Illumination/Brightness Control Conformance Group**

Object	Reference	Project Requirement
dmsIllumControl	NTCIP 1203 Clause 2.8.1.1.1.1	The DMS shall support the following illumination control modes: photocell timer manual
dmsIllumNumBrightLevels	NTCIP 1203 Clause 2.8.1.1.1.4	Shall be at least 16

(j) Scheduling, as defined in NTCIP 1203. The following list indicates the modified object requirements for this conformance group.

**Table 10: Modified Object Ranges for the Scheduling Conformance Group**

Object	Reference	Project Requirement
numActionTableEntries	NTCIP 1203 Clause 2.9.1.1.1.1	Shall be at least 21

- (k) Sign Status, as defined in NTCIP 1203
- (l) Status Error, as defined in NTCIP 1203
- (m) Pixel Error Status, as defined in NTCIP 1203

The NTCIP Component shall also implement the following optional objects:

**Table 11: Optional Object Requirements**

Object	Reference	Project Requirement
globalSetIDParameter	NTCIP 1201 Clause 2.2.1	FSORS
eventConfigLogOID	NTCIP 1201 Clause 2.5.2.7	FSORS
eventConfigAction	NTCIP 1201 Clause 2.5.2.8	FSORS
eventClassDescription	NTCIP 1201 Clause 2.5.6.4	FSORS
defaultFlashOn	NTCIP 1203 Clause 2.5.1.1.1.3	The DMS shall support the full range of these objects with step sizes no larger than 0.5 seconds
defaultFlashOff	NTCIP 1203 Clause 2.5.1.1.1.4	The DMS shall support the full range of these objects with step sizes no larger than 0.5 seconds
dmsMessageBeacon	NTCIP 1203 Clause 2.6.1.1.1.8.6	Support for this object is optional, but the value, as used to calculate the message CRC, etc. shall default to zero (0).
dmsMessagePixelService	NTCIP 1203 Clause 2.6.1.1.1.8.7	Support for this object is optional, but the value, as used to calculate the message CRC, etc. shall default to zero (0).
dmsSWReset	NTCIP 1203 Clause 2.7.1.1.1.2	FSORS
dmsMessageTimeRemaining	NTCIP 1203 Clause 2.7.1.1.1.4	FSORS

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dmsShortPowerRecoveryMessage	NTCIP 1203 Clause 2.7.1.1.1.8	FSORS
dmsLongPowerRecoveryMessage	NTCIP 1203 Clause 2.7.1.1.1.9	FSORS
dmsShortPowerLossTime	NTCIP 1203 Clause 2.7.1.1.1.10	FSORS
dmsResetMessage	NTCIP 1203 Clause 2.7.1.1.1.11	FSORS
dmsCommunicationsLossMessage	NTCIP 1203 Clause 2.7.1.1.1.12	FSORS
dmsTimeCommLoss	NTCIP 1203 Clause 2.7.1.1.1.13	FSORS
dmsEndDurationMessage	NTCIP 1203 Clause 2.7.1.1.1.15	FSORS
dmsMemoryMgmt	NTCIP 1203 Clause 2.7.1.1.1.16	The DMS shall support the following Memory Management Modes: normal clearChangeableMessages clearVolatileMessages
DmsMultiOtherErrorDescription	NTCIP 1203 Clause 2.7.1.1.1.20	If the vendor implements any vendor-specific MULTI tags, the DMS shall provide meaningful error messages within this object whenever one of these tags generates an error.
DmsIllumLightOutputStatus	NTCIP 1203 Clause 2.8.1.1.1.9	FSORS
WatchdogFailureCount	NTCIP 1203 Clause 2.11.1.1.1.5	FSORS
DmsStatDoorOpen	NTCIP 1203 Clause 2.11.1.1.1.6	FSORS
FanFailures	NTCIP 1203 Clause 2.11.2.1.1.8	FSORS
FanTestActivation	NTCIP 1203 Clause 2.11.2.1.1.9	FSORS
TempMinCtrlCabinet	NTCIP 1203 Clause 2.11.4.1.1.1	FSORS
TempMaxCtrlCabinet	NTCIP 1203 Clause 2.11.4.1.1.2	FSORS
TempMinSignHousing	NTCIP 1203 Clause	FSORS

	2.11.4.1.1.5	
TempMaxSignHousing	NTCIP 1203 Clause 2.11.4.1.1.6	FSORS

D. Integration

The Contractor shall furnish and install the variable message sign units and assist as required to integrate the variable message signs with the respective central software systems.

For Locations 1 through 7 (Richmond District), the Contractor shall furnish and install the central computer and software per the Special Provision for Variable Message Sign Central Software. Once the Systems Operational Test is complete, the Contractor-provided computer and software will be disconnected, but retained by the Department. Department-provided central computers and software at the Richmond Smart Traffic Center will be integrated to the signs by a third-party System Integrator who is under separate contract with the Department. Integration will take no longer than 10 working days. If integration problems occur due to Contractor supplied equipment, this 10 day period will restart once the problems are resolved. Once integration is complete, the Contractor will be able to proceed with the 30-Day Continuous Test as described in Section VII.F. For these sites, the Contractor shall work with the Department's System Integrator to resolve any integration issues that occur. Assistance shall include, but may not be limited to, explaining how any specific clauses were interpreted by the sign manufacturer and correcting non-compliance issues in the sign, if any are identified.

For Locations 8 through 11 (Fredericksburg District), the Contractor shall furnish and install the central computer and software per the Special Provision for Variable Message Sign Central Software. The Contractor shall be fully responsible for the integration and testing of the installed system for these sites.

The Department supplied central VMS software currently operates with NTCIP compliant variable message signs. It communicates via leased dial-up telephone line to each sign. The software has been operational since September 2000.

The Systems Integrator will be responsible for troubleshooting the system and pinpointing integration problems involving Contractor supplied equipment. The contractor shall be expected to remedy any deficiencies discovered during integration in the contractor supplied hardware or software. The Contractor shall not be responsible for modifying or debugging any Department supplied hardware or software.

E. Documentation

Software shall be supplied with full documentation, including 3.5" floppy disk(s) and a CD-ROM containing ASCII versions of the following Management Information Base (MIB) files in Abstract Syntax Notation 1 (ASN.1) format:

- The relevant version of each official standard MIB Module referenced by the device functionality.
- If the device does not support the full range of any given object within a Standard MIB Module, a manufacturer specific version of the official Standard MIB Module with

the supported range indicated in ASN.1 format in the SYNTAX and/or DESCRIPTION fields of the associated OBJECT TYPE macro. The filename of this file shall be identical to the standard MIB Module, except that it will have the extension ".man".

- A MIB Module in ASN.1 format containing any and all manufacturer-specific objects supported by the device with accurate and meaningful DESCRIPTION fields and supported ranges indicated in the SYNTAX field of the OBJECT-TYPE macros.
- A MIB containing any other objects supported by the device.

The manufacturer shall allow the use of any and all of this documentation by any party authorized by VDOT for systems integration purposes at any time initially or in the future, regardless of what parties are involved in the systems integration effort.

F. Acceptance Testing

The acceptance test will use the NTCIP Exerciser, or other authorized testing tool and will follow the guidelines established in the ENTERPRISE Test Procedures. The Department reserves the right to enhance these tests as deemed appropriate to ensure device compliance. NTCIP testing is further described in Section VII. G.

G. Interpretation Resolution

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

## VI. VARIABLE MESSAGE SIGN FIELD CONTROLLER CABINET

Cabinets for variable message sign field controllers shall be NEMA 3R, weatherproof and constructed of welded sheet aluminum, mill finish, 0.125-in. minimum thickness, conforming to ASTM B209, alloy 5052-H32. Cabinet mounting attachments shall be durable, corrosion resistant and of heavy duty construction. All seams shall be continuous welds, free from irregularities.

Cabinets shall be of sufficient size to house required equipment and shall fit entirely on the Standard CF-1 foundation. Concrete foundation shall project 4 in. on all four sides of cabinet to edge of concrete. Anchor bolts shall be steel conforming to Section 226.02 (c) 2 of the Specifications and shall be 3/4 in. in diameter and at least 16" in length with a 5 in. L bend. Except when stainless steel is used, the portion of anchor bolts beginning 4 in. below the top of the foundation and extending above the foundation shall be galvanized.

Cabinet doors shall provide full access to the cabinet interior and shall be gasketed to assure weatherproofing. The door(s) shall be equipped with the Department's standard tumbler lock Number 9R48773. Two (2) keys for each lock shall be provided. All hinges and handles shall be stainless steel. Cabinet doors shall have a door stop arrangement that will allow it to be firmly positioned at both 90° and 135° ±10°. The locking mechanism shall be a three-point draw roller system. Rollers shall be fabricated from nylon with a diameter of at least 8/10 in. The door opening shall be double flanged on all four sides. The top of the cabinet shall be sloped to provide for the drainage of water away from the door.

Cabinets shall contain at least three adjustable shelves or equivalent supports or rack mounting with sufficient space to adequately hold the electronic equipment. Rack mounting of equipment shall provide access to all equipment within the cabinet and accessibility to all wiring without removing the rack. The vertical mounting channels for the shelves shall be continuous and shall allow for shelf placement as close as 5 in. from the top and bottom of the cabinet. A slide out drawer shall be provided in the cabinet for placement of a laptop computer. The slide out drawer shall be of sufficient dimensions to adequately hold the laptop with the screen open for on site operation of the local VMS sign controller. The slide out drawer shall be provide with a hinged top with sufficient storage of cabinet and VMS manuals and drawings in the slide out drawer. The equipment and terminals shall be so arranged within the cabinet that they will not interfere with the entrance, tracing and connection of conductors. All wiring panels (terminal blocks) shall be neatly finished and clearly and permanently marked with identifications applied by silk screening. All conductors and communication cable shall be neatly arranged in the cabinet and bundled in groups with cable ties.

All AC circuit wiring shall be a minimum Number 14 AWG stranded copper rated at 600 volts. All DC circuit wiring shall be a minimum Number 20 AWG stranded copper rated at 600 volts. Ribbon cable will not be allowed for cabinet wiring.

Accessory and Auxiliary Equipment - As a minimum, cabinets shall be furnished with the following:

- Duplex ground fault convenience receptacle
  
- Modems shall have a raw data-transfer speed of 56k and shall conform to Microcom Networking Protocol (MNP) classes 2 through 5, and International Telecommunications Union (ITU) V.90, V.42 and V.42bis standards. Modems shall be capable of communicating with 33,600, 28,800,14,400, 9600, 2400 and 1200 bps modems and shall automatically adjust the data rate and modulation to accomplish this. Modems shall interface with the sign controller data port for transmitting of data via conventional dial up telephone. Modems shall have auto dial/auto answer features. Modems shall be capable of operation within an operating ambient temperature range from 0°C to +40°C, and an operating relative humidity range up to 95%, non-condensing. Modems shall support the Hayes AT Command Set and have at least the following function indicators for identifying modem operation:
  - Carrier detect
  
  - Auto answer on
  
  - Modem ready
  
  - Terminal ready

- Modem has taken phone off hook
  
- Received data is being sent to the computer or received transmission from phone line.
  
