DESCRIPTION:
This work shall consist of furnishing, installing and testing of Hybrid LED VMS (HLV) Sign Assemblies at locations indicated in the Contract Documents or as directed by the Engineer. The HLV Assembly shall consist of a static sign panel with one or more LED line or character matrix variable message sign assemblies, the associated sign controller, controller cabinet, bracket supports, cabling and all necessary assembly hardware. The variations on HLV are identical in all respects except for the number and size of the VMS modules and the size and wording on the static sign panel.

NOTE: The HSVMS provided for this project shall comply with the most recent revision of the following standards, even if no revision date for HSVMS is given herein:

1. National Transportation Communications for ITS Protocol (NTCIP) for details refer to NTCIP section in this specification
2. NEMA Standards Publication “Hardware Standards with NTCIP requirements”
3. American Association of State Highway and Transportation Officials (AASHTO)
6. National Electrical Manufacturers Association (NEMA)
7. American Architectural Manufactures Association (AAMA)
8. Underwriter’s Laboratory (UL)
9. UL Standard for flat plate photovoltaic and Panels

MATERIALS:
Requirements
The number of VMS modules connected to a single controller in the HLV is indicated by:
The “X” = item number, where “X” = are 1-2-3.
The “Y” = characters in each VMS module, where “Y” = are 3 and 4.
The Z=“Type” or “Height” of the characters.
The Z=1 indicates Type 1 HLV = eighteen (18” high)
The Z=2 indicates Type 2 HLV = twelve (12” high).

Either character or line matrix technology may be proposed. Access to the sign shall be from the front. The size of the sign panel and orientation of the VMS modules shall be as shown in the Contract Documents. The following requirements apply to both the Type 1 and the Type 2 signs except where explicitly noted.

1 Quality Assurance Requirements
The manufacturer of the HLV Assembly shall meet the following requirements:
1.1 ISO 9001 Certified.
1.2 Experience:
ITEM 683.200XYZ08 – HYBRID STATIC VARIABLE MESSAGE SIGN ASSEMBLY

The sign manufacturer shall have installed in North America a minimum of forty signs of similar technology that have been successfully operating for at least four years and have been installed as part of at least five separate projects.

As part of the thirty day submission, the Contractor shall submit proof of compliance with their experience requirements. This shall include, but not be limited to, a list of sign installations with photographs and names, addresses and telephone numbers of operating personnel who can be contacted regarding the signs. If requested by the Engineer, the Contractor shall arrange for a demonstration of an installed sign from the proposed manufacturer.

2 General Requirements

The HLV Assembly of the type specified in the Contract Documents shall meet the following requirements:

2.1 Power: The equipment shall meet all of its specified requirements when the input power is 120/240 VAC ±15%, 60 ±1 Hz, 3-wire single phase plus ground.

2.2 Electrical:

2.2.1 All wiring interconnecting individual components or assemblies shall be modular harness assemblies and shall be mechanically keyed to prevent insertion into wrong socket or connector.

2.2.2 Shielding of the electronics to prevent radiation of any electrical or electromagnetic signals that could adversely affect any other electrical or electronic device, as per FCC rule Part 15, Class B shall be provided.

2.2.3 The presence of ambient noise generated within 1 foot of any of the components of the HLV shall not adversely affect the performance of the HLV. The sources of ambient noise shall include, but not be limited to, radio signals, magnetic or electromagnetic interface, including those from power lines, roadway lights, transformers or motors.

2.3 Mechanical:

2.3.1 Fabrication shall be such that performance shall not be impaired after the equipment has been subjected to shock and vibration caused by normal installation, transportation and maintenance handling.

2.3.2 Particular attention shall be given to neatness and thoroughness of soldering, wiring, welding, plating, riveting, finishes and machine operations.

2.4 The equipment shall meet all operational requirements under the following environmental conditions:

- Temperature Range: -30° F to +140° F.
- Humidity: 5 to 95% noncondensing
3  **Static Sign**

The sign dimensions, message, character size and mounting configuration shall be as shown in the Contract Documents with Class B Reflective Sheeting used. Signs, brackets and mounting posts furnished as part of these items shall meet the following requirements:

3.1 §730-01  *Aluminum Sign Panels*

3.2 §730-05  *Reflective Sheeting - ASTM Type IX (Class E)*

3.3 §730-12  *Reflectorized Sheeting and Sign Characters (Type IV)*

*Except ASTM Type IX (Class E) sheeting shall be used for the characters.*

3.4 §730-22  *Stiffeners, Brackets and Miscellaneous Hardware*

4  **Variable Message Sign Assembly**

The HLV shall consist of tri-color (R+G) Light Emitting Diode (LED) pixel based matrix modules arranged to form a character matrix display or line matrix display, the sign controller, controller cabinet and associated electronics. The HLV modular display shall contain the number of characters specified in Section 4.1.

For Type 1 signs, the nominal height of each character shall be 18 inches high and 12 inches wide (when measured from the bottom most edge of the lowest pixel to the top most edge of the upper pixel in the character matrix using) a 7x5, or greater, pixel matrix for each character. If a line matrix is used, each line shall have a height of 18 inches and a width to allow for 12 inch wide characters.

For Type 2 signs, the nominal height of each character shall be 12 inches high and 8 inches wide (when measured from the bottom most edge of the lowest pixel to the top most edge of the upper pixel in the character matrix using) a 7x5, or greater, pixel matrix for each character. If a line matrix is used, each line shall have a height of 12 inches and a width to allow for 8 inch wide characters.

4.1  The character modules shall be mounted in housing as described in Section 5. Each Sign Assembly shall consist of the number of VMS modules specified by “X” in the specification item number. Each line shall be of a sufficient size to meet the requirements of section 4 and to be able to display the number of characters specified by “Y” in the specification item number.

4.2  Orientation of the VMS modules shall be as shown in the Contract Documents.

4.3  All pixel modules, assemblies, and components compatible and interchangeable between signs provided under this item.

4.4  The replacement of any display module, or pixel on a display module, shall not require any other unit to be removed, and shall not require the use of any special tools. All display modules shall be replaceable from the front of the sign assembly.

