

Document Control

Issue Date	Comments	Revisions	Revision #
3/12/99	Draft		
3/17/99	Draft		
11/1/99	Revise submittal requirements	631.1.03	1
12/30/99	Include cabinet mounting height requirement. Incorporated Lonnie Jones' comments from e-mail dated 11/18/99	631.3.05B6b	2
1/12/00	Project: CM-00TS(10) Ct. 1 Fulton County P.I. No. 713155 Project: CM-00TS(10) Ct. 2 DeKalb And Fulton County P.I. No. 713157		
2/3/00	Project: CM-056-1(57) Fulton County P.I. No. 721950		
3/22/00	Revise submittal form reference; revise Training Material definition. Delete separate payment for horizontal wire, pullboxes.	631.1.03 631.4.A	3
4/3/00	Delete Dept. responsibility for repair of damages by natural causes or not Contractor activities. Dept. typically pays Contractor to fix such damage. Correct reference to CCTV support pole.	631.3.06.G.3.b 631.4.A	4
4/3/00	Project: CM-285-1(360) DEKALB COUNTY P.I. NO. 713410		
6/8-12/00	Revisions in response to L. Jones review and comments on I-20 jobs Specify training instructor experience Delete requirement for pre-approved Lexan sheets; add rams for Lexan sheets performance criteria. Add Laptop Computer to Materials section Add "laptop" to requirements for test computer and delete "shall remain property of Dept," because laptop separate payitem. Revised contact point to Department's designated representative Allow partial payment of 75% of bid price after pre-instal. testing & 85% after proof-of-performance testing. Delete testing from central computer with NaviGator software Add functional testing requirements (SCR66) Add operational testing requirements (SCR66)	631.3.01 631.3.04.C.2 631.2.D 631.3.06.F.2 631.3.07.C 631.5.A 631.1.03.G 631.3.06.F.3 631.3.06.F.4	5
9/7/00	Provided copy to NET for NTCIP editing		
9/28/00	Revised power consumption per SPCR #	631.3.04.C.1.f	6

Document Control

Issue Date	Comments	Revisions	Revision #
12/11/00	SCR #65: Add that testing is for all signs in the contract	631.4.N	7
1/26/01	SCR #65: laptop is property of Contractor SCR *81: folding step or similar mechanism	631.2.D 631.3.04.C.1.3	8
2/9/01	Document Control No. NAV01-045		1.0
2/14/00	Entered into CM Document Control		1.0
3/5/01	SCR # 185 Modified Appendix B to align with the NTCIP protocol suite	Appendix B	1.1
3/5/01	Modified several sections to reference the new Appendix B	631.1.03.D 631.3.04.D.1 631.3.05.B.1 631.3.06.F.2 631.3.06.F.3 631.3.06.F.4	1.1
3/5/01	Reworded Timing of Work section	631.3.05.B	1.1
3/5/01	Added NTCIP documents to Referenced Documents section	631.1.02.B	1.1
4/20/01	SCR # 185 Removed references to controller functionality that could not be supported by NTCIP	631.3.04.D.3.e (old subsection e deleted), 631.3.04.D.3.f (old subsection f deleted), 631.3.04.D.3.g, 631.3.04.D.3.h, 631.3.04.D.3.l (old subsection l deleted)	1.2
4/28/01	SCR # 185 Removed Appendix A because it contained redundant information; The functionality of the CMS has been adequately described within the body of the Specification and the NTCIP protocol stack defined in the Appendix.	Appendix A	1.2
5/17/01	SCR # 183 Added LED sections	631.3.04.A.3.a, 631.3.04.A.3.b, 631.3.04.C.3.c, 631.3.04.C.3.e (new subsection e added), 631.3.04.C.3.f, 631.3.04.C.3.g, 631.3.04.C.4	1.2
5/23/01	SCR # 195 – Change to installation support items.	631.4	1.3
5/25/01	Published to server		2.0
7/6/01	SCR # 237	631.3.05.B.2	2.1
7/6/01	Published to server		3.0
8/6/01	SCR # 179	631.1.03.L	3.1
8/7/01	Published to server		4.0

Document Control

Issue Date	Comments	Revisions	Revision #
11/19/01	SCR # 300	631.2.D 631.3.06.F.3	4.1
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12/04/01	SCR # 280	631.3.07	5.1
12/10/01	Published to server		6.0
1/17/02	SCR # 290	631.3.04.C.4	6.1
1/22/02	Published to Server		7.0
8/15/02	Inclusion of metric equivalents. SCR #334	631.2.B.7; 631.2.C.1; 631.2.C.2; 631.3.04.A.2; 631.3.04.A.3b; 631.3.04.B.2c; 631.3.04.B.3b; 631.3.04.C.1e; 631.3.04.C.1f; 631.3.04.C.1h; 631.3.04.C.3; 631.3.04.C.3a; 631.3.04.C.3c; 631.3.04.C.4; 631.3.04.C.6b; 631.3.04.C.7; 631.3.04.E; 631.3.04.F.3; 631.3.05.B.5; 631.3.05.B.6a; 631.3.05.B.6b; 631.3.06.D; 631.3.06.E.1; 631.3.06.F.2	7.1
9/25/02	Published to server		8.0
11/17/02	Modified to meet Office of Contract Administration requirements for format per TOPPS document 2445-1. SCR # 371		8.1
12/18/02	Published to server		9.0
3/12/03	SCR # 389 (Addition of LED installation support items.)	631.4.A	9.1
3/21/03	Published to server		10.0
1/25/05	Revised as per SCR # 474 (Modified to incorporate Ethernet Interface)	631.1.02.B; 631.1.02.C; 631.1.03; 631.3.04.A.3.b; 631.3.04.D.1; 631.3.04.D.2; 631.3.04.D.4.a; 631.3.04.D.5.a; 631.3.04.D.5.b; 631.3.04.D.5.d; 631.3.04.D.5.e; 631.3.04.D.5.h; 631.3.04.D.5.i; 631.3.08.B; 631.4.A; 631.4.L; 631.4.M; 631.5.A; Appendix A;	10.1-10.4
1/26/05	Published to server		11.0

**DEPARTMENT OF TRANSPORTATION
STATE OF GEORGIA**

SPECIAL PROVISION

**PROJECT: [INSERT PROJECT NUMBER(S)]
[INSERT COUNTY NAME(S)] COUNTIES
P.I. NO. [INSERT P.I. NUMBER(S)]**

SECTION 631 – PERMANENT CHANGEABLE MESSAGE SIGNS

Section 631 - Permanent Changeable Message Signs

The text included herein is written in the imperative mood (sentences often begin with commands). All commands and references in, or in connection with, the text in this document are written to imply **Contractor responsibility for action** unless otherwise specified.

631.1 General Description

This Work includes furnishing and installing permanent changeable message sign equipment. Major elements of the CMS system include changeable message signs, local changeable message sign controller, and power service to the controller and sign.

Configure the system to provide motorists with textual information using changeable message signs placed over or adjacent to designated roadways. Local CMS controllers provide a base level of control of the CMS display. Primary control and command of the local CMS controllers in the system will be through a communication link to a central facility as identified within the project plans. Auxiliary control will be accomplished from other remote locations to the central facility locations, as identified within the project plans, over communication media that may be different than that used for the primary control and command to/from the central facility. Local control and command may be accomplished manually from the local CMS controller by operator input via a keypad on the front of the controller and through the use of a laptop computer connected to one of the data ports of the local CMS controller.