- Data sent from the computer was received by the modem or transmission made to phone line.
  
- Removable, clear Plexiglas shield for the incoming power panel equipment with an opening to provide for manual operation of breakers.
  
- 2 circuit breakers shall be provided in each cabinet. One circuit breaker shall be rated at least 20 amps and shall operate the vent fan, duplex ground fault convenience receptacle, and lamp. The second circuit breaker shall operate any other equipment. Circuit breakers and wiring shall be rated and in accordance with the NEC.
  
- Screened and louvered vent, designed to prevent rain entry, with a 14 by 20 by 1-in. standard furnace vent filter. The filter tray shall be sized to house and secure the filter in place. The screen shall be constructed from at least 0.031-in. aluminum with 1/8-in. diameter openings positioned on 3/16-inch staggered centers. The screen shall be placed on the inlet side of the filter and held in place by the filter or silicone adhesive.
  
- Thermostatically-controlled vent fan with a screened guard in the top section of the cabinet with the capability of exhausting at least 100 CFM. The thermostat shall be adjustable from 80°F to 130°F. Degree markings shall be indicated on the thermostat in 10° increments.
  
- VAC line filter rated at 50 amps
  
- Fluorescent lamp, ordering code Number F20T12/D located in the cabinet so that it will provide for the unobstructed illumination of electronic equipment adjustments. A toggle switch connected in-line with a momentary switch operated by the door shall be provided for operation of the lamp. The toggle switch shall be mounted on a removable noncorrosive metal panel (13 gage minimum) which shall be located on the backside of the door in a convenient location.
  
- Transient protection devices. Ungrounded conductor wires entering or leaving the cabinet shall be equipped with transient protection devices. The placement of equipment and the cabinet wiring shall be arranged so that the distance between each conductor's point of entry and the protector shall be as short as possible, and the protector shall be located as far as possible from electronic equipment. Wiring between the surge protectors and the point of entry shall be free from sharp bends. The cabinet shall have an extensive ground plane, and the surge protectors shall be grounded to it, or to the cabinet wall.

Variable message sign control cables shall be protected by grounded metal oxide varistors. There shall be one varistor for each wire in the cable.

Transient protection shall be connected on the load side of the main AC breaker. Transient protector shall provide two stages and shall be electrically separate, so that the first stage protects all equipment using the power, while both the first and second stages protect electronic equipment. There shall be no maximum load for the first stage. The second stage shall be capable of protecting equipment drawing a total of 10 amps. The protector shall clamp both the main line and the main neutral at 250 volts. Cables feeding unswitched 120 volt power from the cabinet to variable message signs shall be protected by the first stage of this filter. The main AC transient protector shall conform to the following requirements:

- Withstand a peak 20,000 ampere surge current for an 8 X 20 microsecond waveform.
- 20 minimum peak surge occurrences.
- Clamp voltage at 20,000 amperes 280 maximum.
- Maximum continuous operating current 10 amperes at 120 VAC, 60 Hz.
- Series inductance of 200 microhenrys (nominal).
- Temperature range - 40° to +185°F.
- Approximate dimensions 4 in. wide X 7.25 in. long X 3 in. high.
- Response time voltage not to exceed 280 volts during surge.
- Spike suppression for ±700 volt spike shall deviate ±40 volt from sine wave at all phase angles from 0° to 180°.
- Filtering:

<u>Frequency</u>	<u>Insertion loss(db)</u>
60 Hz	0
10 Khz	30
50 Khz	50

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100 Khz	50
500 Khz	50
2 MHZ	60
5 MHZ	40
10 MHz	20
20 MHz	25

Dial-up telephone lines shall be protected by a two-stage, plug-in surge protector equal to EDCO's Model PC642C-200.

- **UNINTERRUPTIBLE POWER SUPPLY** – The Contractor shall furnish and install an Uninterruptible Power Supply (UPS) at each controller cabinet . The UPS shall provide complete non-interruptible power protection, voltage regulation, surge and spike protection for the equipment installed in the cabinet. The UPS shall meet the requirements of FCC-A and UL-1778. UPS shall be a commercially available package containing all wiring connectors software and cables.

The UPS shall be of sufficient design to fully operate the cabinet electronic equipment a maximum of one (1) hour. The Contractor shall be responsible for determining the appropriate size/capacity of the UPS. The Contractor shall supply the above calculations and all software and hardware manuals at the time of catalog cut submission. The Contractor shall install the software, test all functions and set the initial UPS parameters. The UPS shall instantly transfer the cabinet to the battery back-up mode in the event the main AC power source goes offline and conform to the following minimum requirements.

- Transfer time shall be 4-milliseconds maximum including detection time
- Output Connections - six (6) NEMA 5-15R
- Input Connections - NEMA 5-15P
- Surge protection shall be rated at 320 joules
- Line filtering shall be full time multi-pole noise filtering
- 0.3% IEEE surge let through, zero clamping response time meeting UL-1449
- Brownout voltage protection, 95 VAC user adjustable
- Recharge the batteries to 90% capacity within four (4) hours maximum
- LED status indicators for "On-line", "Battery On", "Replace Battery", and "Overload"
- Batteries shall be user replaceable and be maintenance free, leak-proof, sealed lead acid with suspended electrolyte with a three (3) to six (6) year lifetime

- Audible alarm when the batteries are in the “ON” condition and a separately distinctive “LOW BATTERY” alarm; the end user shall have the capability to turn off the audible alarms

## VII. TESTING

- A. General**—Testing of all equipment furnished and installed under this Contract shall be conducted by, and be the responsibility of the Contractor. The Department reserves the right to perform any inspections deemed necessary to assure that the equipment conforms to the requirements specified herein.

The Contractor shall make arrangements for the witnessing of tests as requested by the Engineer. Full documentation of test results including problems experienced shall be prepared by the Contractor and submitted to the Engineer. Any equipment failing the tests shall be replaced or repaired and re-tested at the Contractor's expense.

Unless otherwise noted, all test documents shall be submitted to the Engineer at least sixty (60) days prior to starting the applicable testing. Should any revisions be required by the Department, the Contractor shall re-submit the document for further review prior to starting the test. No Department review period will exceed thirty days.

The Engineer's approval of any testing document or witnessing of tests shall not relieve the Contractor of his responsibility to provide a completely acceptable and operating system that meets the requirements of these Contract Documents.

- B. Test Plan**—shall be a stand-alone document that covers all aspects of the Contractor's proposed test program. The Contractor shall submit a detailed and comprehensive Test Plan to the Engineer for approval at least ninety (90) days prior to the submittal of any other Test Documentation described in Section VII.C. The Test Plan shall identify all required testing levels for the specific equipment provided by the Contractor. The Test Plan shall identify the Contractor's test organization including the roles and responsibilities of the quality assurance organization. Anticipated test dates and durations shall also be identified. For each piece of equipment that requires testing, the Test Plan shall at a minimum, delineate the following

- Allocation of Special Provision requirements to specific levels of testing
- Submittal of sample test procedures
- Anticipated start time of each level of testing
- Test duration including any re-tests that are required or anticipated
- Submittal of sample test reports

- C. Test Documentation**—The following documentation requirements shall be applicable to the Factory Demonstration/Acceptance Test, the System Operational Test, and the 30-Day Continuous Test. The Contractor shall submit to the Engineer for approval appropriate documentation related to each phase of testing. No testing shall commence without appropriate documentation approval. NTCIP test documentation will be prepared by the Department or the Department's NTCIP representative.

**5. (A) TEST PROCEDURES - TEST PROCEDURES AND TEST DATA FORMS MUST BE SUBMITTED AND SHALL INCLUDE AT A MINIMUM:**

- A description of any special equipment, setup, manpower, or conditions required for the test.
- A step-by-step outline of the test sequence to be followed, showing a test of every function of the equipment to be tested.
- A description of the expected operation, output, pass/fail criteria, test results, and criteria for re-test.
- A summary cross reference of test procedures to these Special Provisions.
- An estimate of the test duration and proposed test schedule.
- A data form to be used to record all data and quantitative results obtained by the test.
- A failure analysis and corrective action plan as described herein, for failed equipment.

**6. (B) TEST REPORTS - THE CONTRACTOR SHALL SUBMIT TEST REPORTS FOR ALL TESTING LEVELS. THE TEST REPORTS SHALL VERIFY THAT THE APPROVED TEST PROCEDURES WERE CONDUCTED. ALL TEST REPORTS SHALL BE PRESENTED AND ORGANIZED IN LOGICAL GROUPS OF EQUIPMENT AND MUST BE SIGNED BY THE CONTRACTOR.**

The Contractor shall compare the results of each test with the requirements specified in the Contract Documents, and with the approved test procedures. Failure to conform to the requirements shall be counted as a complete failure, and the equipment shall be rejected. Rejected equipment may be offered for retest provided all non-compliant items have been corrected and retested by the Contractor. Any corrections deemed necessary by the Engineer shall be made by the Contractor, at no additional cost to the Department.

Failure analysis and corrective action reports shall categorize the cause of failure as material defect, quality/workmanship defect, design defect, or system defect. Failure analysis and corrective action plans shall, at a minimum, include the following items:

- Failure report form and numbering system.
- Applicability: Vendors, Suppliers, Contractor-Component Subsystem and System Levels
- Sign off authority at the different levels of activity
- Incorporation into the test report
- Correlation with configuration management
- Precise corrective action
- Confirmation of corrective action
- Close out of the failure report, with accompanying charts, graphs, evidence, photographs, etc. (The failure analysis/corrective action report shall provide complete traceability and audit trail of each occurrence.)

**D. Factory Demonstration/Acceptance Tests**—Variable Message Sign, controller, and software requirements as stated herein shall be factory demonstrated to the Engineer prior to shipment.

The Contractor shall notify Jeff Wilkinson at 804-524-6194 thirty days in advance of factory tests. The Contractor shall furnish airline tickets to and from Richmond Va. International Airport to destination (closest major airport), and ground transportation to destination city, lodging and per diem expenses for three VDOT Engineers for factory demonstration/acceptance test at the VMS manufacturing facility. The Contractor shall, if requested by the Engineer, postpone any Factory Demonstration/Acceptance Tests for up to seven calendar days in order to accommodate the schedules of the VDOT Engineers. The Contractor shall plan the testing schedule anticipating such requests. Such request for postponement of tests shall not be grounds for extensions of intermediate or final completion times or for additional compensation. Failure of this test shall require additional testing until VMS passes. Additional travel to the manufacturing facility for these additional tests shall be paid by the Contractor as indicated above. Failure to conform to the requirements of any test and these specifications shall be counted as a complete failure, and the equipment shall be rejected. Rejected equipment/tests may be retested after all deviations have been corrected. After successful completion of all factory demonstration/acceptance tests, the VMS for this contract will be accepted for shipment to the implementation site. The Contractor shall provide the documentation to the Engineer of all test and demonstration results.

No equipment for which a demonstration test is required shall be shipped by a manufacturer without successful completion of factory demonstration testing, receipt of documented test results and authorization by the Engineer to ship. Factory acceptance testing will only be required for the first sign manufactured by the VMS manufacturer.