4.5  Each pixel shall be individually addressable and controllable to allow for the display, on any portion of the message face, of static text or the flashing of all or any part of the text, together with message formation by alternating between two or more static or flashing text messages.
4.6 The electronics for the HLV shall be fully configured to drive the total required number of LEDs. The failure of any one pixel shall not affect the operation of any other pixel.

4.7 The power driver circuitry shall be designed to minimize power consumption.

4.8 Each pixel shall be comprised of a symmetrical cluster of LEDs.

4.9 LED lighting source for the pixels shall be as follows:

4.9.1 Each pixel shall be capable of displaying either red, amber, or green. Each pixel shall consist, at a minimum, of a red LED and a green LED (R+G). An additional blue LED is allowed, but not required.

4.9.2 Red LEDs shall utilize AlInGaP semiconductor technology, and shall emit red light that has a peak wavelength of 625 ± 10 nm.

4.9.3 Green LEDs shall utilize InGaN semiconductor technology and shall emit green light that has a peak wavelength of 525 ± 10 nm.

4.9.4 The quantity of LEDs used in each pixel shall be sufficient to provide a minimum pixel output of 19.5 candelas for any available color at full brightness.

4.9.5 LED grouping and mounting angle shall be optimized for maximum readability.

4.9.6 LEDs shall have a 30° viewing cone with a half power angle of 15° measured from the longitudinal axis of the LED.

4.9.7 The LED mean time before failure (MTBF) shall be a minimum of 100,000 hours of permanent use at an operating temperature of 140 degrees Fahrenheit, when driven at the specific forward current used for normal daylight LED HLV display operation. Where failure is defined as a maximum drop in candela output of 70% over 100,000 hours.

4.9.8 The Contractor shall provide LED manufacturer’s data to the Engineer on the LEDs intended for the signs in this Contract.

4.9.9 As part of the LED manufacturer’s technical specification sheet submittal, the specific forward current shall be noted.

4.9.10 Each LED shall be individually installed and separately connected to the circuit board (display module).

4.9.11 The LEDs used in the display shall be obtained from batches sorted for luminous output, where the highest luminosity LED in the batch shall not be more than fifteen percent (15%) more luminous than the lowest luminosity LED in the batch.

4.9.12 To ensure uniformity of display and operational life, all LEDs used to make up a display module shall be obtained from the same manufacturing batch. The Contractor shall submit LED manufacturer’s certification identifying the batch and bin numbers of the LEDs used.

4.9.13 Monitoring of each pixel by the HLV controller for subsequent transmission of pixel status information to the control center.
4.10 The LED display modules shall be protected from degradation due to sunlight. The method and design of the LED HLV sunlight protection shall be approved by the Engineer.

5 HLV Enclosure

The HLV sign enclosure shall as a minimum house the LED display modules and the light sensors. One or more enclosures may be proposed based on the sign configuration specified in the Contract Documents. The enclosure(s) shall open from the front of the sign assembly and shall meet the following requirements:

5.1 The housing shall conform to the requirements of a NEMA 3R enclosure.

5.2 The maximum exterior depth of the enclosure shall be 9 inches. The maximum height and width shall be as shown in the contract drawings.

5.3 The enclosure shall be constructed of aluminum alloy 6061-T6 or 5052-H32 for the internal structural members and aluminum alloy 5052-H32 exterior skin or as specified on approved shop drawings. The minimum thickness shall be 0.1 inch. Seams shall be continuously welded by an inert gas process only in the shop.

5.4 The enclosure shall protect internal components from rain, dust, ice and corrosion in accordance with NEMA Type 3R standards as described in NEMA Standards Publication 250-2003, Enclosures for Electrical Equipment. All gaskets shall be fabricated out of neoprene.

5.5 All hinged access panels and windows shall be equipped with hold-open devices either mechanical or gravitational which shall not release accidentally or by the action of wind. The hold-open devices shall not interfere with the operation of the display, nor with the repair or replacement of user serviceable components.

5.6 The enclosure shall be constructed to present a clean, neat appearance. Seals, baffles and screens to prevent the entry of water, dust and insects shall be used, as required to protect equipment located within the housing from moisture, dust, dirt and corrosion.

5.7 Any interior metal cage support frames required to mount the display elements shall be non-corrosive and shall withstand and minimize vibration when the sign is mounted with the number of display elements specified in these Contract Documents.

5.8 A weatherproof, secure front access lift face shall be provided to provide access to all replaceable components within the enclosure.

5.9 The lift face shall be lockable from the outside to prevent intrusion or vandalism

5.10 The lift face(s) status shall be monitored with an electrical contact(s), such that the contact shall be closed when the lift face is closed and open when the lift face is open. The contact(s) shall be wired to the HLV controller and shall cause a bit to be set in the status message returned to the Transportation Management Center (TMC) when the contact is open.

5.11 Either a device shall be provided or gravity used to hold the lift face open in a 90 degree or greater position.

5.12 When multiple enclosures are used, the enclosures shall be mounted such that when the front face of one panel is opened, it shall not come in contact with the front face of an
adjacent panel.

5.13 The locks shall be keyed the same as the locks provided in other items of this contract. Two keys shall be provided to the Engineer for each lock.

5.14 The front face of the HLV enclosure shall be extended beyond the message area of the sign, as indicated in the Contract Documents, creating a blank, flat black border area that is integral to the housing. Add-on elements to create the border are not allowed.

5.15 All exterior seams shall be continuously welded by an inert process only in the shop such that each weld has a uniform flow. Welding shall be in accordance with ANSI/AWS D1-2/D1.2M, Structural Welding Code-Aluminum.

5.16 Louvered vents shall be provided on both sides of the enclosure and below the enclosure, as necessary, to provide sufficient ventilation. All fans or other forced air devices, if necessary for operation of the sign over its specified operating temperature range, shall be thermostatically controlled and shall use standard-size removable dust filters. The dust filters shall be rated MERV (Minimum Efficiency Reporting Value) 8. All fans shall have ball or roller bearings.

5.17 Screened weep holes shall be provided at each corner of the enclosure(s) to allow the drainage of any water that may collect in the housing.

5.18 All metallic exterior surfaces visually exposed to motorist traffic, including the face (lens panel aluminum mask), top, bottom and sides extending forward of the static sign panel as indicated in the Contract Documents are to be coated with a matte-black Kynar 500 finish or semi-gloss automotive grade acrylic urethane finish. The finish shall be uniform in appearance and completely free from gouges and any other flaws or defects. All other exterior surfaces, extending behind the static sign panel, as indicated in the Contract Documents, shall be a natural aluminum mill finish. All interior surfaces shall be a natural aluminum mill finish.