631.1.01 Definitions

Not applicable

631.1.02 Related References

A. Georgia Specifications

Section 150 – Traffic Control

Section 682 – Electrical Wire, Cable and Conduit

Section 925 – Traffic Signal Equipment

Section 939 – Communications and Electronics Equipment

Section 940 – NaviGator Advanced Transportation Management System

B. Referenced Documents

AASHTO “Standard Specification for Structural Supports for Highway Signs, Luminaires, and Traffic Signals”

American National Standards Institute (ANSI)

American Society of Testing and Materials (ASTM)

American Welding Society (AWS) Standards

Electronic Industries Association (EIA)

Illumination Engineers Society (IES)

International Municipal Signal Association (IMSA)

MIL-STD-429 and any current addendum

MIL-P-13949

MIL-STD-275E

MIL-P-55110

National Electrical Code (NEC)

National Electrical Manufacturers Association (NEMA)

NEMA TS-2-1992, the TS-2-1994 supplemental

National Transportation Communications for ITS Protocol (NTCIP)

Rural Electrification Administration (REA)

Underwriters Laboratory Incorporated (UL)

C. NTCIP References

This specification references several NTCIP standards. Each NTCIP Component covered by these project specifications shall implement the most recent version of the standard that has reached the stage of Recommended or higher as of September 20, 2004, including any and all Approved or Recommended Amendments to these standards as of the same date.

The standards that have been referenced by this specification are listed below.

NTCIP Number	Title
NTCIP 1201:1996	NTCIP Global Object (GO) Definitions
NTCIP 1203:1997	NTCIP Object Definitions for Dynamic Message Signs (DMS)
NTCIP 2001:1996	NTCIP Class B Profile
NTCIP 2101 v01.17	NTCIP SP-PMPP/RS232 (Point-to-Multi-Point Protocol using RS232 Sub-network Profile)
NTCIP 2103 v01.05	NTCIP SP-PPP/RS232 (Point-to- Point Protocol using RS232 Sub-network Profile)
NTCIP 2104	NTCIP SP-Ethernet (Ethernet Profile)
NTCIP 2201 v01.03	NTCIP TP-Transportation Transport Profile (TP-Null)
NTCIP 2202	NTCIP TP-Internet (TCP/IP and UDP/IP)

NTCIP 2301 v01.07	Simple Transportation Management Framework (STMF) Application Profile
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Note that the last four documents reflect the current trend of the NTCIP standardization effort to define profiles that relate to particular protocol levels in the NTCIP Framework. A protocol stack defined in accordance to NTCIP 2101, NTCIP 2201, and NTCIP 2301 directly corresponds to the protocol stack defined in NTCIP 2001.

631.1.03 Submittals

The following chart provides the Contractor with an outline of the submittal requirements for the equipment and components for these pay items. This chart is to be used as a guide and does not relieve the Contractor from submitting additional information to form a complete submittal package.

The following definitions apply to the submittal requirement terms in the following chart:

Catalog Cuts: Information provided by the manufacturer or vendor that pictorially describes the item or component.

Manufacturer Specification: A detailed Specification prepared by the item or component manufacturer.

Shop Drawings: Drawings providing detailed assembly and component layout, used by the manufacturer to assemble or construct the Item.

Structural Calculation: Calculations prepared by a registered Professional Engineer, in the state of Georgia, that indicate that the assembly meets all requirements of these Special Provisions, the Standard Specifications and AASHTO for wind loading, etc.

Lab Test Report: A certified report from a independent laboratory that the component or assembly meets all the requirements of these special provisions.

Installation Procedure: A manual prepared by the manufacturer that indicates the installation procedures for components, sub assemblies or assemblies, as outlined in Section 631.1.03 G of these Special Provisions.

Maintenance Procedure: A manual prepared by the manufacturer that indicates the maintenance of all components, sub assemblies, and assemblies as outlined in Section 631.1.03 O.2 of these Special Provisions.

Test Schedule: A written schedule of the testing required as outlined in Section 631.1.03 C of these Specifications.

Test Plan: A plan developed by the manufacturer to perform the testing required for this item as outlined in Section 631.1.03 H, I, and J, and Section 631.3.05 F1, F2, F3, and F4 of these Special Provisions.

Test Reports: A report developed by the manufacturer that documents the results of each of the required tests as outlined in Section 631.3.05 F1 of these Special Provisions.

Training Schedule: A schedule prepared by the Contractor that outlines the time for the required training sessions as outlined in Section 631.3.06 A, of these Special Provisions.

Training Material: Course material for each of the training sessions required by section 631.3.08 A and B of these Special Provisions.

Material	Specification Reference	Catalog Cuts	Mfg. Spec.	Shop. Drawings	Structural Calc.	Lab Test Report	Install. Proced.	Maint. Proced.	Test Schedule	Test Plan	Test Reports	Training Schedule	Training Material	Submittal Due Date (Calendar Days After NTP)
CMS Test Software	631.1.03 F								x	x				90 days
Capacitors	631.2 B.2	x	x											60 days
Potentiometers	631.2 B.3	x	x											60 days
Resistors	631.2 B.4	x	x											60 days
Semiconductor Devices	631.2 B.5	x	x											60 days
Transformers & Inductors	631.2 B.6	x	x											60 days
Circuit Breakers	631.2 B.7	x	x											60 days
Switches	631.2 B.8	x	x											60 days
Terminal Blocks	631.2 B.9	x	x											60 days
Wiring Cabling & Harnesses	631.2 B.10	x	x											60 days
Pin & Socket Connectors	631.2 C.1	x	x			x		x						60 days
PCB Connectors	631.2 C.2	x	x			x		x						60 days
Indicators	631.3.04 A.2	x	x			x		x						60 days
CMS Pixels	631.3.04 A.3	x	x			x	x	x						60 days
Connectors	631.3.04 B.1	x	x			x		x						60 days
PCB Assemblies	631.3.04 B.2	x	x			x	x	x						60 days
Printed Circuit Boards	631.3.04 B.3	x	x			x	x	x						60 days
Sign Housing	631.3.04 C.1	x	x	x	x	x	x	x						60 days
Sign Face	631.3.04 C.2	x	x	x		x	x	x						60 days
Display Matrix	631.3.04 C.3	x	x	x		x	x	x						60 days
Driving Electronics	631.3.04 C.4	x	x			x	x	x						60 days
Photosensor System	631.3.04 C.5	x	x			x	x	x						60 days
Vent. & Heater	631.3.04 C.6b	x	x			x	x	x						60 days
CMS Controller (All Types)	631.3.04 D	x	x			x	x	x						60 days
CMS Controller Cabinet	631.3.04 E	x	x	x		x	x	x						60 days
Controller Equipment	631.3.05 B.6	x	x			x	x	x						60 days
Pre-Installation Test	631.3.06 F.2								x	x	x			Plan - 60 Days
Proof of Performance Test	631.3.06 F.3								x	x	x			Plan - 60 Days
Acceptance Test	631.3.06 F.4								x	x	x			Plan - 60 Days
Training	631.3.08 A											x	x	Plan - 90 Days

A. General

Clearly identify in the submittals any deviations from the Contract requirements and specifications. Provide a detailed description of the deviation with the reason for the change. Do not interpret approval of the submittals or shop drawings as approval of any deviation unless such deviation is identified in writing in the submittal letter that is separate from the shop drawings.

B. As-Built Plans

Furnish four (4) complete half-size 11" x 17" as-built plans signed and sealed by a Professional Engineer registered in the State of Georgia in accordance with the Standard Specifications. Include in the as-built plans all materials and installation work, along with all structural elements and assemblies that are related to the CMS system at a given location. Prepare the as-built plans and show in them all changes and deviations from the original Plans. On each plan sheet, provide the name of the Contractor and any Subcontractors who performed any work shown on the plan sheet. Submit the as-built plans to the

Engineer no later than 30 days after the completion of acceptance testing. The burn-in period will not commence until the Engineer approves the as-built plans.