- E. **System Operational Test** – shall demonstrate that all equipment is fully integrated and operational. This test shall verify that all equipment installed at each location is installed properly and that all functions are in conformance with the Contract Documents. All Contractor supplied software shall be also tested during the System Operational Test. Testing of the central equipment shall include running and passing each test of the acceptance procedure and demonstrating proper data transfer to and from each remote site.

For deployment where Department supplied central VMS software is to be used for the 30-Day Continuous Test, the System Operational Test shall be conducted using the Contractor supplied computer and software.

- F. **30-Day Continuous Test** – shall not commence until the System Operational Test is successfully completed. During this 30-day period, all aspects of the signs, communications, and control features shall be tested. The goal of this test period is to duplicate real-world usage of the signs. All diagnostic routines available at the central control point shall be run on a weekly basis with results documented and submitted to the Department. The field equipment tests shall include non-central functional tests of the locally installed equipment. In addition, any field diagnostic procedures must be conducted and documented at least once during the 30-day period. Weekly test reports shall be submitted to the Department during the 30-day Continuous Test.

Prior to starting the 30-Day Continuous Test, signs in the Richmond District shall be integrated with Department supplied central software as described earlier in these Special Provisions. Failure of the Department supplied central software shall not cause the 30 day test to be restarted. If the Department software malfunctions, the Department shall have 48 hours to remedy the failed software without additional compensation due to the Contractor. The Department reserves the right to have the Contractor continue testing with the Contractor supplied computer and central software without additional compensation due to the Contractor. The Department reserves the right to switch back from the Contractor software to

Department software anytime during the 30 day test. Downtime shall not count against the 30 days if caused by Department switchover of central software.

Should any element fail during the 30-Day Continuous Test, the current test period shall stop. The Contractor shall repair the problem, document the failure, and submit a detailed report to the Department. The Contractor must then demonstrate that the system is fully operational. The Department may request the Contractor to conduct the System Operational Test (or a portion thereof) once again. Once the system is fully operational, the Contractor shall submit for review and approval to the Department a new 30-Day Continuous Test schedule that conforms with the failure guidelines below. All aspects of repair and re-testing shall be done at no additional cost to the Department.

1. **Action in event of hardware failure:** Failures of any Contractor supplied hardware item during the test period shall necessitate restarting the 30 day test period for its full 30 day duration after its repair.
2. **Action in event of controller/firmware failure:** Any failure of this firmware or discovery of a firmware deficiency which causes a system malfunction shall cause the 30-Day Continuous Test to be halted and repeated in its entirety after correction of the firmware problem.
3. **Intermittent failures:** No intermittent failure shall be permitted to persist during the test period. If such problems are encountered, the test shall be terminated and restarted after the cause of the intermittent failure is identified and removed from the system.
4. **System shutdown for testing/correction:** The system may be shutdown for purposes of testing and correcting identified deficiencies. For each period of system shut down, the scheduled 30-Day Continuous Test shall be extended for the same period of time plus one day.
5. **Maximum downtime:** If the total number of system shut downs attributable to Contractor provided software or hardware exceeds three during the 30-Day Continuous Test, the tests shall be re-performed for the full 30 day period.

Logic tests are required for operator interface errors. The system shall not lockup and fail due to operator entry of data. Erroneous data may result in incorrect answers, but not system crashes. "Reasonableness" checks shall be made for operator data entry to assist in managing errors. Testing of the central equipment shall include demonstrating proper data transfer to and from each remote site.

- G. NTCIP Testing**—shall not commence until the 30-Day Continuous Test is successfully completed. The VMS will be tested by the Department or the Department's representative using the Federally developed and publicly available NTCIP Exerciser, or equivalent (for NTCIP 2101/2201) and SimpleSoft's SimpleTester or equivalent for NTCIP 2103/2202 and using the ENTERPRISE Test Procedures. The Contractor shall be responsible for ensuring that the VMS equipment complies with the NTCIP Standards as specified herein.
- H. LED Pixel Testing**—A complete pixel and cluster as required by the specifications herein shall be tested and certified by an independent testing laboratory for the following:

- Luminous intensity
- Operating voltage
- Drive current
- Voltage

Independent certification shall be provided to the Engineer at the factory acceptance testing.

## VIII. SYSTEM DOCUMENTATION

**A. General** - The Contractor shall supply all documentation necessary for proper identification, scheduling, installation, operation and maintenance of the entire Variable Message Sign System.

### **B. Equipment Documentation**

- 1. Submittal Prior to Equipment Purchase**—The Contractor shall provide six (6) copies of descriptive manuals or brochures for each type of equipment proposed for this project. No equipment shall be accepted for delivery or any payment made until approval of the corresponding submittal has been given by the Engineer. These documents shall contain sufficient technical data for the Engineer to evaluate the system proposed by the Contractor. The quality, function, and capability of each deliverable item shall be described. Manuals, brochures and certifications shall be originals or copies equal to originals. Documentation, catalog cuts and shop drawings submitted for review of VMS and cabinets shall be submitted to the Engineer as one complete package. Documentation furnished shall clearly define the VMS requirements indicated herein and shall be provided in the same order for review as the specifications are written.

Six copies of shop drawings shall also be required for each fabricated item. These drawings shall contain all information required for complete fabrication in accordance with the Plans and Specifications, such as: materials, welds, finish, mounting details, weight, overall dimensions, position of doors and control cabinet foundation detail. Shop drawings shall be on sheets 22 inches in height and 36 inches long. Shop drawings shall be submitted within 60 days after award of bid.

- 2. Documentation Prior to Installation**—The Contractor shall submit an installation summary for each field equipment location. This summary shall include the following information:
  - Equipment complement
  - A complete wiring diagram for each cabinet, covering every cable entering the cabinet.

- VMS software control manuals including hardcopies of every Management Information Base (MIB) used with an indication which MIB's have been used in which VMS.

- 3. Documentation after Installation**—The Contractor shall provide six (6) copies of all instructions and installation manuals. All relevant manuals available from the manufacturer shall be provided. The manuals shall contain sufficient information to operate and maintain the equipment including schematic, wiring, and interconnection diagrams; complete instructions for proper installation including equipment outlines, mounting, weight, power, and cooling requirements; a complete parts list and a list of recommended spares.

A new set of management Information Bases (MIB's) as described in Section V, shall be provided to the Department by the Contractor, if these MIB's have been altered since the delivery of the first set.

The Contractor shall also provide and attach to the inside of each variable message field controller cabinet a printed set of wiring diagrams. Drawings shall be attached to the door with stainless steel fasteners and protected from weather with a waterproof enclosure. A reproducible mylar original of each set of wiring diagrams shall be provided to the Department by the Contractor.

## IX. MEASUREMENT AND PAYMENT

**Variable Message Sign** will be measured in units of each and paid for at the contract unit price per each. This price shall include furnishing and installing the variable message sign unit, testing, protocol compliance, integration, conduits, control and power cables from the cabinet to the sign controllers in the field, telephone cable from the telephone interface box to the VMS control cabinet, wiring connections and hardware, modems, field controller, cabinet, uninterruptible power supply (UPS), concrete foundation, back panels, power panels, duplex groundfault convenience receptacles, thermostatically controlled fan units in the cabinet with a vent, radio frequency interference filters, lamps and receptacles, flexible cables, grounding systems, transient protection devices, fittings, and system documentation including: shop drawings, manuals, wiring diagrams, block diagrams, flow charts, MIB's and other material necessary to document the operation of the system.

**Fifty percent** of the unit price bid for this item will be paid upon delivery of the variable message sign unit and all equipment for each individual location to the job site in each District.

**Twenty percent** of the unit price bid for this item will be paid upon successful installation of the VMS on the overhead sign structure, installation of controller cabinet, sign controller, modem, telephone connection, electrical service, installation of sign controller software and all wiring of VMS to controller for a fully operational VMS at each job site in each District.

**Thirty Percent** of the unit price bid for this item will be paid upon successful completion of all testing as required in Section VII TESTING. Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>
Variable Message Sign	Each

**ANNEX A-2: VMS SPECIFICATIONS – SALEM DISTRICT 2001**

Parties interested in additional information should contact Mr. Michael L. Winn with VDOT at (804) 692-0308.

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VIRGINIA DEPARTMENT OF TRANSPORTATION  
SPECIAL PROVISION FOR  
**VARIABLE MESSAGE SIGN SYSTEM**

**Editor’s Note: (For Butterfly Structures Used in Salem District 2001)**

August 1, 2001

**I. DESCRIPTION**

This work shall consist of furnishing and installing LED variable message signs (VMS) associated control, operation, 120/240VAC power, telephone and monitoring equipment in accordance with these specifications and as directed by the Engineer.

**II. MATERIALS**

**A. Aluminum** for fabricated items shall conform to the requirements of Section 229 of the Specifications and shall be fabricated, welded and inspected in accordance with the requirements of Section 407 of the Specifications.

**B. Steel** for fabricated items shall conform to the requirements of Section 226 of the Specifications and shall be fabricated, welded and inspected in accordance with the requirements of Section 407 of the Specifications.

**C. Electrical Items** shall conform to the requirements of Section 238 of the Specifications.

**D. Galvanizing** shall conform to the requirements of Section 233 of the Specifications.

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**Annex A – Project-Specific NTCIP Items**

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**E. Hydraulic Cement Concrete** shall conform to the requirements of Section 217 of the Specifications.

**F. Paint** for the sign front and mask shall be a fluoropolymer based coating system containing KYNAR 500 resin or equivalent.