5.19 The pixels within the message area of the sign shall be covered and protected with a UV stabilized polycarbonate front panel. The panel shall be a minimum of 1/4 inch thick. The front panel shall be mounted to withstand applicable wind load criteria specified in §30.27, Permanent Variable Message Signs, without deflecting sufficiently to obscure any of the pixels in the sign. The panel shall be replaceable and shatter resistant.

5.20 The lens panel shall be heated to prevent fogging, frost or ice and snow build-up.

5.21 All internal diagonals and other structural supports shall be spaced so as not to interfere with the maintenance or replacement of any of the components mounted within the sign.

5.22 Markings: The contract number, pay-item number, and month and year of installation shall be marked using permanent ink, paint or stamping into the wall. Characters shall be 1-1 3/4 inches high, horizontal when the variable message sign is in its final position, and be located on the inside near the middle of the panel opposite the lift face. The markings shall not be visible when viewing the HLV Assembly head-on.

5.23 The manufacturer’s name, product name, model number, serial number, and city and state or province of manufacturer shall be permanently marked on the outside and an easily accessible location inside the enclosure.
6 **HLV Controller**

Each sign shall be operated by a microprocessor-based controller that provides the electronics necessary to receive and interpret commands from software at the Transportation Management Center (TMC), to issue a response to the TMC, and to display messages on the sign. The HLV controller shall be housed in a cabinet provided as part of this item. The cabinet shall be ground mounted, pole mounted, or mounted on the sign structure, as shown in the contract documents. The HLV controller shall meet the following requirements:

6.1 Designed to mount in a standard 19-inch rack, occupying a maximum of 10U rack space with a depth not exceeding 15 inches.

6.2 Support TCP/IP communications between the TMC and the HLV controller.

6.3 Communications Interface:

6.3.1 Provide two NTCIP-compatible Ethernet ports for communication between the sign controller and the TMC or a local laptop, with each port connected to a separate communication channel through an external communications device. The controller shall respond to the last command received, which may be on either channel, and respond on both channels. The TMC will only transmit commands over one channel at a time.

6.3.2 Provide an NTCIP-compatible RS-232 port for communication between the sign controller and a local laptop (provided under a separate bid item) for configuration, running diagnostics, selecting messages, monitoring status and downloading/uploading messages through a direct null-modem connection. A password must be entered for commands from the notebook to be considered valid.

6.3.3 The Ethernet ports shall have a standard RJ45 connector.

Communications on Ethernet ports shall comply with NTCIP 2104 and NTCIP 2202 Internet transport profile. This shall permit the controller to be operated on any typical Ethernet network using the TCP/IP and UDP/IP protocols. The IP address shall be configurable.

The baud rate, connection type, and NTCIP communication protocol shall be configurable. The baud rate for each port for each of the serial ports shall be settable to any typical serial baud rate ranging from 1200 to 115,200. All three (3) ports shall be capable of supporting either of the following sub network profiles: NTCIP 2101 (PMPP) or NTCIP 2103 (PPP). They shall also be capable of supporting either NTCIP 2201 (Null) or NTCIP 2202 (Internet) profiles. Only one each of the transport and sub network profiles shall be active at any time on each port. The default settings of the serial ports shall be as follows:

<table>
<thead>
<tr>
<th>Port</th>
<th>Baud Rate</th>
<th>Connection Type</th>
<th>NTCIP Sub network</th>
<th>NTCIP Transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Control - 1</td>
<td>9600</td>
<td>Modem (External)</td>
<td>NTCIP 2101 – PMP</td>
<td>NTCIP 2201 – Internet</td>
</tr>
</tbody>
</table>
### Communications between the HLV controller and the TMC and notebook computer

shall comply with the NTCIP as detailed in the following NEMA Standards Publications:

6.4.1 **NTCIP 1101:1996 and Amendment 1** – Simple Transportation Management Framework (STMF)

6.4.2 **NTCIP 1102 v1.12** – Octet Encoding Rules (OER) Based Protocol

6.4.3 **NTCIP 1201 v02.32** – Global Object (GO) Definitions

6.4.4 **NTCIP 1203:1997 and Amendment 1** – NTCIP Object Definitions for Dynamic Message Signs

6.4.5 **NTCIP 2001 v01.19** – NTCIP Class B Profile

6.4.6 **NTCIP 2101:2001** – Point-to-MultiPoint Protocol (PMPP) Using RS-232 Subnetwork Profile

6.4.7 **NTCIP 2103 v1.13** – Point-to-Point Protocol Over RS-232 Subnetwork Profile

6.4.8 **NTCIP 2201 v1.15** – Transportation Transport Profile

6.4.9 **NTCIP 2202:2001** – Internet (TCP/IP and UDP/IP) Transport Profile

6.4.10 **NTCIP 2301** – AP-STMF (Simple Transportation Management Framework)

### Unless otherwise stated in these Contract Documents, the software shall comply with the versions of the NTCIP standards that are current at the date of Contract award.

### As part of the 30-day submission the HLV manufacturer shall submit details of the specific standards to be implemented, applicable conformance groups, applicable data objects and their associated range values, and any other information, including, but not limited to manufacturer specific MIBs, that are pertinent to the implementation of this specification.

### Have sufficient non-volatile memory for downloading and uploading messages, and configuration, status, and alarm data as specified herein.

### Storage of all local messages and configuration parameters in non-volatile memory that shall not be affected by complete loss of power at any point in its operation.

### Perform all messaging operations, including but not limited to flashing on and off, writing any message at a minimum effective rate of 60 characters per second.

### Incorporate a watchdog timer to detect an out-of-program condition and reset the microprocessor.

### Operate on a TCP/IP network, with a user-assigned and user-adjustable IP address.

### Provide a means for the user to configure I/O parameters. The I/O configuration shall be stored in non-volatile memory, and may be changed either at the controller or via the TMC.

### Designed for fail-safe prevention of improper information display in the case of...
malfunction. As a minimum, this shall include an automatic blanking feature that immediately clears the message displayed on the sign in the event of a power failure, communication failure or invalid transmission from the TMC.