C. Submittal Data Requirements

Submit submittal data and shop drawings for all equipment, materials, test procedures, and routine maintenance procedures required in this Contract within 60 calendar days after Notice to Proceed and prior to any installation, unless noted otherwise in the Contract documents. Submit structural foundation, support, and mounting shop drawings for changeable message signs within 90 calendar days after Notice to Proceed.

Submit to the Engineer for approval, six (6) copies of the manufacturer's descriptive literature, technical data, operational documentation, service documentation, and other materials fully describing the design, equipment, and materials that will be used for all non-structural equipment or materials required in this Specification.

Provide shop drawings for all structural support materials, changeable message sign housing material, and all other special design, non-electrical, non-mechanical fabricated items.

Provide submittal data and shop drawings that are neat, legible, and orderly. Neatly organize each package of submittal data and separate by hardware item. Use the "Material Certification Package Index and Transmittal Form," contained in Section 105.02 of the Special Provisions, for each pay item to document and list all material and components that are included in the submittal package. Any submittal data submitted without the Index/Transmittal form or that is incomplete will be rejected.

Include with submittal data a copy of the calculations of the light value expected at the output of the fiber pixel.

D. CMS Test Software

Within 90 days of Notice to Proceed, submit for Department review proposed CMS test software that will be used to verify the functional and performance capabilities of the CMS using the NTCIP protocol stack defined in Appendix A of Section 631. The review of the test software will not relieve the Contractor of any requirements to provide a fully functioning CMS that performs in accordance with the Specifications.

E. Documentation for Electronic Equipment

Provide the documentary items specified in this section for all changeable message sign equipment and materials. The documentary items shall provide a complete and precise technical description of all CMS equipment and materials and shall thoroughly demonstrate that the design and construction of all CMS equipment and materials fully conforms to all requirements of this Specification.

Provide the following documentary items in a neat, legible, clearly identified, and suitably bound fashion:

- Manual fully describing the theory of operation with complete technical data including block diagrams showing operational relationships between major components, wave forms, etc.
- Manual for troubleshooting including flowcharts, test procedures, test points, alignment procedures, etc.
- Electronic schematics on 11" x 17" drawings.
- Pictorial layout of components on circuit boards showing locations of all components and referencing each component to its entry in the parts list/manufacturer's data sheet.
- Complete parts lists/manufacturer's data sheets of all passive and active electrical and electronic components. Parts lists/data sheets shall provide complete technical materials and performance data, environmental specifications, manufacturer's names/part numbers, etc.
- Drawings and materials lists of all equipment and assembly frames, mounting brackets, mechanical items, etc.
- Diagrams of field installation wiring showing all terminal block positions and identifications.
- Recommended routine maintenance procedures and schedules for all equipment and materials.

F. Pre-Installation Testing

Submit the Pre-installation Test Plan in accordance with these Special Provisions. The Pre-Installation Test Plan shall be a detailed and thorough procedure that fully demonstrates that the changeable message sign, local CMS controller, and local CMS controller cabinet meet all requirements of the Specifications. Include the following items within the Pre-Installation Test Plan as a minimum:

- Review of updated documentation
- Review of updated schematics and drawings
- Review of electrical design, components, and construction of CMS assembly
- Review of mechanical design and construction of CMS assembly
- Operational performance testing of CMS assembly
- Environmental testing of CMS assembly
- Software functional testing of CMS assembly from local computer
- Operational test for a continuous 24 hour period

Request a Pre-Installation Test for one or more signs in writing a minimum of 30 calendar days in advance of the requested test session date. Permit the Engineer to adjust the proposed schedule of the Pre-Installation Test by up to seven (7) calendar days to allow for availability of Department representatives.

G. Proof of Performance Testing

Submit a Proof of Performance Test Plan in accordance with these Special Provisions. The Proof of Performance Test Plan shall be a detailed and thorough procedure that fully demonstrates that the complete changeable message sign installation and all work required in the Plans and Specifications at that location meet all Contract requirements. Include with these requirements testing of the following items as a minimum:

- Verification of installation as per the Plans and Specifications, including construction, structural installation, guardrail installation, landscaping, grounding system, and utility installation
- Verification of identical components as installed to those used at the conclusion of pre-installation testing
- Operational performance testing of CMS assembly, including visibility testing, communications testing, display alignment, and workmanship items as per the Plans and Specifications
- Functional testing from local computer
- 48-hour operational testing

Request a Proof of Performance Test for one or more signs in writing a minimum of 15 calendar days in advance of the requested test session date. Permit the Engineer to adjust the proposed schedule of the Proof of Performance Test by up to seven (7) calendar days to allow for availability of Department representatives.

H. Acceptance Testing

Submit an Acceptance Test Plan in accordance with these Special Provisions. The Acceptance Test Plan shall be a detailed and thorough procedure that fully demonstrates that the complete changeable message sign system and all work required in the Plans and Specifications meet all Contract requirements. Include in these requirements testing to demonstrate that all changeable message signs can be operated simultaneously as an integrated system. The Acceptance Test Plan shall include a method to verify that all operational items for each CMS can be controlled from a central control facility using the Department's NTCIP communication software and verified by field observation and status response messages.

Request an Acceptance Test in writing a minimum of 15 calendar days in advance of the requested test session date. Permit the Engineer to adjust the proposed schedule of the Acceptance Test by up to seven (7) calendar days to allow for availability of Department representatives.

I. Burn-In Period

Request in writing to begin the burn-in period at least seven (7) calendar days in advance of requested burn-in commencement, but no less than 15 calendar days after successful completion of the following requirements:

- All CMS work required in all Contract documents (may be combined with construction contract) has been completed and inspected by the Engineer (except this burn-in period).
- All Acceptance Testing is successfully completed.

Furnish written reports to the Engineer of the nature, date, and time of all malfunctions, the nature of the repair or corrective action, and the description of any replaced components by equipment and the equipment serial and model numbers. Complete all corrective action within the time defined within these Specifications.

J. CMS Support

Clearly identify in writing the designated contact person and alternate for support and warranty liaison with the Department.

K. Environmental Control and Protection

Provide documentation of the design calculations to support the performance of the ventilation and heating systems.

L. CMS Controller

Submit to the Construction Project Manager six copies of the Technical Specifications for the CMS controller unit as specified in Subsection 631.3.04.D. This submission shall include all information for the Department to determine the acceptability of the controller related to construction of the internal components, PCB construction, enclosure construction, power supply construction and capabilities, and operational characteristics and environments for construction and environmental tolerance of the CMS controller.

M. Documentation

Provide three sets of documentation for all components in accordance with these Specifications. Assemble the documentation in volumes of 3-ring binders and include title pages, indexes, page numbering and section dividers.

The documentation shall consist of the following types of manuals:

1. User's Manuals

Describe in the User's Manual how to operate the particular type of equipment, layout of controls, displays, and all other information required to correctly operate a fully functional unit.

2. Operation and Maintenance Manuals

Provide an Operation and Maintenance Manual(s) for the CMS and for the CMS controller unit. Include in the manual(s) all the information required to maintain and repair the equipment to the component level. Provide sections which completely describe the theory of operation using block diagrams and schematic drawings, diagnostic and repair procedures for corrective maintenance of the unit; assembly and disassembly instructions and drawings, layout drawings showing location of all components; and complete components listing showing component type, ratings and acceptable manufacturers. Provide complete schematic diagrams to the component level. The Operation and Maintenance Manual shall fully describe all adjustments and alignment procedures and provide descriptions of expected signals at all test points and outputs. Provide a repair and troubleshooting decision tree that describes each function, a series of tests of each function, and an "if it does this, do that" process that defines faulty elements that require repair, replacement, or adjustment to restore operation of a malfunctioning sign or system element. Provide detailed operating specifications of equipment performance.

3. System Documentation Manual

The System Documentation Manual shall describe the overall operation of the equipment with block level diagrams. Identify all equipment in the system with module and option numbers. Give a functional description of each element of the system and explain how they function together in a complete system. Provide operating procedures describing the initial turn-on,

adjustments to ensure that the system is operating within the performance requirements, and system level corrective maintenance procedures.