### **III. VARIABLE MESSAGE SIGN**

**D. Displays** - The sign displays shall be two types and conform to the following requirements:

- TYPE A shall be provided with 18 in. characters. TYPE B shall be provided with 12" characters. Both types shall be provided with 10 characters per line and three lines of display. Sign width shall not exceed 18 ft for TYPE "A" and 13 ft for TYPE "B". Pixel matrix shall be approximately 27 pixel rows in height by 60 pixel columns in width.
  - The sign display shall only consist of LEDs as specified in III.B.
  - Displays shall be full matrix. Pixels shall be evenly spaced.
  - Signs shall be designed to provide proper spacing between the lines of text for the characters and lines of text as indicated herein.
  - Sign displays shall have sufficient borders on all four sides for display clarity and background contrast. Border dimensions shall be indicated on detail submitted for contract review.
  - TYPE A sign displays shall be legible from a distance of 1000 feet when displaying 18 in. characters. TYPE B sign displays shall be legible from a distance of 700 feet when displaying 12 in. characters. Legibility of displays shall include daylight hours with direct sunlight on the face and behind the VMS.
  - The sign displays shall be capable of graphic displays upon upgrade of software.
  - The time required to clear any display and post any new display shall not exceed 500 milliseconds.
- B. LEDs** - All LEDs provided for the manufacture of VMS shall conform to the following minimum requirements:

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**Annex A – Project-Specific NTCIP Items**

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- LEDs shall be untinted, non-diffused, high-output, solid state lamps utilizing aluminum indium gallium phosphide (AlInGaP) LED technology.
  - LEDs shall emit a true amber color at a wavelength of 592 nm ( $\pm 4$ nm).
  - Size of the LED shall be T-1 $\frac{3}{4}$  (5 mm).
  - LEDs shall be nominally rated for 100,000 hours of operation under field conditions, which shall include operating temperatures between -22° and +185°F (-30° and +85° C).
  - LEDs shall have a 22° viewing angle. Note: Larger viewing angle LEDs may be utilized providing the viewing legibility distance is provided as indicated herein.
  - LEDs shall be of the same degree viewing angle and of the same manufacturer for all signs.
  - LEDs shall have no less than 50% of the normalized intensity at their 22° viewing angles.
  - LEDs shall be soldered to circuit boards with through-hole type of circuit board mounting. Surface mounting of LEDs will not be allowed.
- C. Pixel's**—Each light emitting pixel of an LED display shall consist of a cluster of closely spaced LED's. LED pixels shall conform to the following requirements:
- Pixels shall be constructed with strings of LEDs. The number of LEDs in each string shall be determined by the manufacturer as required to produce the candela requirement as stated herein.
  - LED pixels shall produce the luminous intensity levels required herein at a drive current of 20 mA per string with a forward voltage drop not to exceed 24 VDC. The LED drive current shall be adjustable up to and shall not be allowed to exceed 30 mA per string.
  - Type A 18 in. pixel's shall produce a luminous intensity of 40 Cd when driven with a LED drive current of 20 mA per string.
  - Type B 12 in. pixels shall produce a luminous intensity of 20 Cd when driven with a led drive current of 20 mA per string.

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**Annex A – Project-Specific NTCIP Items**

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- Pixels shall be driven with direct-drive pulse width modulation. Maximum pulse amplitude shall not exceed 30 mA.
  - Materials used in the fabrication of LED clusters shall contain UV light inhibitor and shall be designed for direct exposure to sunlight.
  - Each LED pixel shall be rated for outdoor use over the environmental range expected for the sign locations (including heat absorption due to sunlight).
  - LED pixels shall be attached to the display panel with a secure fastening system.
  - LED pixels shall be mounted perpendicular to the display panel.
  - LED pixels shall be replaceable either individually or in groupings. Groupings with three or more pixels shall be permitted only if bench level repairs and replacements to individual pixels are possible.
  - Pixels shall be replaceable from the inside rear of the display. Clusters shall be interchangeable between signs employing the same display technology.
  - Characters formed by the VMS displays shall have a minimum of seven (7) pixels in height. The number of pixels making up the character width shall vary by character and shall be in accordance with the characters described herein.
  - The pixel pitch, or center to center spacing, shall be such that seven (7) pixels in height shall produce a character 18 in. in height for the type "A" and 12 in. in height for the type "B" ( $\pm 0.5\%$ ) measured from the top of the top pixel to the bottom of the bottom pixel.
- D. Power Supplies**—Power supplies shall operate from 120 VAC power. The LED displays shall be operated at low internal DC voltage not exceeding 24 VDC. Power supplies shall be solid state electronic regulated output. Signs shall be powered with two or more supplies for each 1/3 of the display. Power supplies shall be wired in redundant parallel configuration for each section and shall provide equal amounts of current to each section. Power supplies shall be rated such that if one supply fails, the other can operate the entire LED section under full load conditions. Power supplies shall operate from -22° to +140°F (-30° to +60°C).

Power supplies shall be short circuit protected by DC power off and shall reset automatically after 5 seconds of AC power off. Power supplies shall also be protected by a minimum overload allowance of 105% and have an efficiency rating of at least 75%. Power supply shall be UL listed if the power supply is manufactured by specific power supply manufacturer. Power supplies shall be installed with the terminals/connectors unobstructed by hardware or

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**Annex A – Project-Specific NTCIP Items**

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mounting brackets. The operator shall be able to read the terminal designations and measure voltages without removing the power supply or obstructions.

- E. Sign Housings, Faces, Framing and Mounting Members**—VMS housings shall be ground mount butterfly. Sign housings shall be constructed of aluminum, alloy 5052 H34, and shall not be less than 1/8-inch thick. Seams shall be continuously welded except for the KYNAR 500 coated sign face. Framing structural shapes shall be constructed of aluminum, alloy 6061-T6. Non-corrosive materials shall be used where possible and corrosion protection shall be provided between dissimilar metals. Sign cases shall be cleaned and de-oxidized after welding. The front of the cases shall be finished matte black.

Signs shall have polycarbonate sign face coverings. Coverings shall be weather tight, ultraviolet protected, non-diffusing, polycarbonate 1/8-in. thick. Polycarbonate sign face shall be covered with a .090 inch minimum thickness aluminum mask. Aluminum mask shall provide openings directly in front of each pixel. Pixel openings shall be of sufficient size as to not interfere with LED light output. Sign face shall be designed to minimize bowing.

Sign housing, windows, framing and mounting members shall be designed to conform to the requirements of the *2001 (4<sup>th</sup> edition) of AASHTO's Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* and the following clarifications:

- Basic wind speed shall be used in the designs. Alternate method for wind pressures (Appendix C) shall not be used.
- When the installation location of the structures being designed lie between isotachs, the basic wind speed shall be determined by using the higher adjacent isotach.
- Any optional design parameters indicated in the AASHTO specification that are allowed when acceptable to the owner shall not be used for the designs.

Signs shall be constructed to present a clean, neat appearance; and the equipment located therein shall be protected from moisture, dust, dirt and corrosion. Sign enclosures shall contain small weep holes for draining moisture that accumulates in the signs from condensation. Weep holes shall be designed to prevent the entrance of insects.

Signs shall be attached to ground mounted butterfly sign structures in accordance with attached drawing for butterfly sign structures. VMS shall be angled towards lane of travel for optimum viewing of the sign. Contractor shall review foundation and sign positions with the Engineer prior to installation of foundation and VMS.

Number of Z-bars needed and the method of attaching the Z-bars to the sign housing shall conform to the *2001 4<sup>th</sup> edition of AASHTO's Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* and the following clarifications:

- Basic wind speed shall be used in the designs. Alternate method for wind pressures (Appendix C) shall not be used.
- When the installation location of the structures being designed lie between isotachs, the basic wind speed shall be determined by using the higher adjacent isotach.

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**Annex A – Project-Specific NTCIP Items**

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- Any optional design parameters indicated in the AASHTO specification that are allowed when acceptable to the owner shall not be used for the designs.

Lifting eyes or the equivalent shall be provided for moving and mounting signs. VMS housings shall be designed such that the VMS can be shipped and temporarily stored without damage or undue stresses prior to installation on the support structure. VMS shall be shipped with a temporary wood support frame that will permit the shipping/storage of the VMS in an above-ground vertical position without damage to the sign housing. The Contractor shall remove the lifting eyes from the VMS after installation. Holes shall be sealed with a bolt and nylon washer and secured in place with nut and lock washer. The holes shall then be sealed with clear silicone sealant on both the outside and inside. The lifting eyes shall be stored in the VMS cabinet for future use.

Exterior of sign housing shall not have any decals or ID plates of any kind attached to the housing.

**F. Design of Housings**

All VMS equipment, components, modular assemblies, and other materials located in the VMS housing shall be removable, transportable, and capable of being installed by a single technician utilizing a one-person aerial lift truck. Structural members and components thereof are not included in this requirement.

Housings shall have interior non-corrosive, metal cage support frames to mount the display clusters. The cage support frame shall be designed to withstand and minimize vibrational effects to the display and/or electronics.

Access door(s) shall be installed on the VMS housing. VMS doors shall be furnished with a door lock(s) that is keyed to the Department's standard tumbler lock number 9R48773.

Doors shall be provided with door switch(s) and control wiring for office monitoring of door(s) when open.

- G. Circuit Breaker Panel Box**—The VMS housing shall include a circuit breaker panel box installed inside the cabinet for power to circuits inside the cabinet. Main power to the circuit breaker panel box shall be from the main service disconnect. Circuit breakers and wiring shall be rated and in accordance with the NEC.

- H. Cooling Fans** - Signs shall contain vented thermostatically controlled fans with filters which shall be used to circulate the air inside the enclosures for cooling. Cooling fans shall be located behind the display modules and shall blow air directly on the back of the LED pixels once the internal VMS air temperature reaches 100° F. Fans shall be designed to provide the CFM required to properly cool the enclosure and display modules. Fans shall operate from 120-volt, 60-Hz, single phase, AC power. Vents for fan intake and exhaust shall be weatherproof in design.

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**Annex A – Project-Specific NTCIP Items**

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- I. **Temperature Sensor**—Cabinet shall be provided with an adjustable temperature sensor to monitor the interior temperature of the VMS. Sensor shall be selectable from 90° to 150°F ( $\pm 10^\circ$ ). Sensor shall be wired to VMS field controller for control as required in Section IV. F. 4.
- J. **Serviceable Parts**—LED driver boards shall be in the VMS housings for all signs. Plug-in locking connectors shall be provided on each driver board for all connections. Connectors shall be held in place with screws. Driver boards shall be easily removable for service/replacement with simple hand tools. Driver boards and all electronic circuit boards installed in the VMS housing shall be thoroughly coated with an acrylic conformal coating for moisture-resistance.
- K. **Transient Protection**—Variable message sign control cables shall be protected at their point of connection in the sign by grounded metal oxide varistors or approved equivalent devices. The metal case of each sign shall be electrically bonded to the support structure at all mounting bolt locations. The bonding shall consist of an electrical bond wire or properly prepared electrical contact points. The structure, in turn, shall be electrically bonded to earth ground.
- L. **Other**—The Contractor shall provide any other equipment required in order to monitor and control the VMS/DMS and associated equipment per these specifications.

**IV. VARIABLE MESSAGE SIGN FIELD CONTROLLER**

- A. **General**—Each sign shall include an associated controller, which shall be installed in each cabinet on the sign structure. Laptop computer and necessary equipment to program sign controllers shall be provided by the Contractor and remain property of the Contractor.

Controllers shall be installed to operate over dial-up telephone lines.

Controllers shall be a microprocessor based intelligent unit, capable of controlling and monitoring all of the variable message sign and associated functions as described within these specifications. Controllers shall be integral units with their own power supplies. Controllers shall be housed in durably fabricated aluminum enclosures. Controller's volume, and power supplies, shall not exceed five cubic feet and shall fit inside the controller cabinet.

- B. **Memory**—Controllers shall have both permanent and changeable memory. Permanent memory shall be in the form of plug-in EEPROM integrated circuits and shall contain the software. Changeable memory shall be in the form of RAM integrated circuits with a lithium battery backup (or other approved backup) that retains the data in memory for a minimum of one year following a power failure. Changeable memory shall contain all of the changeable operating parameters including the set-able data defined by the NTCIP requirements of Section IV.F.