6.14 Diagnostic software to detect and identify failed pixels, display drivers, power supplies, and alarm conditions shall be provided.

6.15 Have a local control mode where the following operations may be initiated:
   6.15.1 Operator selection of dimming levels
   6.15.2 Operator selection of configuration parameters
   6.15.3 Diagnostic routines capable of testing full sign operation

6.16 Provide a switch on the front of the HLV controller to activate local control and a keypad and menu-driven LCD display on the controller's front panel to select the operations. The switch must be in the local position to permit entry from the keypad.
   6.16.1 A valid password must be entered to permit local entry.
   6.16.2 A timeout function shall be provided such that if no activity is detected from any of the local control interfaces within a user specified time, the HLV shall revert to the remote controlled mode.
   6.16.3 While in the local control mode, the TMC software will continue to monitor the sign's status and display. The HLV controller, however, shall not respond to any commands from the TMC while in local control mode.

6.17 The sign controller’s front panel shall be capable of performing the following functions with the sign controller and the HLV:
   6.17.1 Monitor the current status of the sign controller, including the status of all sensors and a representation of the message visible on the display face.
   6.17.2 Perform diagnostics testing of various system components, including pixels, power systems and sensors.
   6.17.3 Activate messages stored in memory.
   6.17.4 Configure display parameters, including display size, colors, and communications.

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

6.19 Provide for the continuous monitoring of the temperature within the sign enclosure and
automatically activate the enclosure’s ventilating system, if required, when the temperature exceeds a user defined limit. If the temperature exceeds a second user defined temperature limit, an error condition shall be generated and reported to the TMC when the sign is polled. If a manufacture’s set temperature limit is exceeded, the sign shall automatically shut down and an error condition shall be generated and reported to the TMC when the sign is polled.

6.20 The controller shall provide two 120VAC beacon outputs, each supporting a minimum of a 500 Watt load. The beacons shall be configurable for either steady output, or flashing at 1Hz rate, 50 percent duty cycle nominal. The beacon outputs shall be configurable to either flash on and off together, or to alternate between the outputs. The beacon active / inactive state shall be controlled from the TMC with NTCIP set beacon objects. Beacon status shall be available with NTCIP get beacon objects.

7 Sign Dimming System

Each sign shall be provided with a system that senses the background ambient light level and provides field- adjustable intensities (dimming). Pixel luminance levels shall be controlled both directly (through operator input) and automatically (based on ambient light levels obtained from the photocells).

The sign dimming system shall meet the following requirements:

7.1 It shall consist of commercially available photo-electric sensors either installed in watertight metal enclosures on the sign enclosure(s) or as part of the LED displays. The method of dimming shall produce a consistent intensity level across all of the LED displays used to make up the sign assembly. If the photoelectric sensors are mounted on the sign enclosure, it shall be placed in an easily accessible location for maintenance, as approved by the Engineer and shall be capable of having its aiming angle adjusted.

7.2 Each of the photo-electric sensors shall be capable of being continually exposed to direct sunlight without impairment of performance.

7.3 Luminance levels shall be stored in the HLV Controller and shall be adjustable, in a range of 3% to 100%, on either:

7.3.1 A continuous logarithmic basis, to match the normal human eye luminous response characteristic.

7.3.2 A half incremental dimming basis, where each lower dimming level is half the previous level.

7.4 Dimming sign circuitry shall be provided to select an illuminance level based on the ambient light sensed by the photocells and a lookup table of intensity level vs. photocell reading. A minimum of 100 intensity levels shall be supported.

7.5 The lookup tables shall be downloadable from the TMC. Each row shall contain a range of photocell readings.

7.6 The dimming level selected shall be determined by the row whose range corresponds to the sensed level of ambient light.

7.7 Overlap shall be provided in the table’s ranges to prevent flickering of the sign caused
by subtle changes in the ambient light.

7.8 The intensity levels shall be adjustable by means of a software control through the field controller, or other method approved by the Engineer.

7.9 Continuous current drive shall be used at the maximum brightness level and at all lower levels of brightness.

7.10 The current used for maximum brightness shall not exceed the current used to achieve the rated MTBF. The current used for maximum brightness shall be indicated as part of the shop drawing submittal.

7.11 The LED dimming circuit shall incorporate temperature controlled dimming, which shall reduce the current through the LEDs based on the temperature inside the sign enclosure, such that the LED current does not exceed the rated LED current at that temperature.

7.12 If the temperature of the sign exceeds the rated operating temperature of the LEDs, the sign shall blank-out until the temperature has returned to safe operating levels.

7.13 A complete schematic of the LED display power, driver and dimming circuits shall be provided for approval by the Engineer.

8 Power Supplies

8.1 The LED display shall be operated at an internal DC nominal voltage not exceeding 24 volts.

8.2 Multiple power supplies shall be provided and employed such that the failure of any individual power supply does not inhibit full operation of the HLV.

8.3 The quantity of power supplies shall also provide at least 50% spare capacity over that required to light every pixel of the LED HLV. The Contractor shall provide details of methodology proposed for the integration of the spare capacity to Engineer for approval.

8.4 All power supply voltages shall be continuously measured by the sign controller. The sign controller shall provide these voltage readings to the central controller or laptop computer when the sign controller is polled by the TMC or notebook computer.

8.5 The HLV Controller shall have either redundant power sources or a backup UPS/battery wired so that the failure of one power source shall not interrupt the operation of the controller.

8.6 The power supplies shall be short circuit protected. They shall also have suitable overcurrent protection devices and shall reset automatically after 5 seconds of AC power off.

8.7 Power supplies shall be UL listed, have an efficiency rating of 80% minimum, and operate over an ambient temperature range of -30° F to +140° F.

9 Electrical Circuit Protection

9.1 Circuit breakers shall be installed in the controller cabinet. Payment for these breakers shall be included in the cost bid for this HLV item. The main breaker shall protect the cabinet and the sign enclosure and shall be rated for 30 amps. Activation of the main breaker shall result in the removal of all power from the cabinet and sign enclosures. All
breakers shall be approved and listed by the UL. The operating mechanism shall be enclosed, trip free from the operating handle on overload and trip indicating. Contacts shall be silver alloy enclosed in an arc quenching chamber. Breakers shall have a minimum interrupt capacity of 5000 A. Thermal magnetic breakers are not acceptable.