4. Software Manual

Fully document all CMS controller software in a Software Manual provided with the CMS controller. Include in the documentation a full description of the software code, functions, flowcharts, development tools, and utilities required to generate, debug, and support the CMS controller software (firmware). Provide descriptions of what actions are required to implement the software on the CMS controller, including compile options or sequence of building an operable software package directly loadable into the CMS controller, as a part of the CMS software documentation included in the manual.

Documentation included within the Software Manual shall include descriptions and listings required to describe the complete operation of all software programs. Submit software documentation to the Engineer for review and approval six (6) weeks prior to installation of the CMS controller units. The Engineer will review the documentation and return any comments and/or changes to the Contractor within four (4) weeks.

5. MIB Documentation Manual and Disk

Provide full documentation of the Management Information Base (MIB) that is used in the CMS controller. Specify the MIB in Abstract Syntax Notation 1 (ASN.1) format, and provide a copy of the MIB specified in ASN.1 on a single CD-ROM. If the CMS controller does not support the full range of any object of the Standard MIB, then provide a custom MIB in ASN.1 format that specifies the supported ranges and includes meaningful description fields.

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

N. Working Drawings

Submit working drawings to the Engineer no later than 30 calendar days after the Notice to Proceed. Include in the working drawings a pictorial representation of the assemblies that form a complete CMS system, the connection and wiring between assemblies, switch and adjustable control settings, and a description of the functionality of the assemblies including a listing of the assemblies required to form a complete CMS system.

O. Training Material

Provide each training participant with a copy of course material. Include in course material copies of both a comprehensive manual and of the presentation material that will be used. Provide two (2) additional copies to the Department. Provide the classroom, audio-visual equipment, demonstration equipment and "hands-on" equipment required.

Provide a draft of the course material to the Engineer who will approve or reject the course material or content within three (3) weeks of receipt.

P. Personnel Qualifications

Submit qualifications in writing of any workers performing work on the CMS within 60 calendar days after Notice to Proceed.

631.2 Materials

A. General

Furnish only new equipment that conforms to the applicable requirements of the Underwriters Laboratory Incorporated (UL), the Electronic Industries Association (EIA), the National Electrical Code (NEC), the American Society of Testing and Materials (ASTM), the American National Standards Institute (ANSI), International Municipal Signal Association (IMSA), the National Electrical Manufacturers Association (NEMA), Rural Electrification Administration (REA), Illumination Engineers Society (IES), American Association of State Highway and Transportation Officials (AASHTO), American Welding Society (AWS), and the applicable Standards, Specifications, and Regulations of the Georgia Department of Transportation and to any other codes, standards, or ordinances which may apply. Whenever reference is made to any of the

standards mentioned, consider the reference to mean the code, ordinance, or standard that is in effect at the time of the bid advertisement. Where conflicts occur between any of the Standard Specifications defined above and these Special Provision Specifications, the Special Provision Specifications shall prevail.

B. Components

1. General

This Specification defines the minimum specifications for the specific components that are used in any subassembly of the CMS. Devices not described within this section shall be of the highest quality, industrial grade or MIL Spec. available consistent with the design of the equipment or subassembly.

2. Capacitors

The DC and AC voltage ratings as well as the dissipation factor of a capacitor shall nominally exceed the worst case design parameters of the circuitry by 150 percent.

A capacitor, or the board that it is attached to, which may be damaged by shock or vibration, shall be properly supported by a clamp or fastener.

Use capacitor encasements that are resistant to cracking, peeling and discoloration.

Ensure that all capacitors are insulated and marked with their capacitance values and voltage ratings.

Do not use electrolytic capacitors for capacitance values of less than 1.0 microfarad. Electrolytic capacitors shall be marked with polarity. Electrolytic capacitors shall only be used in applications where they are continuously energized.

3. Potentiometers

Use no potentiometers less than 1 watt rating (except for trimmer type functions).

Ensure that the power rating of any potentiometer is at least 100 percent greater than the maximum power requirements of the circuit.

4. Resistors

Use only resistors that are insulated and marked with their resistance values. Resistance values shall be indicated by EIA color codes or stamped value (power resistor).

Resistors shall be 5 percent or less tolerance.

Do not use resistors that have a rating exceeding 2 watts unless special ventilation or heat sinking is provided. Insulate them from the PCB.

5. Semiconductor Devices

All solid state devices, except LEDs, shall be of the silicon type. Ensure that all transistors, integrated circuits, and diodes are standard types listed by EIA and clearly identifiable.

Use metal oxide semiconductor components that contain circuitry to protect their inputs and outputs against damage due to high static voltages or electrical fields.

6. Transformers and Inductors

Ensure that all power transformers and inductors have the manufacturer's name or logo and part number clearly and legibly printed on the side of the case or laminations. All transformers and inductors shall have their windings insulated and shall be protected to exclude moisture.

All transformer and inductor leads shall be color coded with an approved EIA color code or identified in a manner to facilitate proper identification.

Where custom transformers are used, provide complete specifications and fabrication information sufficient to allow the transformer to be acquired directly from the component manufacturer or from alternate sources.

7. Circuit Breakers

Use only circuit breakers listed by UL or ETL. The trip and frame sizes shall be plainly marked (marked on the breaker by the manufacturer), and the ampere rating shall be visible from the front of the breaker. All circuit breakers (30 amperes or greater) shall be quick break on either automatic or manual operation. Use only contacts that are silver alloy and enclosed in an arc quenching chamber. Overload tripping cannot be influenced by ambient air temperature ranges of from 0 °F (-18 °C) to 122 °F (50 °C). Minimum interrupting capacity shall be 10,000 amperes, root mean square.

Use circuit breakers of the trip free type.

Multi pole breakers shall be the common trip types.

8. Switches

Ensure that the switch contacts of all switches, except dip switches, are rated for a minimum of 5 amperes resistive load at 120 VAC or 28 VDC and are gold plated over brass (or equal). The switch shall be rated for a minimum of 100,000 no load operations.

9. Terminal Blocks

Unless otherwise noted, the blocks shall be barrier type rated at 20 amperes, 600 volts AC RMS minimum. The terminal screws shall be 0.3125 in. (7.9 mm) minimum length nickel plated brass binder head type with screw inserts of the same material.

10. Wiring, Cabling, and Harnesses

Ensure that all electrical conductors are stranded copper. Harnesses shall be properly bundled and tie-wrapped with external protection. Ensure that each harness is of adequate length to allow any conductor to be connected properly to its associated connector or termination point.

Provide CMS harness conductors that conform to the following color code requirements:

- Identify the grounded conductors of AC circuits by a continuous gray or white color.
- Identify the equipment grounding conductors by solid green or green with a striped yellow color with one or more stripes.
- Identify the DC logic ground conductors by solid white color with a red stripe.
- Identify the ungrounded AC+ conductors by a solid black or black with colored stripe.
- Identify the DC logic ungrounded conductor or signal conductors by any other color not specified above.

C. Mechanical

1. Pin and Socket Connectors

Use beryllium copper pin and socket contacts subplated with 0.00005 in. (0.0013 mm) nickel and plated with 0.00003 in. (0.00076 mm) gold. Pin diameter shall be 0.062 in. (1.6 mm).

Use connectors of a standard manufacturer with quick connect/disconnect capability and thread assist, positive detent coupling. Use connectors that are UL listed glass filled nylon, 94 V-I rated, heat stabilized, and fire resistant.

2. PCB Connectors

Use PCB edge connectors that have bifurcated gold plated contacts.