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**Annex A – Project-Specific NTCIP Items**

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- C. Data Transmission Requirements**—Each controller shall have a minimum of two TIA/EIA-232E communication ports: one for the central computer, which shall be labeled “CENTRAL,” and one easily accessible for the maintenance technician, which shall be labeled “LAPTOP.” Each of these ports shall be capable of operation at all industry standard speeds up to 19,200 bits per second and shall support all of the Subnet Profiles defined in Section V.C.1. It shall be possible for a maintenance technician to directly connect a laptop computer to the “LAPTOP” port via a direct serial cable, and carry out all operations that could be carried out by the central computer via the “CENTRAL.” All other communication requirements such as checksum and parities are specified by NTCIP per Section V.

Installation of telephone service will be coordinated by VDOT (Salem district) for each VMS. The Contractor shall install all cable and connections between the telephone interface box and the VMS/DMS modem(s). The Contractor shall provide 8 weeks notice to the Engineer prior to telephone service installation. The VMS/DMS control cabinet shall be installed prior to requesting telephone service.

- D. Clock**—Controller shall contain a computer-readable time-of-year clock with a lithium battery or other equivalent backup. Back up shall keep the clock operating properly for at least 10 years without external power. Clock shall automatically adjust for daylight saving time and leap year through hardware or software or a combination of both. It shall be set by the sign controller's microprocessor. Clock shall be accurate to within 1 minute per month. Clock shall be Y2K compliant.
- F. Local Interface**—The controller shall support a local user interface in addition to the laptop interface. At a minimum, the local user interface shall allow the user to display a test message on the sign. If the local interface allows the user to display any other messages, the user shall be prompted to enter a password, which shall be stored and verified by the sign controller. Password shall not be echoed on the operator interface when entered by the user. Controllers shall be initially shipped with the password VMSSIM. The sign controller shall store a minimum of three (3) passwords that are user configurable.

**F. Controller Software**

- 1. Display Presentation**—VMS controller shall control the driver modules in such a way as to create the desired display on the sign. At a minimum, the signs shall be able to display the characters as described in Section V.C.4.(e). Space allocated to each character shall be proportional to the character's true width.
- 2. Display Selection**—The controller shall implement the display per the logic defined in the NTCIP documentation referenced in V. Per the recent NTCIP DMS WG interpretation, the schedule shall control the sign display when the current buffer is set to reference the scheduled message.
- 3. Dimming System**—With each VMS display and controller, the Contractor shall furnish and install a system which shall sense the background ambient light level and provide a minimum of sixteen field adjustable intensities (dimming). Dimming shall be implemented

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**Annex A – Project-Specific NTCIP Items**

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with high frequency variation of the display duty cycle (pulse width modulation). The frequency shall be selected to minimize any detrimental flickering.

The dimming system shall conform to the following minimum requirements:

- a. **Photo-Electric Sensors**—The dimming system shall contain three photo-electric sensors installed in water-tight metal enclosures on the VMS housing. The photo-electric sensors shall have a 0.25 in. (minimum) photo-sensitive area. The photo-electric sensors shall be capable of being continually exposed to direct sunlight without impairment of performance. The water-tight metal enclosure shall have a 1.00 square in. (minimum) glass window area. The photo-electric sensors shall be placed so that they sense the ambient light levels striking the front, and rear of each sign.
- b. **Dimming Levels**—Manual and automatic dimming modes shall be provided enabling the user to select the desired mode of operation.

The dimming system shall select one of sixteen levels from the sensed ambient light. The set points for each of the sixteen ambient light levels shall be set within user adjustable software.

- c. **Interference**—The dimming circuit and VMS power system shall have electrical devices installed to minimize RFI noise generated by the VMS both on the power line and radiated by sign circuitry.

#### 4. Exception Reporting

The sign controller shall issue an SNMP trap under the following conditions:

- **Power Supply Failure**—The sign controller shall be capable of sensing the failure of each individual power supply. When one of the power supplies in a group has failed, the sign controller shall issue an SNMP trap.
- **Power Restoration**—Whenever the sign controller detects restoration of AC power at the sign controller, it shall issue an SNMP trap.
- **Temperature Limit**—Whenever internal VMS temperature initially exceeds programmed safety limit, the sign controller shall issue a new trap, another trap will not be issued until the temperature once again falls below the safety limit and then exceeds it.
- **Door Open**—Whenever the door of the VMS housing or the door of the controller cabinet is opened, the sign controller shall issue a trap.

The format and precise definitions of the traps will be provided to the contractor after award of the contract.

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If the connection is dial-up, the controller shall additionally initiate a phone call to the central computer as necessary. If the central computer's line is busy, the sign controller shall keep trying at intervals selectable by the operator until it gets through. When it does connect with the central computer, it shall transmit the appropriate SNMP trap. Sign controller shall automatically disconnect dial-up communications within one (1) minute if communications is not sensed from the central computer to the sign controller.

The controller shall have a minimum of two serial ports: one for the central computer and one easily accessible for the maintenance technician. Each serial port shall support all of the Subnet Profiles defined in Section V. C. 1. It shall be possible for a maintenance technician to connect a laptop computer to the remote control port, and carry out all operations that could be carried out by the central computer.

5. **Controller ID**—A 4 byte IP Network Address shall be assignable to each controller so that SNMP Trap messages are able to identify the originating sign.
6. **Diagnostic Test**—Upon command from a remote computer, the controller shall test the electrical operation of all drivers and the over current, under current and normal current of the pixels. Field controller shall analyze the pixel current and determine whether the pixel is operating with “normal,” “under,” or “over,” current and shall communicate the result using a Department specified NTCIP compatible message. The format of these objects will be provided to the contractor after award of the contract.
7. **Power Interruptions**—The contents of the controller's memory shall be preserved by battery power during power interruptions and the controller shall resume operation automatically when power is restored. Upon recovering from a power interruption, the controller shall report to the central computer that it has just recovered from a power interruption per Section IV. F. 4.
8. **Software Duplication Rights** - The Department shall have the right to duplicate the sign controller software as needed for use in controlling signs under its jurisdiction. VDOT and its agents, shall have the right to reverse engineer the communications interface to the sign as necessary, in order to debug the system and perform systems integration activities in the future.

## 6-4 COMMUNICATION REQUIREMENTS

This portion of the specification defines the detailed Communication requirements for the Dynamic Message Signs covered by the procurement package.

### A. Definitions

The following terms shall apply within the scope of this procurement specification:

DMS - A Dynamic Message Sign, includes the sign display, controller, cabinet, and other associated field equipment. The specific type of dynamic message sign (i.e., blank-out sign, changeable message sign, character matrix sign, full-matrix

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sign, etc.) for this procurement is specified elsewhere within this procurement specification.

**FSORS - Full, Standardized Object Range Support**

Full, Standardized Object Range Support – Support for, and proper implementation of, all valid values of an object as defined within the object's OBJECT-TYPE macro in the subject NTCIP standard; this is further defined in two distinct sub-requirements. (1) If the ACCESS of the object is read-write, a Management System shall be able to set the object to any valid value as defined by the SYNTAX and DESCRIPTION fields (except that the value of 'other' need not be supported when such a value is defined) and the indicated functionality shall be provided. (2) The value indicated by the object (e.g., in response to a 'get'), regardless of the ACCESS, shall reflect the current condition per the rules specified in the object's DESCRIPTION.

**Management System**—A computer system used to control an NTCIP component. This includes any laptop software used for field control as well as the central control software.

**NTCIP**—National Transportation Communication for ITS Protocol

**NTCIP Component**—A DMS or a Management System.

**NTCIP System**—A Management System plus the various ASCs and DMSs controlled by the Management System.

**Response Time**—The time to prepare and begin transmission of a complete response containing the requested Application Layer information. This is measured as the time from receipt of the closing flag of the request to the transmission of the opening flag of the response when the device has immediate access to transmit.

**B. References**

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

Each NTCIP Component covered by these project specifications shall implement the most recent version of the standard that is at the stage of Recommended or higher as of March 30, 2001, including any and all Approved or Recommended Amendments to these standards as of the same date. For any referenced document which is not yet at the Recommended level, the version cited below shall be used. If the Contractor wishes to use later versions of these standards, the Engineer's approval is required. It is the ultimate responsibility of the Contractor to monitor NTCIP activities to discover any more recent documents.

**Table 1: NTCIP Standards**

<b>Abbreviated Number</b>	<b>Full Number</b>	<b>Title</b>	<b>Known Amendments</b>
NTCIP 1101	<b>NTCIP 1101:1997</b> (NEMA TS 3.2-1996)	Simple Transportation Management Framework	Amendment #1:2001 dated November 2,

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			1998.
NTCIP 1201	<b>NTCIP 1201:1997</b> (NEMA TS 3.4-1996)	Global Object Definitions	Amendment #1:2001 dated November 2, 1998.
NTCIP1203	<b>NTCIP 1203:1997</b> (NEMA TS 3.6-1997)	Object Definitions for Dynamic Message Signs	
NTCIP 2001	<b>NTCIP 2001:1997</b> <b>(NEMA TS 3.3-1996)</b>	Class B Profile	Amendment #1 dated November 2, 1998.
NTCIP 2101	<b>NTCIP 2101v01.17</b> <b>(Recommended)</b>	Subnet Profile for PMPP over RS-232	
NTCIP 2103	<b>NTCIP 2103v01.05 (User Comment)</b>	Subnet Profile for Point-to-Point Protocol over RS-232	
NTCIP 2202	<b>NTCIP 2202v01.04</b> <b>(Recommended)</b> (NEMA TS 3.Internet	Internet Transport Profile	

C. General Requirements

1. Subnet Level

Each serial port on each NTCIP Component shall support NTCIP 2103 over a dial-up connection with a contractor provided external modem with data rates of 56 kbs, 33 kbs, 28.8 kbps, 19.2 kbps, 14.4 kbps, 9600 bps, 4800 bps, 2400 bps, 1200 bps, 600 bps, and 300 bps. The NTCIP Component shall be able to make outgoing and receive incoming calls as necessary and support the following modem command sets:

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

Each serial port on each NTCIP Component shall support NTCIP 2103 over a null-modem connection with data rates of 19.2 kbps, 14.4 kbps, 9600 bps, 4800 bps, 2400 bps, 1200 bps, 600 bps, and 300 bps.

Each serial port on each NTCIP Component shall support NTCIP 2101 with data rates of 9600 bps, 4800 bps, 2400 bps, 1200 bps, 600 bps, and 300 bps.

All “CHAP” secrets shall be user configurable via the CHAP Secret Table.

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

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2. Transport Level

Each NTCIP Component shall comply with NTCIP 2000 when using the NTCIP 2101 Subnet Profile.

Each NTCIP Component shall comply with NTCIP 2202 when using the NTCIP 2103 Subnet Profile.

NTCIP Components may support additional Transport Profiles at the manufacturer's option. Response datagrams shall use the same Transport Profile used in the request.

3. Application Level

Each NTCIP Component shall comply with NTCIP 1101 and shall meet the requirements for Conformance Level 1 (NOTE - See Amendment to standard).

Each NTCIP Component shall support the standard SNMP traps as well as those traps as defined in IV.F.

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

4. Information Level

Each NTCIP Component shall provide Full, Standardized Object Range Support of all objects required by these procurement specifications unless otherwise indicated below. The maximum Response Time for any object or group of objects shall be 200 milliseconds.