Secondary breakers shall be installed to protect the following circuits:

9.1.1 To protect the equipment in the controller cabinet.
9.1.2 As required to energize the HLV enclosure.
9.1.3 15 amps for the maintenance lights.
9.1.4 15 amps for the maintenance outlets.
9.1.5 15 amps for communications equipment.

9.2 Appropriate devices shall be installed in the sign enclosure and local control cabinets to protect all external cabling entering the controller cabinet and sign housing from over-voltage situations, such as lightning strikes and power surges over the lines. The surge protectors shall be grounding in accordance with the manufacturer’s recommendation. Circuitry protection shall include, but not limited to the following:

9.2.1 Overcurrent protection devices. All AC power circuit(s) to the LED HLV and associated control equipment enclosures shall be protected by Ground Fault Circuit Interrupting type devices.
9.2.2 Surge protector to guard against circuit damage resulting from voltage surges on all incoming power lines. The surge suppressor shall meet the following minimum specifications:

9.2.2.1 Working voltage rating: 130 Vrms each leg.
9.2.2.2 Surge voltage: Limit the surge voltage applied to the equipment to 650 V peak while conducting a peak surge current of 20,000 A. The peak surge current shall be an 8x20 us unsymmetrical triangle wave.
9.2.2.3 Response Time: 5 nanoseconds.
9.2.2.4 Occurrences: 20 times at peak current.
9.2.2.5 Maximum Series Inductance: 200 micro henries.

9.2.3 Data Line protectors to guard against circuit damage resulting from voltage surges on all data/communication lines between the sign enclosures and controller cabinet if applicable.

10 Central Control of the HLV

The HLV system uses a poll-response method of communications over a multi-drop channel or link. The TMC (Central Control System) initiates all communications and only one HLV controller on the channel will respond to a command from the TMC. Each controller on a channel is given a unique drop address. One drop address is reserved as a broadcast address. All controllers on a channel listen to transmissions to the broadcast address, but no
controllers respond, thus avoiding any conflicts on the channel.

10.1 The IP address shall be user configurable, stored in non-volatile memory, and may be changed only at the controller.

10.2 For message creation, the HLV, HLV sign controller, and HLV control software shall include the following characters:

10.2.1 The letters “A” through “Z”

10.2.2 Decimal digits “0” through “9”

10.2.3 A blank or space

10.2.4 Eight (8) directional arrows

10.2.5 Punctuation marks, such as: .,!?-’””

10.2.6 Other characters, such as: #&*+/( )[ ] < >

10.3 The following character font file shall be supplied with the HLV, at a minimum:

7x5 Single Stroke – a typical font is seven (7) pixel rows high by five (5) pixel columns wide and has a single-pixel stroke width.

11 **NTCIP**

11.1 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 the date of this letting, including any and all Approved or Recommended Amendments to these standards as of the letting date. It is the ultimate responsibility of the sign manufacturer to monitor NTCIP activities to discover any more recent documents.

11.2 Variable Message Sign assemblies shall be compliant with the latest version of the NTCIP Standards, as defined by AASHTO, ITE, and NEMA.

11.3 **SUBNETWORK PROFILES**

11.3.1 Each serial or modem port on each NTCIP device shall be configurable to support both NTCIP 2101 and NTCIP 2103. Only one of these profiles shall be active at any given time. Serial ports shall support external dial-up, leased line, radio, cellular and fiber optic modems.

11.3.2 The NTCIP device(s) may support additional Subnet Profiles at the manufacturer’s option. At any one time, only one subnet profile shall be active on a given port of the NTCIP device. All response datagram packets shall use the same transport profile used in the request. The NTCIP device shall be configurable to allow a field technician to activate the desired subnet profile and shall provide a visual indication of the currently selected subnet profile.

11.4 **TRANSPORT PROFILES**

11.4.1 Each serial or modem port on each NTCIP device shall be configurable to support both NTCIP 2201 and NTCIP 2202.

11.4.2 Each Ethernet port on the NTCIP device shall comply with NTCIP 2202.
11.4.3 The NTCIP device(s) may support additional transport profiles at the manufacturer’s option. Response datagrams shall use the same transport profile used in the request. Each NTCIP device shall support the receipt of datagrams conforming to any of the supported transport profiles at any time.

11.5 APPLICATION PROFILES

11.5.1 Each NTCIP device shall comply with NTCIP 2301 and shall meet the requirements for Conformance Level 1.

11.5.2 An NTCIP device may support additional application profiles at the manufacturer’s option. Responses shall use the same application profile used by the request. Each NTCIP device shall support the receipt of application data packets at any time allowed by the subject standards.

11.5.3 The following conformance groups within the NTCIP 1203:1997 and Amendment 1 standard shall be supported with the values defined in these tables. For the purposes of this specification NTCIP 1203 Conformance Statements shall be considered mandatory, except where noted.

11.6 Each NTCIP device shall support all mandatory objects in all optional conformance groups that are required herein. All optional objects listed in these specifications as mandatory, shall be supported.

11.7 CONFORMANCE STATEMENTS

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<th>NTCIP Reference</th>
<th>NYSDOT Specification Reference</th>
<th>Expected Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.11.2.1.1.2</td>
<td>pixelFailureTableNumRows</td>
<td>NTCIP 1203:1997</td>
<td>-</td>
<td>0..65535</td>
</tr>
<tr>
<td>2.11.2.1.1.3</td>
<td>pixelFailureTable</td>
<td>NTCIP 1203:1997</td>
<td>Sequence</td>
<td></td>
</tr>
<tr>
<td>2.11.2.1.1.4</td>
<td>pixelTestActivation</td>
<td>NTCIP 1203:1997</td>
<td>5.15</td>
<td>1..4</td>
</tr>
</tbody>
</table>

11.20  Multi Tags

11.20.1 Each NTCIP device shall support the following message formatting MULTI tags. The manufacturer may choose to support additional standard or manufacturer-specific MULTI tags.