The PCB receptacle connector shall meet or exceed the following:

- Operating Voltage: 600 VAC (RMS) at sea level
- Insulation Resistance: 5,000 megohms
- Contact Material: Copper alloy plated with 0.00005 inch (0.001 mm) of nickel and 0.000015 inch (0.00038 mm) of gold
- Contact Resistance: 0.006 ohm maximum

D. Laptop Computer

Provide a laptop computer for testing that will run the testing software as specified in Subsection 631.3.06.F. The laptop computer shall remain the property of the Contractor after the completion of all CMS testing.

631.2.02 Delivery, Storage and Handling

Not applicable

631.3 Construction Requirements

631.3.01 Personnel

Training instructors shall be technically knowledgeable, competent, and proficient in the English language. Instructors shall have the following experience:

- Three (3) years in the design, maintenance, and implementation of CMS
- Taught at least one (1) training course within the last twelve (12) months

631.3.02 Equipment

Not applicable

631.3.03 Preparation

Not applicable

631.3.04 Fabrication

A. Components

1. General

Use only electrical/electronic components that are of modular, interchangeable, plug-in type fabrication and are standard manufacturers' components and UL certified. The design shall be such that a single pixel driver board failure will not effect more than the light emitting modules directly controlled by the failed driver board. During replacement of defective driver boards or light emitting modules, ensure that the sign remains operational but need not display messages as defined within the failure modes described elsewhere in these specifications. Do not use socket or jack mounted electronic components, except for large scale integrated circuits having more than 16 leads. Use IC sockets that have high grade, industrial quality, machined pin contacts and dual spring, gold plated type sockets. Ensure that all components and printed circuit boards are conformal coated. The PCB edge connectors shall have bifurcated gold plated contacts. All components shall be capable of withstanding the extreme environmental conditions as specified without degrading their design life. The design shall be

inherently temperature compensated to prevent abnormal operation. Circuit designs shall include compensation as is necessary to overcome adverse effects due to temperature in the specified environmental range.

2. Indicators

All indicators shall have a minimum ± 45 degrees cone of visibility with its axis perpendicular to the front panel. Ensure that all indicators are readily visible at a radius of up to 4 ft. (1.3 m) within the cone of visibility when the indicator is subjected to 9,000 foot-candles of white light with the light source at $45 (\pm 2)$ degrees to the front panel. All indicators shall have a rated life of 100,000 hours minimum.

3. CMS Pixels

- a. Fiber Optic Pixels: Each fiber pixel shall consist of at least one light point made up of a fiber optic bundle with its end fitted with a lens, closed and opened by a shuttering device using electromagnetic technology. The shutters shall be controlled by electromagnetic pulses, and the shutters shall remain in their state after the pulse is removed. In a stable position, ensure that power consumption of the electromagnetic shutters is zero. Flip disks or split flap disks are not acceptable.

Arrange adjacent pixels in groups to create display modules, illuminated by a single lighting source, that are then assembled into the total sign display. The light emitting elements of the display modules shall be perpendicular to the sign face.

Ensure that the fiber optic cable is constructed of glass with a suitable jacket to ensure maximum light output and protect the fibers from damage. Use only high quality step index glass optical fiber. Use fiber optic harnesses that each contain spare bundles equal to 5 percent of the total bundles used per display module. Each optical fiber light guide end shall be fitted with a lens that produces an emission controlled angle equal to 10 degrees centered around the optical axis.

Movement and replacement of fiber elements cannot dislodge other elements of the display or reorient them from their set positions. Replacement of one display module cannot require the removal or displacement of any other display module. Attachment of the glass fibers to the light source and shutters shall be secure to prevent disengagement under NEMA rated vibration and normal movement of the CMS components under operation and during maintenance or repair activity.

Use two 50-watt quartz halogen lamps for the lighting source of the fiber pixels, with a primary lamp and a secondary lamp per display module. Normally only one lamp is energized at any one time to illuminate all of the fibers within a fiber optic bundle used for a single display module. Ensure that lamp on/off sensing and switching between the primary lamp and the secondary lamp automatically reacts to primary lamp failure. The wiring to primary and secondary lamps shall be of different colors to aid in determining the location of the primary and secondary lamps in an assembly. When a display module is blank (no pixels are illuminated within a display module) all quartz halogen lamps serving that module shall be turned off. Install lamps in the orientation defined by the manufacturer to maximize lamp life.

The primary lamp is normally on when any pixel is on in the display module served by that lamp and may be commanded to be on with the secondary lamp. The secondary lamp is normally off unless the sign system detects that the primary lamp has malfunctioned or if commanded by the sign system to be on with the primary lamp. If the primary lamp has malfunctioned, the secondary lamp shall automatically be turned on if any pixel is on in the display module served by that lamp. Ensure that all fibers in a bundle are illuminated by the primary lamp during normal operation. The secondary lamp is off during normal operation. Ensure that all fibers in a bundle are illuminated by the secondary lamp during periods of primary lamp failure. The primary and secondary lamps shall illuminate all fibers in a bundle if commanded by the sign system. Bifurcation of the light source is not acceptable for illumination of the fibers in a bundle.

Verify that the maximum primary and secondary lamp voltage to be 10.0 volt root mean square. Use lamps with an average service life of 8,000 hours based upon a daily operational cycle of 12 hours at 100 percent, 8 hours at 50 percent and 4 hours at 70 percent of rated lamp voltage. Provide voltage filtering of the halogen lamp circuits to assure that spike or transient variations are suppressed to the extent that lamp life is enhanced.

The lamp and reflector shall be a single unit. Allow the lamps to be serviced from the inside of the sign and without the use of any special tools or removal of the shuttering devices. The lamp switching (turning the lamp on or off) circuitry shall provide for "soft-start" energizing of the lamps to extend filament life. Light output from each pixel shall be at least 33 cd during periods of operation when 100 percent of the rated lamp voltage is applied to the lamp. The color of the emitted light shall be white.

Alternative lighting source arrangements will be considered for approval by the Engineer but any alternative shall meet all of the requirements of the CMS pixel as described within this specification.

- b. LED Pixels: Use LED pixels that consist of a minimum of six (6) LEDs arranged in at least two interlaced strings with equal numbers of LEDs. Connect the LEDs in a string in series. Connect the pixel strings in parallel, and power the pixel strings from a regulated DC power source. Ensure that the failure of a single LED in one string within a pixel does not affect the operation of any other strings of the pixel. Do not exceed 1.5 watts (W) per pixel for pixel power drawn from the DC supplies, including the driving circuitry.

Use LEDs that are untinted, non-diffused, solid state lamps using aluminum indium gallium phosphide (AlInGaP) or indium gallium aluminum phosphide (InGaAlP) technology or equivalent technology. Use LEDs that emit a true amber color at a wavelength of 592 nm (± 5 nm) and are T-1 3/4 (5 mm) size. Ensure that the LEDs' mean time before failure (MTBF) is a minimum 100,000 hours permanent use at an operating temperature of 130 °F (54 °C) or below. In all CMSs supplied for this project, use LEDs that are identical and manufactured by the same manufacturer. Use LEDs with a display operating range of -20 °F (-30 °C) to +130 °F (54 °C) at 95% relative humidity, non-condensing. Ensure that the LED display operates at a DC voltage not exceeding 24V.

Use LED pixels that produce the luminous intensity levels required herein at a maximum allowed drive current of 25mA per LED, with a voltage that does not exceed 24VDC. Ensure that the light output from each pixel is at least 33 cd during periods of operation when 25mA of current is applied to each LED.

Ensure that all materials used in fabrication of LED character modules are not damaged by direct exposure to sunlight. Ensure that each LED character module is rated for outdoor use over the environmental range, including heat absorption due to sunlight. Install the LEDs individually in the circuit boards. Organize the pixels as a character matrix display with the ability to address each pixel individually. Space the centers of all pixels to maintain the same horizontal and vertical clearance between adjacent pixels. Optimize the LED grouping and mounting angle within a pixel for maximum readability.