The DMS shall support all mandatory objects of all mandatory Conformance Groups as defined in NTCIP 1201 and NTCIP 1203. Table 2 indicates the modified object requirements for these mandatory objects.

**Table 2: Modified Object Ranges for Mandatory Objects**

Object	Reference	Project Requirement
moduleTableEntry	NTCIP 1201 Clause 2.2.3	Shall contain at least one row with moduleType equal to 3 (software). The moduleMake shall specify the name of the manufacturer, the moduleModel shall specify the manufacturer's name of the component and the modelVersion shall indicate the model version number of the component.
maxGroupAddresses	NTCIP 1201 Clause 2.7.1	shall be at least 1
communityNamesMax	NTCIP 1201 Clause 2.8.2	Shall be at least 3
ChapMaxSecrets	NTCIP 2103 Annex B	Shall be at least 3;

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		Upon delivery, the names shall be VMSSIM1, VMSSIM2 and VMSSIM3 and the secrets shall be identical to the name.
dmsNumPermanentMsg	NTCIP 1203 Clause 2.6.1.1.1.1	Shall be at least 1*
dmsMaxChangeableMsg	NTCIP 1203 Clause 2.6.1.1.1.3	Shall be at least 21
dmsFreeChangeableMemory	NTCIP 1203 Clause 2.6.1.1.1.4	Shall be at least 20 when no messages are stored.
dmsMessageMultiString	NTCIP 1203 Clause 2.6.1.1.1.8.3	The DMS shall support any valid MULTI string containing any subset of those MULTI tags listed in Table 4
dmsControlMode	NTCIP 1203 Clause 2.7.1.1.1.1	Shall support at least the following modes: local external central centralOverride

\* The Permanent Messages shall display the content shown in Table 3.

**Table 3: Content of Permanent Messages**

Perm. Msg. Num.	7. DESCRIPTION
1	Shall be a test message that allows the user to determine if all pixels are properly and configured for their actual locations in the display.

**Table 4: Required MULTI Tags**

Code	Feature
f1	field 1 - time (12hr)
f2	field 2 - time (24hr)
f8	field 8 - day of month
f9	field 9 – month
f10	field 10 - 2 digit year
f11	field 11 - 4 digit year
fl (and /fl)	flashing text on a line by line basis with flash rates controllable in 0.5 second increments.
fo	font
jl2	justification – line - left

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jl3	justification – line - center
jl4	justification – line - right
jl5	justification – line - full
jp2	justification – page - top
jp3	justification – page - middle
jp4	justification – page - bottom
mv	moving text
nl	new line
np	new page, up to 2 instances in a message (i.e., up to 3 pages/frames in a message counting first page)
pt	page times controllable in 0.5 second increments.

The NTCIP Component shall also implement all mandatory objects of the following optional conformance groups.

(b) Time Management, as defined in NTCIP 1201

(b) Timebase Event Schedule, as defined in NTCIP 1201. The following list indicates the modified object requirements for this conformance group.

**Table 5: Modified Object Ranges for the Timebase Event Schedule Conformance Group**

Object	Reference	Project Requirement
maxTimeBaseScheduleEntries	NTCIP 1201 Clause 2.4.3.1	Shall be at least 28
maxDayPlans	NTCIP 1201 Clause 2.4.4.1	Shall be at least 14
maxDayPlanEvents	NTCIP 1201 Clause 2.4.4.2	Shall be at least 10

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

**Table 6: Modified Object Ranges for the Report Conformance Group**

Object	Reference	Project Requirement
maxEventLogConfigs	NTCIP 1201 Clause 2.5.1	Shall be at least 50
eventConfigurationMode	NTCIP 1201 Clause 2.4.3.1	The NTCIP Component shall support the following Event Configuration Modes: onChange greaterThanValue

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		smallerThanValue
maxEventLogSize	NTCIP 1201 Clause 2.5.3	Shall be at least 200
maxEventClasses	NTCIP 1201 Clause 2.5.5	Shall be at least 16

(e) Font Configuration, as defined in NTCIP 1203. The following list indicates the modified object requirements for this conformance group.

**Table 7: Modified Object Ranges for the Font Configuration Conformance Group**

Object	Reference	Project Requirement
numFonts	NTCIP 1203 Clause 2.4.1.1.1.1	Shall be at least 4*
maxFontCharacters	NTCIP 1203 Clause 2.4.1.1.1.3	Shall be at least 127**

\*Upon delivery, the first font shall be a standard 18 in. (Type A Sign / (12 in. Type B Sign) font. The second font shall be a double-stroke 18"/12" font. The third font shall be a 28.3 in./ 18.9 in.font. The fourth font shall be empty.

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

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

(f) VMS Configuration, as defined in NTCIP 1203.

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

**Table 8: Modified Object Ranges for the MULTI Configuration Conformance Group**

Object	Reference	Project Requirement
defaultBackgroundColor	NTCIP 1203 Clause 2.5.1.1.1.1	The DMS shall support the following background colors: black
defaultForegroundColor	NTCIP 1203 Clause 2.5.1.1.1.2	The DMS shall support the following foreground colors: amber
defaultJustificationLine	NTCIP 1203 Clause 2.5.1.1.1.6	The DMS shall support the

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		following forms of line justification: left center right full
defaultJustificationPage	NTCIP 1203 Clause 2.5.1.1.1.7	The DMS shall support the following forms of page justification: top middle bottom
defaultPageOnTime	NTCIP 1203 Clause 2.5.1.1.1.8	The DMS shall support the full range of these objects with step sizes no larger than 0.5 seconds
defaultPageOffTime	NTCIP 1203 Clause 2.5.1.1.1.9	The DMS shall support the full range of these objects with step sizes no larger than 0.5 seconds
defaultCharacterSet	NTCIP 1203 Clause 2.5.1.1.1.10	TheDMS shall support the following character sets: eightBit

(h) Multi Error Configuration, as defined in NTCIP 1203

(i) Illumination/Brightness Control, as defined in NTCIP 1203. The following list indicates the modified object requirements for this conformance group.

**Table 9: Modified Object Ranges for the Illumination/Brightness Control Conformance Group**

Object	Reference	Project Requirement
dmsIllumControl	NTCIP 1203 Clause 2.8.1.1.1.1	The DMS shall support the following illumination control modes: photocell timer manual
dmsIllumNumBrightLevels	NTCIP 1203 Clause 2.8.1.1.1.4	Shall be at least 16

(j) Scheduling, as defined in NTCIP 1203. The following list indicates the modified object requirements for this conformance group.

**Table 10: Modified Object Ranges for the Scheduling Conformance Group**

Object	Reference	Project Requirement
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numActionTableEntries	NTCIP 1203 Clause 2.9.1.1.1.1	Shall be at least 21
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- (k) Sign Status, as defined in NTCIP 1203
- (l) Status Error, as defined in NTCIP 1203
- (m) Pixel Error Status, as defined in NTCIP 1203

The NTCIP Component shall also implement the following optional objects:

**Table 11: Optional Object Requirements**

Object	Reference	Project Requirement
globalSetIDParameter	NTCIP 1201 Clause 2.2.1	FSORS
eventConfigLogOID	NTCIP 1201 Clause 2.5.2.7	FSORS
eventConfigAction	NTCIP 1201 Clause 2.5.2.8	FSORS
eventClassDescription	NTCIP 1201 Clause 2.5.6.4	FSORS
defaultFlashOn	NTCIP 1203 Clause 2.5.1.1.1.3	The DMS shall support the full range of these objects with step sizes no larger than 0.5 seconds
defaultFlashOff	NTCIP 1203 Clause 2.5.1.1.1.4	The DMS shall support the full range of these objects with step sizes no larger than 0.5 seconds
dmsSWReset	NTCIP 1203 Clause 2.7.1.1.1.2	FSORS
dmsMessageTimeRemaining	NTCIP 1203 Clause 2.7.1.1.1.4	FSORS
dmsShortPowerRecoveryMessage	NTCIP 1203 Clause 2.7.1.1.1.8	FSORS
dmsLongPowerRecoveryMessage	NTCIP 1203 Clause 2.7.1.1.1.9	FSORS
dmsShortPowerLossTime	NTCIP 1203 Clause 2.7.1.1.1.10	FSORS
dmsResetMessage	NTCIP 1203 Clause 2.7.1.1.1.11	FSORS
dmsCommunicationsLossMessage	NTCIP 1203 Clause 2.7.1.1.1.12	FSORS
dmsTimeCommLoss	NTCIP 1203 Clause 2.7.1.1.1.13	FSORS
dmsEndDurationMessage	NTCIP 1203 Clause 2.7.1.1.1.15	FSORS

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dmsMemoryMgmt	NTCIP 1203 Clause 2.7.1.1.1.16	The DMS shall support the following Memory Management Modes: normal clearChangeableMessages clearVolatileMessages
DmsMultiOtherErrorDescription	NTCIP 1203 Clause 2.7.1.1.1.20	If the vendor implements any vendor-specific MULTI tags, the DMS shall provide meaningful error messages within this object whenever one of these tags generates an error.
DmsIllumLightOutputStatus	NTCIP 1203 Clause 2.8.1.1.1.9	FSORS
WatchdogFailureCount	NTCIP 1203 Clause 2.11.1.1.1.5	FSORS
DmsStatDoorOpen	NTCIP 1203 Clause 2.11.1.1.1.6	FSORS
FanFailures	NTCIP 1203 Clause 2.11.2.1.1.8	FSORS
FanTestActivation	NTCIP 1203 Clause 2.11.2.1.1.9	FSORS
TempMinCtrlCabinet	NTCIP 1203 Clause 2.11.4.1.1.1	FSORS
TempMaxCtrlCabinet	NTCIP 1203 Clause 2.11.4.1.1.2	FSORS
TempMinSignHousing	NTCIP 1203 Clause 2.11.4.1.1.5	FSORS
TempMaxSignHousing	NTCIP 1203 Clause 2.11.4.1.1.6	FSORS

D. Documentation

Software shall be supplied with full documentation, including 3.5" floppy disk(s) and a CD-ROM containing ASCII versions of the following Management Information Base (MIB) files in Abstract Syntax Notation 1 (ASN.1) format:

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

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- A MIB Module in ASN.1 format containing any and all manufacturer-specific objects supported by the device with accurate and meaningful DESCRIPTION fields and supported ranges indicated in the SYNTAX field of the OBJECT-TYPE macros.
- A MIB containing any other objects supported by the device.

The manufacturer shall allow the use of any and all of this documentation by any party authorized by VDOT for systems integration purposes at any time initially or in the future, regardless of what parties are involved in the systems integration effort.

**E. Acceptance Testing**

The acceptance test will use the NTCIP Exerciser, or other authorized testing tool and will follow the guidelines established in the ENTERPRISE Test Procedures. The Department reserves the right to enhance these tests as deemed appropriate to ensure device compliance. NTCIP testing is further described in Section VII. G.