<table>
<thead>
<tr>
<th>MULTI Tag</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fo</td>
<td>Font</td>
</tr>
<tr>
<td>Jl2</td>
<td>Justification - line left</td>
</tr>
<tr>
<td>Jl3</td>
<td>Justification - line center</td>
</tr>
<tr>
<td>Jl4</td>
<td>Justification - line right</td>
</tr>
</tbody>
</table>

11.21  Documentation

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

11.21.1.1 The relevant version of each official standard MIB modules referenced by the device functionality.

11.21.1.2 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”.

11.21.1.3 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.

11.21.1.4 A MIB containing any other objects supported by the device

11.22  Acceptance Testing

11.22.1 The acceptance test will use the NTCIP Exerciser, Trevilon’s NTester, and Intelligent Devices’ Device Tester for NTCIP, or other testing tool approved by the Engineer. If the vendor implements any vendor-specific Multi tags, the VMS shall provide meaningful error messages within the NTCIP Standard
DMS MIB 2.7.1.1.20 DMSMULTIOOTHERERRORDESCRIPTION whenever one of these tags generates an error.

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

11.23 Interpretation Resolution

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

CONSTRUCTION DETAILS

12 Installation

The Contractor shall install the HLV Assemblies in accordance with the Contract Documents. This item shall include all sign modules, sign housing(s), HLV controller, fittings, grounding and all cabling in the sign, HLV controller, and between the sign and controller required for a fully operational HLV. Installation of the controller cabinet shall be included as part of this item. The exact installation locations shall be field staked and approved by the Engineer prior to the start of construction.

12.1 The permanent HLV shall be mounted to support structures as shown in the Contract Documents and as approved by the Engineer. Construction methods and details for the sign panel assembly shall be in accordance with §644-3, Sign Structures, Construction Details and Standard Drawings except as modified under this Contract to accommodate the installation of the Variable Message Sign (VMS) Assembly and the controller cabinet.

12.1.1 The Contractor shall submit shop drawings for the HLV Assembly. The shop drawings shall include the proposed method of mounting the HLV Assembly and controller cabinet to the flat panel sign and sign posts and show the size of all members.

12.1.2 All structural steel elements shall be hot dipped and galvanized.

12.2 Field measurements and adjustments to height/orientation shall be completed to ensure that minimum vertical clearance, as shown on the Contract Drawings, and legibility distances are achieved. Adjustments to the photosensor control thresholds shall be made to ensure the legibility distance is maintained under all ambient light conditions.

12.3 The Contractor shall make all power connections to the HLV Assembly. All power shall be routed through the main circuit breaker in the controller cabinet. The neutral bus shall be isolated from the cabinet and equipment ground. The Contractor shall ground the sign in accordance with §680-3.12, Grounding. A direct ground wire shall be installed between the power distribution panel within the sign and the nearest ground rod. Grounding through the sign structure is not acceptable. The controller cabinet shall
be grounded through the same ground rod.

12.4 The Contractor shall connect the HLV controller and the modem of the type specified in the Contract Documents. Payment for installation of the modem and connection to either the optic fiber cable plant or to an antenna shall be paid for as part of other bid items. Where a fiber optic modem is specified, the connection to the fiber optic cable plant shall be through the fiber optic patch panel contained in the controller cabinet. Where fiber is installed, the fiber shall be neatly racked in the controller cabinet complying with the minimum bend radius for the cable. The optical fiber cable shall be fusion spliced to the patch panel pig tails. Slack fiber shall be stored in the patch panel. Where a wireless modem is installed, the Contractor shall install the antenna as shown in the Contract Documents.

12.5 All wire shall be cut to the appropriate length prior to installation. All cabling shall be neatly routed and tied back so as not to interfere with access to other cabling or equipment or maintenance of the sign. Doubling back of wiring is not permitted. All cabling shall be permanently identified as to its termination point.

12.6 All cable shields shall be grounded using an approved grounding termination kit.

12.7 After installation of all cables into the sign housing(s) and controller cabinet, all of the conduit entries shall be sealed with duct seal or an approved equivalent, to prevent water or rodent ingress.

12.8 The Contractor shall touch up all painted surfaces of the sign assembly that were scratched, chipped or damaged during installation with a matching color of paint.

13 **Test Software**

The Contractor shall provide test software that will run on a notebook computer under the Windows operating system to emulate the central software. This software shall permit downloading and uploading of the commands and responses through the Ethernet port of the HLV controller. Three copies of the test software on disk or CD-ROM shall be delivered to the Engineer.

14 **Documentation**

**Sign Control Parameters**

14.1 As part of the thirty-day submission, the Contractor shall include a definition of all required control parameters necessary for the proper operation of this sign and not defined in this document. These shall include but not be limited to the following:

14.1.1 Range and definition of photocell readings.
14.1.2 Diagnostic tests.
14.1.3 Error and status bits.
14.1.4 Manufacturer specific NTCIP data objects and their associated range values.

**Shop Drawings**

14.2 The Contractor shall submit ten (10) copies of manufacturer's shop drawings, schematics, performance specifications, circuit descriptions, and catalog cut sheets to
the Engineer for approval prior to ordering the piece of equipment.

14.2.1 The Contractor shall develop and deliver calculations, approved by a New York State Licensed Professional Engineer, demonstrating the HLV enclosure’s ability to withstand the design loads.

14.2.2 Included in the shop drawings shall be parts lists, schematics, wiring lists, mechanical details including material, dimensions, and finish, and assembly drawings.

14.2.3 The Contractor shall develop and deliver shop drawings approved by a licensed New York State Professional Engineer which illustrates, in detail, how to mount and connect the HLV enclosure to the structure shown in the plans.

14.2.4 The submission shall be of adequate detail for the Engineer to determine compliance with the specification and shall be neatly drawn and legible.

14.2.5 The submission shall be complete and clearly indicate the contract item number for which the submission is being made and the model or part number for which approval is being sought.

14.2.6 Incomplete submissions will be returned for re-submission.

14.2.7 Manuals

14.3 Manuals that detail the operation of the system shall be furnished as part of the HLV Assembly.

14.3.1 User Manuals shall be provided for each system component. The User Manuals shall fully identify the system’s, or the component’s, features and functions and give detailed step-by-step instructions on how to operate and adjust the system or component and how to respond to system or component failures.

14.3.2 Operations Manuals shall be provided and shall, as a minimum, include:

14.3.3 Detailed description of normal system operation.

14.3.4 Detailed description of sign control software operation and procedures. The manual shall clearly describe all functions supported by the sign control software. The software operations manual shall be written for beginner personal computer users who are not familiar with detailed computer operations and terms. It shall contain step-by-step procedures with examples containing pictures of the computer screens.