Shade each LED pixel with flat black aluminum visors protected from degradation from sunlight. Multiple visors may be connected together to form a single visor unit that protects each character. Ensure that each visor or visor unit is individually removable and is designed for the required LED viewing angle and to promote effective LED cooling. Attach LED character modules to the display panel with a secure fastening system.

B. Mechanical

1. Connectors

Verify that all connectors are keyed to prevent improper insertion of the wrong connector or PCB.

The mating connectors shall be designated by the connector number and male/female relationship such as CAP (plug or PCB edge connector) and CAS (socket).

2. PCB Assemblies

- a. Design: Ensure that all assemblies are easily replaceable and incorporate plug-in capability for their associated devices or PCBs. Provide assemblies with a minimum of two guides for each plug-in PCB or associated device (except relays). The guides shall extend to within 0.75 in. (19 mm) from the face of either the socket or connector and front edge of the assembly. If nylon guides are used, securely attach the guides to the file or assembly chassis. Use only silk screened PCBs that show all component locations and are identified as such by markings matching the drawings and schematics.

No components, traces, brackets or obstructions can be within 0.125 in. (3.2 mm) of the board edge (guide edges).

Permanently mark the manufacturer's name or logo, model number, serial number, and circuit issue or revision number on the PCB. Make all identification readily visible.

The mounting and choice of components shall ensure that PCBs are not damaged or discolored due to the heat generated either individually or collectively by the components.

- b. Workmanship: Perform all workmanship in accordance with the highest industry standards.

Verify all PCB connectors mounted on a motherboard are mechanically secured to the chassis or frame of the unit.

All screw type fasteners shall use locking devices or locking compounds except for finger screws, which shall be captive.

c. Dimensions: Apply the following tolerances, except as specifically shown on the Plans or in these Specifications:

- Sheet Metal 0.0525 in. (1.33 mm)
- PCB +0, -0.010 in. (+0, -0.25 mm)
- Edge Guides 0.015 in. (0.38 mm)

d. Hardware: Unless otherwise noted, use stainless steel hardware in electronic assemblies.

e. Printed Circuit Boards

Definitions: For the purpose of this subsection on PCBs, use design standards taken from MIL-STD-429 and any current addendum.

Design, Fabrication and Mounting: Verify that all contacts on PCBs are plated with a minimum thickness of 0.000030 in. (0.00076 mm) gold over a minimum thickness of 0.000075 in. (0.0019mm) nickel.

PCB design shall be such that components may be removed and replaced without damage to boards, traces, tracks, or other components mounted on the board.

Use only PCBs fabricated in compliance with Military Specification: MIL-P-13949, except as follows:

- Use only NEMA FR-4 glass cloth base epoxy resin copper clad laminates 0.0626 inch (1.59 mm) minimum thickness. Wire intercomponents by laminated copper clad track having a minimum weight of 2 oz./ft² (0.6 kg/m²) with adequate cross section for the current to be carried. All copper track shall be plated or soldered to provide complete coverage of all exposed copper track. Do not use jumper wires, except from plated-through padded holes to an external component or for designed function selection with the jumper insulated and as short as possible.
- Section 3.3.3 of Military Specification: MIL-P-13949E shall read "Pits and Dents. Grade of Pits and Dents shall be of Grade B quality (3.3.3.2) or better."
- Omit Section 3.3 of Military Specification: MIL-P-13949.
- Section 3.4 of Military Specification: MIL-P-13949 shall read "Warp or Twist. Class of permissible warp or twist shall be Class A (Table II) or better."
- Omit Sections 4.2 through 6.6 of Military Specification: MIL-P-13949 (inclusive) except as referenced in previous sections of this specification. Conform the fabrication of PCBs and the mounting of parts and assemblies thereon to Military Specification: MIL-STD-275E, except as follows:

Mount all semiconductor devices required to dissipate more than 250mW or any case temperature that is 50 °F (10 °C) above ambient with spacers or transpads to prevent direct contact with the PCB.

When completed, remove all residual flux from the PCB.

The resistance between any two isolated, independent conductor paths shall be at least 100 megohms when a 500 VDC potential is applied.

All PCBs shall be coated with moisture and mildew resistant conformal coating.

Where less than 0.25 inch (6.3 mm) lateral separation is provided between the PCB (or the components of a PCB) and any metal surface, provide a 0.03125 in. (-0.0 in. to +0.0156 in.) [0.8 mm (-0.0 mm to +0.40 mm)] thick Mylar (polyester) plastic cover on the metal to protect the PCB.

Verify that each PCB connector edge is chamfered at 30 degrees from board side planes. The key slots shall also be chamfered so that the connector keys are not extracted upon removal of board or jammed upon insertion. The key slots shall be 0.045 in. (±0.005 in.) [1.1 mm (±0.13 mm)] for 0.1 in. (2.5 mm) spacing and 0.055 in. (±0.005 in.) [1.4 mm (±0.1 mm)] for 0.156 in. (4.00 mm) spacing.

Fuse all circuits that are routed using printed circuit traces or protect them to ensure that no damage to the printed circuit traces will occur due to circuit malfunction, component failure, connector installation or removal, or surges. Include protection from improper installation of control cables or short circuits between conductors. Do not splice the traces or circuit tracks on the PCB. No jumpers to correct a PCB design deficiency are allowed.

- f. Soldering: Hand solder in compliance with Military Specification: MIL-P-55110.
Perform automatic flow soldering in accordance with EIA standards.

C. CMS

This subsection describes the minimum requirements for the CMS assembly including the following major subassemblies:

- Sign housing and mounting hardware
- Sign face
- Display matrix
- Driving electronics
- Photosensor control
- Environmental control and protection
- Associated cables and wiring

1. Sign Housing

- a. Design: Provide interior non-corrosive metal cage support frames for the sign housing to mount the display elements. Ensure that the cage support withstands and minimizes vibration when the sign is mounted with any number of display elements. Provide the CMS housing with a minimum of two lifting eyes to be used when placing the housing on the sign structure. Locate the lifting eyes where required to minimize the stress on the housing and to facilitate a balanced support of the sign during the installation on and any subsequent removal of the sign from the sign supporting structure. Each lifting eye shall have a minimum inside diameter of 1 inch (25 mm). Lift the fully assembled sign into place using both lifting eyes. Each lifting eye, however, shall have sufficient structural strength to allow the sign to be lifted or moved without damage or deformation to any part of the sign. The sign housing shall be designed to allow mounting angles up to +/- 3 degrees from the vertical. The sign housing frame, exterior metal work, supporting structure attachment, catwalks, and lifting eyes assembly shall be certified by a Georgia registered structural engineer provided by the Contractor.

Use high strength aluminum alloy or stainless steel external mounting assemblies (including clamps and all associated brackets) conforming to the diameter of the sign support truss beams. Provide all internal and external assemblies with stainless steel bolts, washers and stainless steel nuts with nylon inserts. The clamping mechanisms shall be capable of mounting the sign on an overhead truss or bridge structure with an adjustment of the attachment angles. Adjustments to the position of the sign housing cannot require the removal of the housing from the supporting structure in order to align the housing into a different position.

The housing shall be constructed of reinforced 0.125 in. (3.18 mm) minimum thick 3003-H14 or 5052-H32 aluminum alloy and conform to the latest AASHTO publication entitled "Standard Specification for Structural Supports for Highway Signs, Luminaires, and Traffic Signals". All sharp edges and corners shall be rounded.

Fabricate all CMS housings to present a clean, neat appearance. Protect the equipment located within the sign housing from moisture, dust, dirt, vehicle exhaust fumes, and corrosion.

Provide padding of cross members and posts on the opposing side of the lift eye in the walk-in enclosure.

Provide corrosion protection between dissimilar metals.