**F. Interpretation Resolution**

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

**VI. VARIABLE MESSAGE SIGN FIELD CONTROLLER CABINET**

Cabinets for variable message sign field controllers shall be NEMA 3R, weatherproof and constructed of welded sheet aluminum, mill finish, 0.125-in. minimum thickness, conforming to ASTM B209, alloy 5052-H32. Cabinet mounting attachments shall be durable, corrosion resistant and of heavy duty construction. All seams shall be continuous welds, free from irregularities.

Cabinets shall be of sufficient size to house required equipment and shall be installed on the Structure. Cabinets shall be attached to the structure with stainless steel bands and sufficient supports to support the weight the cabinet with all equipment installed. Cabinet shall be installed on the backside of the sign structure 180 degrees from the front of the DMS sign. Cabinet shall be installed approximately 4 foot from the ground to the center of the cabinet.

Note: Some locations may require cabinets to be positioned on the side or front of the structure as indicated by the Engineer.

A concrete pad shall be installed as part of the structure foundation and shall project to the rear side or front (as required) of the sign for maintenance technicians to stand while working in the control cabinet. Concrete pad shall extend 4 ft and be the same width as the structure foundation.

The cabinet shall include conduits from the cabinet to the VMS for power and control cables to enter and exit the cabinet.

Cabinet doors shall provide full access to the cabinet interior and shall be gasketed to assure weatherproofing. The door(s) shall be equipped with the Department's standard tumbler lock

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Number 9R48773. Two (2) keys for each lock shall be provided. All hinges and handles shall be stainless steel. Cabinet doors shall have a door stop arrangement that will allow it to be firmly positioned at both 90° and 135° ±10°. The locking mechanism shall be a three-point draw roller system. Rollers shall be fabricated from nylon with a diameter of at least 8/10 in. The door opening shall be double flanged on all four sides. The top of the cabinet shall be sloped to provide for the drainage of water away from the door.

Cabinets shall contain adjustable shelves or equivalent supports or rack mounting with sufficient space to adequately hold the electronic equipment. Rack mounting of equipment shall provide access to all equipment within the cabinet and accessibility to all wiring without removing the rack. The vertical mounting channels for the shelves shall be continuous and shall allow for shelf placement as close as 5 in. from the top and bottom of the cabinet. A slide out drawer shall be provided in the cabinet for placement of a laptop computer. The slide out drawer shall be of sufficient dimensions to adequately hold the laptop with the screen open for on site operation of the local VMS sign controller. The slide out drawer shall be provide with a hinged top with sufficient storage of cabinet and VMS manuals and drawings in the slide out drawer. The equipment and terminals shall be so arranged within the cabinet that they will not interfere with the entrance, tracing and connection of conductors. All wiring panels (terminal blocks) shall be neatly finished and clearly and permanently marked with identifications applied by silk screening. All conductors and communication cable shall be neatly arranged in the cabinet and bundled in groups with cable ties.

All AC circuit wiring shall be a minimum Number 14 AWG stranded copper rated at 600 volts. All DC circuit wiring shall be a minimum Number 20 AWG stranded copper rated at 600 volts. Ribbon cable will not be allowed for cabinet wiring.

Accessory and Auxiliary Equipment - As a minimum, cabinets shall be furnished with the following:

- Duplex ground fault convenience receptacle
  
- Modems shall have a raw data-transfer speed of 56k and shall conform to Microcom Networking Protocol (MNP) classes 2 through 5, and International Telecommunications Union (ITU) V.90, V.42 and V.42bis standards. Modems shall be capable of communicating with 56k, 33,600, 28,800, 14,400, 9600, 2400 and 1200 bps modems and shall automatically adjust the data rate and modulation to accomplish this. Modems shall interface with the sign controller data port for transmitting of data via conventional dial up telephone. Modems shall have auto dial/auto answer features. Modems shall be capable of operation within an operating ambient temperature range from 0°C to +40°C, and an operating relative humidity range up to 95%, non-condensing. Modems shall support the Hayes AT Command Set and have at least the following function indicators for identifying modem operation:

-- Carrier detect

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- Auto answer on
  
- Modem ready
  
- Terminal ready
  
- Modem has taken phone off hook
  
- Received data is being sent to the computer or received transmission from phone line.
  
- Data sent from the computer was received by the modem or transmission made to phone line.
  
- Removable, clear Plexiglas shield for the incoming power panel equipment with an opening to provide for manual operation of breakers.
  
- 2 circuit breakers shall be provided in each cabinet. One circuit breaker shall be rated at least 20 amps and shall operate the vent fan, duplex ground fault convenience receptacle, and lamp. The second circuit breaker shall operate any other equipment. Circuit breakers and wiring shall be rated and in accordance with the NEC.
  
- Screened and louvered vent, designed to prevent rain entry, with a 14 by 20 by 1-in. standard furnace vent filter. The filter tray shall be sized to house and secure the filter in place. The screen shall be constructed from at least 0.031-in. aluminum with 1/8-in. diameter openings positioned on 3/16-in. staggered centers. The screen shall be placed on the inlet side of the filter and held in place by the filter or silicone adhesive.
  
- Thermostatically-controlled vent fan with a screened guard in the top section of the cabinet with the capability of exhausting at least 100 CFM. The thermostat shall be adjustable from 80°F to 130°F. Degree markings shall be indicated on the thermostat in 10° increments.
  
- VAC line filter rated at 50 amps
  
- Fluorescent lamp, ordering code Number F20T12/D located in the cabinet so that it will provide for the unobstructed illumination of electronic equipment adjustments. A toggle switch connected in-line with a momentary switch operated by the door shall be provided for operation of the lamp. The toggle switch shall be mounted on a removable noncorrosive metal panel (13 gage minimum) which shall be located on the backside of the door in a convenient location.

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- Transient protection devices. Ungrounded conductor wires entering or leaving the cabinet shall be equipped with transient protection devices. The placement of equipment and the cabinet wiring shall be arranged so that the distance between each conductor's point of entry and the protector shall be as short as possible, and the protector shall be located as far as possible from electronic equipment. Wiring between the surge protectors and the point of entry shall be free from sharp bends. The cabinet shall have an extensive ground plane, and the surge protectors shall be grounded to it, or to the cabinet wall.

Variable message sign control cables shall be protected by grounded metal oxide varistors. There shall be one varistor for each wire in the cable.

Transient protection shall be connected on the load side of the main AC breaker. Transient protector shall provide two stages and shall be electrically separate, so that the first stage protects all equipment using the power, while both the first and second stages protect electronic equipment. There shall be no maximum load for the first stage. The second stage shall be capable of protecting equipment drawing a total of 10 amps. The protector shall clamp both the main line and the main neutral at 250 volts. Cables feeding unswitched 120 volt power from the cabinet to variable message signs shall be protected by the first stage of this filter. The main AC transient protector shall conform to the following requirements:

- Withstand a peak 20,000 ampere surge current for an 8 X 20 microsecond waveform.
- 20 minimum peak surge occurrences.
- Clamp voltage at 20,000 amperes 280 maximum.
- Maximum continuous operating current 10 amperes at 120 VAC, 60 HZ.
- Series inductance of 200 microhenrys (nominal).
- Temperature range - 40 to +185 degrees F.
- Approximate dimensions 4 in. wide X 7.25 in. long X 3 in. high.
- Response time voltage not to exceed 280 volts during surge.
- Spike suppression for  $\pm 700$  volt spike shall deviate  $\pm 40$  volt from sine wave at all phase angles from  $0^\circ$  to  $180^\circ$ .
- Filtering:

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<u>Frequency</u>	<u>Insertion loss(db)</u>
60 Hz	0
10 Khz	30
50 Khz	50
100 Khz	50
500 Khz	50
2 MHZ	60
5 MHZ	40
10 MHZ	20
20 MHZ	25

Dial-up telephone lines shall be protected by a two-stage, plug-in surge protector equal to EDCO's Model PC642C-200.

- **UNINTERRUPTIBLE POWER SUPPLY** – The Contractor shall furnish and install an Uninterruptible Power Supply (UPS) at each controller cabinet . The UPS shall provide complete non-interruptible power protection, voltage regulation, surge and spike protection for the equipment installed in the cabinet. The UPS shall meet the requirements of FCC-A and UL-1778. UPS shall be a commercially available package containing all wiring connectors software and cables.

The UPS shall be of sufficient design to fully operate the cabinet electronic equipment a maximum of one (1) hour. The Contractor shall be responsible for determining the appropriate size/capacity of the UPS. The Contractor shall supply the above calculations and all software and hardware manuals at the time of catalog cut submission. The Contractor shall install the software, test all functions and set the initial UPS parameters. The UPS shall instantly transfer the cabinet to the battery back-up mode in the event the main AC power source goes offline and conform to the following minimum requirements.

- Transfer time shall be 4-milliseconds maximum including detection time
- Output Connections - six (6) NEMA 5-15R
- Input Connections - NEMA 5-15P
- Surge protection shall be rated at 320 joules
- Line filtering shall be full time multi-pole noise filtering
- 0.3% IEEE surge let through, zero clamping response time meeting UL-1449
- Brownout voltage protection, 95 VAC user adjustable
- Recharge the batteries to 90% capacity within four (4) hours maximum

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- LED status indicators for "On-line", "Battery On", "Replace Battery", and "Overload"
- Batteries shall be user replaceable and be maintenance free, leak-proof, sealed lead acid with suspended electrolyte with a three (3) to six (6) year lifetime
- Audible alarm when the batteries are in the "ON" condition and a separately distinctive "LOW BATTERY" alarm; the end user shall have the capability to turn off the audible alarms

**VII. TESTING**

- A. General**—Testing of all equipment furnished and installed under this Contract shall be conducted by, and be the responsibility of the Contractor. The Department reserves the right to perform any inspections deemed necessary to assure that the equipment conforms to the requirements specified herein.

The Contractor shall make arrangements for the witnessing of tests as requested by the Engineer. Full documentation of test results including problems experienced shall be prepared by the Contractor and submitted to the Engineer. Any equipment failing the tests shall be replaced or repaired and re-tested at the Contractor's expense.

Unless otherwise noted, all test documents shall be submitted to the Engineer at least sixty (60) days prior to starting the applicable testing. Should any revisions be required by the Department, the Contractor shall re-submit the document for further review prior to starting the test. No Department review period will exceed thirty days.

The Engineer's approval of any testing document or witnessing of tests shall not relieve the Contractor of his responsibility to provide a completely acceptable and operating system that meets the requirements of these Contract Documents.

- L. Test Plan**—shall be a stand-alone document that covers all aspects of the Contractor's proposed test program. The Contractor shall submit a detailed and comprehensive Test Plan to the Engineer for approval at least ninety (90) days prior to the submittal of any other Test Documentation described in Section VII.C. The Test Plan shall identify all required testing levels for the specific equipment provided by the Contractor. The Test Plan shall identify the Contractor's test organization including the roles and responsibilities of the quality assurance organization. Anticipated test dates and durations shall also be identified. For each piece of equipment that requires testing, the Test Plan shall at a minimum, delineate the following

- Allocation of Special Provision requirements to specific levels of testing
- Submittal of sample test procedures
- Anticipated start time of each level of testing
- Test duration including any re-tests that are required or anticipated
- Submittal of sample test reports

- M. Test Documentation**—The following documentation requirements shall be applicable to the Factory Demonstration/Acceptance Test, the System Operational Test, and the 30-Day Continuous Test. The Contractor shall submit to the Engineer for approval appropriate

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documentation related to each phase of testing. No testing shall commence without appropriate documentation approval. NTCIP test documentation will be prepared by the Department or the Department's NTCIP representative.