14.3.5 Error and alarm handling procedures, including recovery from communications failures.

14.3.6 System start-up and shutdown procedures.

14.3.7 Detailed Maintenance Manuals shall be provided and shall, as a minimum, include:

14.3.7.1 Diagnostic routines for trouble shooting the system from the system computer and from each sign location. The manuals shall contain theory of operation, specifications, installation instructions,
14.3.7.2 All the requirements for the Operations manuals.

14.3.7.3 Detailed description of procedures for modifying the LED HLV, sign controller and sign control software configuration settings.

14.3.7.4 Description of operating procedures and troubleshooting procedures for each subsystem. This shall include step-by-step field and bench troubleshooting procedures to isolate and repair faults, as well as normal waveforms and test voltages.

14.3.7.5 Hard copy listing for all non-volatile or similar memory devices used in the equipment. The Contractor shall also supply complete instructions for the hardware and software equipment that shall enable NYSDOT to change, add and delete messages stored in non-volatile memory.

14.3.7.6 As installed color-coded interconnection wiring diagrams, both "factory" and "field."

14.3.7.7 Equipment wiring and all circuit board schematic diagrams indicating "factory" and "field" wiring. This shall include drawings showing the physical location of each component, as well as logic diagrams and stage-by-stage explanation of the circuit theory for each circuit board.

14.3.7.8 Complete nomenclature and commercial number of replacement parts, including current prices, listing of spare parts initially provided, and a second source of supply where applicable, cross-referenced as to component designation.

14.3.7.9 Each manufacturer's product data sheet annotated to clearly identify product or part.

14.3.7.10 Each manufacturer's printed operating and maintenance instructions.

14.3.7.11 List of recommended cleaning agents, maintenance procedures and schedules.

14.3.7.12 List of recommended test equipment including manufacturer's name, address, and model number.

14.3.8 Three (3) copies of each manual shall be furnished with each HLV. These manuals are in addition to the manuals provided during training courses. All manuals of each type shall be identical and shall be originals, not reproduced copies.

14.3.9 Options identified in a manual, which are not furnished with the HLV System shall be marked "NOT USED."
14.3.10 The manuals shall consist of sturdy, hard cover, 3-ring, loose-leaf binders made for 8 ½" by 11" sheets. They shall be provided with a table of contents clearly itemizing the catalog and with loose-leaf hole reinforcements, except for those sheets where the full length of the fastener-edge is, in an approved manner, either reinforced or made of a high-strength material. Loose-leaf holes shall not be punched through the body of drawings or other sheets. They shall be punched in the margin only, and each drawing and other large sheet shall have the margin trimmed and the sheet properly folded so that it may be unfolded and viewed without the need to remove it from the binder. Labels, protected by plastic covering, shall be securely affixed to both the face and spine of each binder. The labels shall contain the title of the manual, the manual number, the Contract title, and the Contract number.

14.4 For all custom application software necessary to operate the HLV, the Contractor shall provide NYSDOT with the software source code, and compiler necessary to compile it. The Contractor shall also demonstrate the compiling, linking, and loading of the source code as part of this test.

14.5 Electronic copies of all manuals shall be provided on CD in PDF format. Three copies of the CD’s shall be provided.

14.6 NYSDOT shall have the right to make copies of all manuals both hard copy and electronic.

15 Testing

Design Approval Tests

15.1 The following tests shall be performed as part of the design approval test in addition to those specified in the Special Notes. The Design Approval Test shall be performed on a complete HLV assembly. While performing these tests a test set shall be used to issue commands to the sign controller to verify that the sign remains operational throughout the test:

15.1.1 Power variation: Test the sign with the line voltage at the maximum, minimum and nominal specified values. Using a power interruption meter, at each of these voltages interrupt the power for 0.1 seconds five times. Repeat for a 0.5 second interruption and for a 1 second interruption.

15.1.2 Transient immunity: Using a transient generator set to the following conditions:

15.1.3 Amplitude: 300 volts ±5 percent, positive and negative polarity

15.1.4 Peak power: 5000 watts

15.1.5 Repetition: One pulse every other cycle moving uniformly over the full wave in order to sweep once every 3 seconds across 360 degrees of line cycle.

15.1.6 Pulse rise time: 500 ns.
15.1.7 Power line surge: Discharge a 25 uF capacitor charged to plus and minus 2000 volts applied directly across the incoming AC line at a rate of once every 10 seconds. Perform the test 10 times for each polarity. The unit shall be operated at 120 ± 12 VAC.

15.1.8 Temperature: All functional operations of the equipment shall be successfully performed under the following conditions and in the order specified below:

15.1.8.1.1 The equipment shall be stabilized at -30 degrees Fahrenheit. After stabilization at this temperature, the equipment shall be operated without degradation for two (2) hours.

15.1.8.1.2 The equipment shall be stabilized at 140 degrees Fahrenheit. After stabilization, the equipment shall be operated without degradation for two (2) hours.

15.1.8.1.3 The equipment shall be subjected to temperature shock of 30 degrees Fahrenheit per hour, during which time the relative humidity shall not exceed 95%. The equipment shall be operated without failure during and after the temperature shock.

15.1.9 Relative Humidity: All equipment shall meet its performance requirements when subjected to temperature and relative humidity of 110 degrees Fahrenheit and 95%, respectively. The equipment shall be maintained at this condition for 48 hours. At the conclusion of the soak, within 30 minutes, the equipment shall meet all of its operational requirements.

15.1.10 Vibration: The equipment shall show no degradation of mechanical structure, soldered components, plug-in components or satisfactory operation in accordance with the manufacturer's specification after being subjected to the following vibration test:

15.1.10.1 The equipment shall be secured to the head of suitable electro-mechanical shaker in the vertical, lateral, and longitudinal planes, respectively. The object of the test is to vibrate the equipment in each of the three (3) mutually perpendicular axes, in accordance with the following parameters:

- Amplitude: 1/16 in. "Double Amplitude" (peak to peak)
- Linear Acceleration (g's): 5 maximum
- Linear Velocity: approximately 7 ½ in/s
- Frequency: 40 Hz
- Duration: five (5) minute dwell in each axis

15.1.11 If the equipment fails the design approval test, the design fault shall be corrected and the entire design approval test shall be repeated. All deliverable equipment shall be modified, without additional cost to the New York State Department of Transportation, to include design changes required to pass the design approval tests.
Factory Demonstration Tests

15.2 Following Design Acceptance Testing and prior to shipping of any signs, the Contractor shall perform a factory demonstration test on a single sign. Factory Demonstration Tests shall test the full functionality of a sign, controller, central control and maintenance software and communications between them.