- b. Welding: Provide documentation as specified in Subsections 631.1.03.O. and 631.1.03.S that the fabrication of the CMS sign housings provided under this specification are constructed by welders and materials so qualified and in conformance with the materials and procedures so defined.

Ensure that all exterior seams are continuously welded and each seam is uniform in flow. Spot or stitch welding is not acceptable.

Weld aluminum housings by gas metal arc (MIG) or gas tungsten arc (TIG) process using bare aluminum welding electrodes. The electrodes shall conform to the requirements of the American Welding Society (AWS) A5.10 for ER5356 aluminum alloy bare welding electrodes. Procedures, welders, and welding operators for welding on aluminum shall be qualified in accordance with requirements of AWS B3.0, "Welding Procedure and Performance Qualification", and to the practices recommended in AWS C5.6.

- c. Housing Finish: Paint or anodize all outside surfaces. Clean the CMS housing, treat with chemical conversion coating, and apply a paint primer suitable to the housing material. The finish shall be of automotive quality epoxy paint and be designed for outdoor use with a minimum design life of ten (10) years. Color shall be flat gray on all exterior surfaces except for the front face. Provide a color sample to the Engineer for approval. All visible surfaces of the front face shall be entirely matte black except for the sign face perimeter strip. Include on the perimeter of the housing a 2 in. (50 mm) wide strip of retro-reflective fluorescent sign material; Amery Fasign (color: Chartreuse) or 3M Scotchal (color: Saturn Yellow), or approved equivalent.
- d. Housing Access: The housing shall be either walk-in or non-walk-in as identified on the Plans. For the non-walk-in housing, permit front access to modules, wiring, and internal components for maintenance purposes. Provide all display modules with a swing-down assembly such that all equipment can be removed and replaced from the front (non-walk-in housings) of the housing. Secure modules to the housing and frames by use of aircraft grade, vibration proof stainless steel thumbscrews. Do not use turn screws of less than one turn (one quarter turn, etc.). Provide all walk in housings with replaceable component access from the inside of the sign, excepting the sign face, and other miscellaneous items external to the sign housing.
- e. CMS Platform and Housing Door: Provide all CMS signs with a suitable cat walk on the front of the sign housing. Include with all walk-in CMS sign housings a 4 ft. (1.2 m) wide or greater cat walk that extends from the right or left shoulder support structure, as defined in the plans, to flush with or extending underneath the sign enclosure. Provide fold-down safety rails as a part of the catwalk. Provide a catwalk that will support at least 2,000 lbs. (907 kg) with no discernible displacement. All walk-in CMS sign housings shall provide for all display module and associated electronic and electrical maintenance, replacement, and field repair from the inside of the housing. In each walk-in CMS sign housing, provide folding step or a similar mechanism to allow a technician to reach the upper interior of the sign during maintenance without the need of a portable device such as a ladder or step stool and which does not interfere with the normal operation of the sign. External repair of the housing and sign face shall be the only items requiring access to the external portions of the housing.

Provide walk-in housings with a minimum 2.5 ft. (0.76 m) by 6 ft. (1.8 m) opening that is dust and moisture tight, lockable, with external and internal stainless steel lever handled door latch system. Ensure that the door latch system can be locked, unlocked, opened, or closed from either the outside or inside of the housing. Ensure that the door latch system does not require a key to lock, unlock, or open the door from the inside of the housing. The outside lock shall be a swing cover, plated brass, tumbler type that is designed for outdoor "no freeze up" applications. Use a No. 2 Corbin key. Provide hold open braces and door stops that allow the door to be held in the full, 90, 45, or 30 degree open positions without the use of tools. Use hold open braces, doors, and hinges designed to withstand a minimum of 90 MPH (145 km/hr) winds while the door is held in any of these positions.

- f. CMS Weight and Dimension: Total weight, including all internal and external components, cannot exceed 5800 lbs. (2630 kg) for signs ten characters wide or less and 8000 lbs. (3630 kg) for signs greater than ten characters wide.

Individually limit the maximum outside dimensions, excluding minor appurtenances, of the sign to the following.

- Width 38 feet (11.6 m)
- Height 11 feet (3.4 m)
- Depth 5 feet (1.5 m)

Limit the power consumption to 6000 watts for signs ten characters wide or less and 13,000 watts for the signs greater than ten characters wide, with all pixels, fans, heaters, and auxiliary equipment operating at their maximum output setting.

- g. Hardware Material: Use stainless steel hardware unless otherwise specified. Use nylon friction washers.
- h. Maintenance Safety Eyebolts: Supply the sign with 3 eyebolts capable of supporting 600 lbs. (270 kg) for attachment points for safety belts at points on the CMS housing as defined in the Plans.

2. Sign Face

Protect the sign face by weather tight non-glare polycarbonate sheets, General Electric Lexan Type S300-112 or approved equivalent UV stabilized polycarbonate. Use sheets that conform to the following performance criteria, at a minimum, after being exposed to conditions per ASTM G53 for 1500 hours:

- Haze per ASTM D1003 shall be greater than 6
- Yellowness Index per ASTM D1925 shall be greater than 5
- Falling Silica Carbide 1600 per ANSI Z26.1 greater than 10 times percent haze
- Taber abrasion 100 cycles per ASTM D1044 and ANSI Z26.1 greater than two times percent haze

Mount the Lexan sheets in dual tracks to form doors that attach to the front face of the sign to allow the doors to be opened to fully expose the front of the light emitting modules. The front face doors shall be constructed of a frame that is securely attached to the sign housing through captive hinges and that securely holds the Lexan sheet in that door. Use protective sheets that are rigid and will not deform as a result of wind or temperature. The sheets and frames shall only be removable by mechanically disengaging the latches and thumbscrew attachments and by mechanically detaching the door hinges. Fit the Lexan doors with a series of vibration proof latches to lock the panels into a fixed position with adjacent side frames overlapping in order to minimize blockage of pixels.

3. Display Matrix

- a. Spacing: Each character will be of the height specified in the Plans and formed within a 7 pixels high by 5 pixels wide area. The pixel spacing shall be a maximum of 2.6 inches (66. mm) center to center. The spacing between characters shall be a minimum of 5.1 inches (130 mm). The border between the characters and the edge of the sign face shall at a minimum, be equal to the character height. The vertical distance between each line of the sign shall be a minimum of 10 inches (250 mm). Each module shall have a maximum of 105 pixels and rack-mounted driver boards shall control each module. Allow each display element to be individually addressable to allow custom fonts to be displayed.
- b. Display Module Attachment: Mount the light emitting modules to the sign face with a gasket, or other suitable method approved by the Engineer, to provide a moisture, dust, and fume tight seal between the face of the sign and the inside of the sign.
- c. Display Visibility: Ensure that the sign display is clearly visible and legible from distances between 170 ft. (52 m) and 900 ft. (270 m) under normal freeway operating conditions. Verify the luminous intensity of the pixel will not decrease more than 50 percent when viewed at an angle of 10 degrees for fiber optic pixels and eight (8) degrees for LED pixels centered about the optical axis and perpendicular to the surface of the display.

The luminance level (or luminous intensity level) for different elements cannot vary by more than 10 percent of the mean output of all the elements. Ensure that the contrast ratio is within the following ranges:

External Illuminance (Lux)	Contrast Ratio
40,000	7 to 50
20,000	7 to 50
10,000	7 to 50

4,000	7 to 50
400	7 to 50
40	15 to 100

Calculate the contrast ratio as follows:

Contrast Ratio = (LA-LB)/LB., where LA = measured intensity resulting from the Active Test Area Under Illumination. LB. = measured intensity resulting from the Inactive Test Area Under Illumination.