**8. (A) TEST PROCEDURES - TEST PROCEDURES AND TEST DATA FORMS MUST BE SUBMITTED AND SHALL INCLUDE AT A MINIMUM:**

- A description of any special equipment, setup, manpower, or conditions required for the test.
- A step-by-step outline of the test sequence to be followed, showing a test of every function of the equipment to be tested.
- A description of the expected operation, output, pass/fail criteria, test results, and criteria for re-test.
- A summary cross reference of test procedures to these Special Provisions.
- An estimate of the test duration and proposed test schedule.
- A data form to be used to record all data and quantitative results obtained by the test.
- A failure analysis and corrective action plan as described herein, for failed equipment.

**9. (B) TEST REPORTS - THE CONTRACTOR SHALL SUBMIT TEST REPORTS FOR ALL TESTING LEVELS. THE TEST REPORTS SHALL VERIFY THAT THE APPROVED TEST PROCEDURES WERE CONDUCTED. ALL TEST REPORTS SHALL BE PRESENTED AND ORGANIZED IN LOGICAL GROUPS OF EQUIPMENT AND MUST BE SIGNED BY THE CONTRACTOR.**

The Contractor shall compare the results of each test with the requirements specified in the Contract Documents, and with the approved test procedures. Failure to conform to the requirements shall be counted as a complete failure, and the equipment shall be rejected. Rejected equipment may be offered for retest provided all non-compliant items have been corrected and retested by the Contractor. Any corrections deemed necessary by the Engineer shall be made by the Contractor, at no additional cost to the Department.

Failure analysis and corrective action reports shall categorize the cause of failure as material defect, quality/workmanship defect, design defect, or system defect. Failure analysis and corrective action plans shall, at a minimum, include the following items:

- Failure report form and numbering system.
- Applicability: Vendors, Suppliers, Contractor-Component Subsystem and System Levels
- Sign off authority at the different levels of activity
- Incorporation into the test report
- Correlation with configuration management
- Precise corrective action
- Confirmation of corrective action
- Close out of the failure report, with accompanying charts, graphs, evidence, photographs, etc. (The failure analysis/corrective action report shall provide complete traceability and audit trail of each occurrence.)

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- D. Factory Demonstration/Acceptance Tests**—Variable Message Sign, controller, and software requirements as stated herein shall be factory demonstrated to the Engineer prior to shipment.

The Contractor shall notify Mr. Robert Yates (540) 387-5395, thirty days in advance of factory tests. The Contractor shall, if requested by the Engineer, postpone any Factory Demonstration/Acceptance Tests for up to seven calendar days in order to accommodate the schedules of the VDOT Engineers. The Contractor shall plan the testing schedule anticipating such requests. Such request for postponement of tests shall not be grounds for extensions of intermediate or final completion times or for additional compensation. Failure of this test shall require additional testing until VMS passes. Additional travel to the manufacturing facility for these additional tests shall be paid by the Contractor. Failure to conform to the requirements of any test and these specifications shall be counted as a complete failure, and the equipment shall be rejected. Rejected equipment/tests may be retested after all deviations have been corrected. After successful completion of all factory demonstration/acceptance tests, the VMS for this contract will be accepted for shipment to the implementation site. The Contractor shall provide the documentation to the Engineer of all test and demonstration results.

No equipment for which a demonstration test is required shall be shipped by a manufacturer without successful completion of factory demonstration testing, receipt of documented test results and authorization by the Engineer to ship. Factory acceptance testing will only be required for the first sign manufactured by the VMS manufacturer.

- E. System Operational Test**—shall demonstrate that all equipment is fully integrated and operational. This test shall verify that all equipment installed at each location is installed properly and that all functions are in conformance with the Contract Documents. All Contractor supplied software shall be also tested during the System Operational Test. Testing of the central equipment shall include running and passing each test of the acceptance procedure and demonstrating proper data transfer to and from each remote site.
- F. 30-Day Continuous Test**—shall not commence until the System Operational Test is successfully completed. During this 30-day period, all aspects of the signs, communications, and control features shall be tested. The goal of this test period is to duplicate real-world usage of the signs. All diagnostic routines available at the central control point shall be run on a weekly basis with results documented and submitted to the Department. The field equipment tests shall include non-central functional tests of the locally installed equipment. In addition, any field diagnostic procedures must be conducted and documented at least once during the 30-day period. Weekly test reports shall be submitted to the Department during the 30-day Continuous Test.

Should any element fail during the 30-Day Continuous Test, the current test period shall stop. The Contractor shall repair the problem, document the failure, and submit a detailed report to the Department. The Contractor must then demonstrate that the system is fully operational. The Department may request the Contractor to conduct the System Operational Test (or a portion thereof) once again. Once the system is fully operational, the Contractor shall submit for review and approval to the Department a new 30-Day Continuous Test schedule that conforms with the failure guidelines below. All aspects of repair and re-testing shall be done at no additional cost to the Department.

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2. **Action in event of hardware failure:** Failures of any Contractor supplied hardware item during the test period shall necessitate restarting the 30 day test period for its full 30 day duration after its repair.
6. **Action in event of controller/firmware failure:** Any failure of this firmware or discovery of a firmware deficiency which causes a system malfunction shall cause the 30-Day Continuous Test to be halted and repeated in its entirety after correction of the firmware problem.
7. **Intermittent failures:** No intermittent failure shall be permitted to persist during the test period. If such problems are encountered, the test shall be terminated and restarted after the cause of the intermittent failure is identified and removed from the system.
8. **System shutdown for testing/correction:** The system may be shutdown for purposes of testing and correcting identified deficiencies. For each period of system shut down, the scheduled 30-Day Continuous Test shall be extended for the same period of time plus one day.
9. **Maximum downtime:** If the total number of system shut downs attributable to Contractor provided software or hardware exceeds three during the 30-Day Continuous Test, the tests shall be re-performed for the full 30 day period.

Logic tests are required for operator interface errors. The system shall not lockup and fail due to operator entry of data. Erroneous data may result in incorrect answers, but not system crashes. "Reasonableness" checks shall be made for operator data entry to assist in managing errors. Testing of the central equipment shall include demonstrating proper data transfer to and from each remote site.

**G. NTCIP Testing**—shall not commence until the 30-Day Continuous Test is successfully completed. The VMS will be tested by the Department or the Department's representative using the Federally developed and publicly available NTCIP Exerciser, or equivalent (for NTCIP 2101/2201) and SimpleSoft's SimpleTester or equivalent for NTCIP 2103/2202 and using the ENTERPRISE Test Procedures. The Contractor shall be responsible for ensuring that the VMS equipment complies with the NTCIP Standards as specified herein.

**H. LED Pixel Testing**—A complete pixel and cluster as required by the specifications herein shall be tested and certified by an independent testing laboratory for the following:

- Luminous intensity
- Operating voltage
- Drive current
- Voltage

Independent certification shall be provided to the Engineer at the factory acceptance testing.

## VIII. SYSTEM DOCUMENTATION

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**A. General** - The Contractor shall supply all documentation necessary for proper identification, scheduling, installation, operation and maintenance of the entire Variable Message Sign System.

**B. Equipment Documentation**

**1. Submittal Prior to Equipment Purchase**—The Contractor shall provide six (6) copies of descriptive manuals or brochures for each type of equipment proposed for this project. No equipment shall be accepted for delivery or any payment made until approval of the corresponding submittal has been given by the Engineer. These documents shall contain sufficient technical data for the Engineer to evaluate the system proposed by the Contractor. The quality, function, and capability of each deliverable item shall be described. Manuals, brochures and certifications shall be originals or copies equal to originals. Documentation, catalog cuts and shop drawings submitted for review of VMS and cabinets shall be submitted to the Engineer as one complete package. Documentation furnished shall clearly define the VMS requirements indicated herein and shall be provided in the same order for review as the specifications are written.

Six copies of shop drawings shall also be required for each fabricated item. These drawings shall contain all information required for complete fabrication in accordance with the Plans and Specifications, such as: materials, welds, finish, mounting details, weight, overall dimensions, position of doors and control cabinet foundation detail. Shop drawings shall be on sheets 22 in. in height and 36 in. long. Shop drawings shall be submitted within 60 days after award of bid.

**2. Documentation Prior to Installation**—The Contractor shall submit an installation summary for each field equipment location. This summary shall include the following information:

- Equipment complement
- A complete wiring diagram for each cabinet, covering every cable entering the cabinet.
- VMS software control manuals including hardcopies of every Management Information Base (MIB) used with an indication which MIB's have been used in which VMS.

**3. Documentation after Installation**—The Contractor shall provide six (6) copies of all instructions and installation manuals. All relevant manuals available from the manufacturer shall be provided. The manuals shall contain sufficient information to operate and maintain the equipment including schematic, wiring, and interconnection diagrams; complete instructions for proper installation including equipment outlines,

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mounting, weight, power, and cooling requirements; a complete parts list and a list of recommended spares.

A new set of management Information Bases (MIBs) as described in Section V, shall be provided to the Department by the Contractor, if these MIBs have been altered since the delivery of the first set.

The Contractor shall also provide and attach to the inside of each variable message field controller cabinet a printed set of wiring diagrams. Drawings shall be attached to the door with stainless steel fasteners and protected from weather with a waterproof enclosure. A reproducible mylar original of each set of wiring diagrams shall be provided to the Department by the Contractor.

**IX. MEASUREMENT AND PAYMENT**

**Dynamic Message Sign** will be measured in units of each and paid for at the contract unit price per each. This price shall include furnishing and installing the variable message sign unit, testing, protocol compliance, integration, conduits, control and power cables from the cabinet to the sign controllers in the field, telephone cable from the telephone interface box to the DMS control cabinet, wiring connections and hardware, modems, field controller, cabinet, uninterruptible power supply (UPS), concrete foundation, back panels, power panels, duplex groundfault convenience receptacles, thermostatically controlled fan units in the cabinet with a vent, radio frequency interference filters, lamps and receptacles, flexible cables, grounding systems, transient protection devices, fittings, and system documentation including: shop drawings, manuals, wiring diagrams, block diagrams, flow charts, MIBs and other material necessary to document the operation of the system.

**Fifty percent** of the unit price bid for this item will be paid upon delivery of the Dynamic Message Sign unit and all equipment for each individual location to the job site.

**Twenty percent** of the unit price bid for this item will be paid upon successful installation of the DMS on the butterfly sign structure, installation of controller cabinet, sign controller, modem, telephone connection, electrical service, installation of sign controller software and all wiring of DMS to controller for a fully operational DMS at each location.

**Thirty Percent** of the unit price bid for this item will be paid upon successful completion of all testing as required in Section VII TESTING. Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>
Dynamic Message Sign (type)	Each

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