15.2.1 Using a notebook computer loaded with test software provided by the sign manufacturer demonstrate the following with the computer connected to the input (remote) port of the controller:

15.2.2 Exercising of all sign functions as defined in this document.

15.2.3 Simulation of error and fault conditions to demonstrate the detection and reporting of the status conditions defined in this document. Including, but not limited to, open cabinet door, bad pixels, bad drivers, illegal message, and illegal character.

15.2.4 With the notebook computer loaded with the test software provided by the sign manufacturer demonstrate operation through the local port of the sign controller.

15.2.5 Demonstrate compliance with the NTCIP specific standards to be implemented, applicable conformance groups, applicable data objects and their associated range values that are pertinent to the implementation of this specification.

15.2.6 Water Test: A water spray test shall be performed to demonstrate that the enclosure meets the NEMA 3R rating. At the completion of the test, verify that the inside of the housing is dry.

15.2.7 For all custom application software necessary to operate the HLV Assembly, the Contractor shall provide NYSDOT with the software source code, and compiler necessary to compile it. The Contractor shall also demonstrate the compiling, linking, and loading of the source code as part of this test.

15.2.8 If the HLV Assembly fails the factory demonstration test, the fault(s) shall be corrected and the entire factory demonstration test shall be repeated. All deliverable equipment shall be modified, without additional cost to the NYSDOT, to include any changes required to satisfactorily complete the factory demonstration tests.

Stand Alone Tests

The following stand-alone tests shall be performed after the sign is installed:

15.3 Insulation, continuity and ground tests shall be performed in accordance with §680-3.32, Tests.

15.4 After installation and prior to integration of the HLV into the system, the Contractor shall perform an operational stand-alone test in the field for each unit. The test, as a minimum, shall demonstrate operation of the HLV Assembly using the test software running on a notebook computer provided by the Contractor.

15.5 Using a notebook computer loaded with test software provided by the sign manufacturer demonstrate the following with the notebook computer connected to the input (remote) port of the controller:
port of the controller:

15.5.1 Exercising of all sign functions as defined by the Contract.

15.5.2 Simulation of error and fault conditions to demonstrate the detection and reporting of the status conditions defined in this document. Including, but not limited to, open cabinet door, bad pixels, bad drivers, illegal message, and illegal character.

15.5.3 With the notebook computer loaded with the test software provided by the sign manufacturer demonstrate operation through the local port of the sign controller.

15.5.4 Operate the sign for thirty-days in a test mode that shall continuously exercise the display. At the end of the thirty-day period, operation of the sign using the test software shall again be demonstrated. If a failure occurs, the sign shall be repaired and the thirty-day test repeated. A test pattern, approved by the Engineer, shall be displayed during the test.

Remote Site Verification Test

15.6 The Contractor shall verify the operations of the sign by operating it from the control center via the communications network.

System Acceptance Tests

15.7 Following the satisfactory completion of the Site Verification Tests, a system acceptance test shall be performed. Testing shall meet the requirements of the Contract Documents.

15 Training

15.1 The Contractor shall provide training courses to NYSDOT personnel as specified in the Special Notes section of this package.

16 Spare Parts

16.1 The following spare parts identified in the table below shall be provided by the Contractor and handed over to the Engineer after completion of system acceptance, for use by maintenance personnel.

16.2 The spare parts shall not be used by the Contractor during the construction period, and shall be delivered to the Engineer in a new and working condition.

16.3 All spare parts shall be certified by the manufacturer that they are suitable for use on the signs provided under this contract, and are in a working condition. Manufacturer’s certification shall include tests conducted, date of such tests, and the pass/fail criteria for these tests.

16.4 The Engineer reserves the right to witness any such testing of spare parts.

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Quantity of Spares</th>
</tr>
</thead>
<tbody>
<tr>
<td>HLV Controller (including all associated cards and hardware)</td>
<td>2</td>
</tr>
<tr>
<td>Display Modules</td>
<td>2 or 5% of each type, whichever is greater</td>
</tr>
</tbody>
</table>
METHOD OF MEASUREMENT

This work will be measured as the number of HLV Assemblies of the type specified furnished, completely installed, successfully tested, and operational. Any necessary conduit and cabling required for the power feed and communications to the HLV Assembly will be paid for separately under the applicable items. The static sign panel shall be paid for under § 645.03010011, Ground-Mounted Sign Panels.

BASIS OF PAYMENT

The unit price for each HLV Assembly of the type specified shall include the cost of furnishing all labor, materials and equipment necessary to complete the work. All miscellaneous hardware and software, required for the installation and testing of the unit shall be included under this item. Payment for the communication equipment will be made under their respective items. Payment for all documentation, testing, test equipment, spare parts and software shall be included under this item.

Progress payment will be made as follows:

- Ten percent (10%) of the bid price for the sign will be paid upon approval of the shop drawings.
- Thirty percent (30%) of the bid price for each item will be paid upon satisfactory completion of installation of the assembly at the job site.
- Forty percent (40%) of the bid price for each item will be paid upon satisfactory completion of the operational stand-alone test.
- Ten percent (10%) of the bid price for each item will be paid upon satisfactory completion of the remote site verification test.
- Ten percent (10%) of the bid price will be paid upon system acceptance.

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>683.200XYZ08 Hybrid Static Variable Message Sign Assembly</td>
<td>Each</td>
</tr>
</tbody>
</table>

The number of VMS modules connected to a single controller in the HSVMS is indicated by:
The “X” = item number, where “X” = are 1-2-3.
The “Y” = characters in each VMS module, where “Y” = are 3 and 4.
The Z = “Type” or “Height” of the characters.
The Z=1 indicates Type 1 HLV = eighteen (18” high)
The Z=2 indicates Type 2 HLV = twelve (12” high).