- d. **Shuttered Fiber Optic Technology:** Use light emitting type display elements (pixels) that do not require external or supplementary illumination. Control the pixels' visibility to the motorist through electromagnetic shutter devices. Use electromagnetically controlled shutters designed such that they block the pixel from view, without light leakage, when in the "off" position. Do not use flip disk or split flap disk elements to block the light emitted from pixels.

Use a shutter consisting of a valve activated by electromagnetic technology. The shutter shall effectively block light from the fiber optic bundle when closed and allow the passage of light when open. Include with the shutter an aperture located approximately on the centerline of the pixel through which the fiber optic light is transmitted for the "on" position. When the shutter is in the "off" or reset position, the shutter shall effectively block the passage of light such that the pixel is no more illuminated than the surrounding surface of the sign face. The shutter's movement when changing state will be essentially invisible when approaching the sign.

The luminance of the shuttered display shall be a minimum of 8,000 cd/square meter when both lamps are turned on and operating at 10.0 volts RMS and with all the pixels activated into the on position. Use pixels that individually emit at least 33 cd when 100 percent of the rated voltage is applied to the lamp and the shutter is open.

Each CMS pixel shuttering device shall be pinged or commanded to exercise on an automatic, periodic basis and in such a way that the exercising action does not interfere with the sign display. The exercising or pinging can have no perceptible effect on the message being displayed at the time of exercising. Verify that the exercising is controlled locally and occurs regardless of the control state or command from the central control center.

Use shuttering devices designed, manufactured, and rated for a minimum of 100 million on-to-off or off-to-on operations, exclusive of the pinging exercise.

Use display elements consisting of fiber optic cable, provided with approved lamp light sources, convergence cone, and reliable shutter mechanisms.

- e. **LED Technology:** Use an LED display module that consists of an LED circuit board, a connector for power, and a connector for controls and data. Use an LED circuit board that contains thirty-five (35) LED pixels arranged into a 5 (wide) by 7 (high) matrix. Ensure that the board contains the solid state electronics necessary to control pixel data and read pixel status. Ensure that the LEDs are individually mounted directly to a printed circuit board and are easily replaceable and individually removable using conventional electronics repair methods. Epoxy encapsulation of the LEDs is not permitted.
- f. **Display Performance:** Display messages at a minimum rate of 60 characters per second from any display state.
- g. **Display Elements:** Restrain the fiber ends of the shuttered fiber optic pixels to receive the ends of the fiber optic convergence cone display element. Lamps, LEDs, reflecting devices, filters, dimmers and the like shall be suitably housed for proper heat dissipation and protection from dust.

4. Driving Electronics

Driving electronics consist of, at a minimum, an LED driver system, or a lamp driver system and a shutter/pixel driver system for a shutter fiber optic system.

For shuttered pixel fiber signs, provide drivers that are EIA 19" rack mountable, with all the boards located within the same rack for ease of maintenance. Do not locate the lamp and shutter/pixel drivers on the light emitting module board.

5. Photosensor System

Provide a changeable message sign with three commercially available water and dust proof photovoltaic sensors.

Use photosensors capable of being continually exposed to direct sunlight without impairment of performance of the sensors.

The photosensors shall be internally read by the CMS dimming system. The dimming system shall read each of the photosensors' 255 levels. The CMS dimming system shall transmit the read value to the CMS ground mounted controller for distribution to the central system. When the CMS is operating in local mode control, the dimming of the CMS display shall be consistent with the ambient light sensed and the dimming system shall command the display into one (1) of three (3) configurable display intensity levels.

Sense the ambient illumination level by orienting and optimizing the system of three photovoltaic sensors in the following manner to sense the ambient illumination level:

- Cell 1 - Northern sky
- Cell 2 - Facing towards oncoming traffic (upstream)
- Cell 3 - Facing towards passed traffic (downstream)

6. Environmental Control and Protection

- a. **Lighting and Duplex Receptacles:** On the interior of the walk-in sign housing, provide a circuit breaker protected, shielded, fluorescent lighting system to allow maintenance personnel ample working light during day or night maintenance or repair conditions. Activate the light by a timer switch located on the inside of the housing near the door. The light switch timer shall begin timing a "lights on" condition of two hours upon activation of the switch. Turning the switch off and back on will reset the time out to another two hours from the time of the off-on cycle of the switch. Upon time out of the two hour period, the switch shall deactivate the fluorescent lighting by disconnecting the 120 VAC ungrounded circuit from the light. Use a circuit breaker to protect two separate duplex 120V ground fault interrupter (GFI) receptacles that are provided on each end of the sign case for the use of maintenance personnel. Use receptacles rated for 20 amperes. Each receptacle shall be fed from a 20 ampere nominal 120 VAC circuit.
- b. **Ventilation and Heater:** Provide the CMS housing with the necessary louvered vents positioned such that vehicle exhaust fume intrusion into the sign housing is minimized while the housing is provided with sufficient ventilation to maintain the thermostat temperature settings. Provide fans, thermostatically and parallel timer switch controlled, to pull warm air out of the sign housing to support the venting of the heat within the sign housing to the extent that an interior temperature of no more than 130 °F (54 °C) is reached with a 120 °F (49 °C) direct sunlight generated ambient temperature with the access door closed and locked. Provide documentation of the design calculations to support the performance of the ventilation and heating systems as specified in Subsection 631.1.03.

Use replaceable waterproof washable dust filters across all vents and position them such that when in place a secure dust tight joint exists between the filter and the housing. Install fans in protected fan openings within the CMS housing such that moisture, dust, vehicle exhaust fumes, or insects or birds will not enter the fan opening.

Control the ventilation fan and heater by thermostats adjustable to operate the fan between the range of 70 °F to 130 °F (20 °C to 54 °C) and a separate heater thermostat adjustable between the range 30 °F to 80 °F (-1 °C to 27 °C). The on-off temperature delta of the thermostats shall be nominally 3 °F (1.7 °C). Verify that the current rating of the thermostats is no less than 200 percent of the respective controlled equipment. Provide a 2 hour timed on fan switch for operation of the fans by maintenance personnel that, when placed in the on position will turn on the fans for a period of two hours. Turning the switch into the off position then back on shall reset the timer to two more hours from the off-on cycle of the switch. Install Quencharc or other suitable devices across the thermostat and switch contacts that will prevent electromagnetic interference being generated with the opening or closing of the thermostat contacts under electrical load.

If required, provide a heating system and thermal insulation to keep condensation on critical elements to a minimum or to maintain performance on temperature sensitive items.

- c. **Ambient Noise:** Design the CMS to emit no more than 60 dBA of noise during operation of all sign pixels from the on to off condition or the off to on condition as measured 10 ft. (3 m) from the sign housing from all six sides of the housing.

7. Associated Cables and Wiring

Use only standard copper, thermoplastic insulated, 600V, 221 °F (105 °C) power cables.

All control or signal cables shall be copper conductor, stranded (except for circuits terminated on punch down type 66 blocks), shielded, twisted pair thermoplastic insulated, low capacitance, minimum 30V rated, minimum 221 °F (105 °C) rated.

Protect all cables against lightning or over-voltage conditions with appropriate surge protectors. Protect the low voltage circuits by three element gas tube arrestors rated at 150 VDC breakdown voltage and 20 kA (8/20 microsecond waveform) single impulse current. Provide secondary protection to match the input of the equipment protected. Mount surge protection units in such a manner that component testing is not impaired and the replacement of components is easily accomplished without the removal of other components.

Minimum wire size is 22 AWG.

Use fork tongue compression type wire connectors for terminal connections. All connectors shall have suitable strain relief and positive retention.

Ensure that grounding wire and connectors meet the requirements of the appropriate electrical codes and the applicable sections of GDOT Supplemental Specification 925.

D. CMS Controller

1. CMS Controller Type A

Provide the CMS controller unit an EIA 232-C serial communication port to allow connections between the controller and the CMS central control facility or hub via the field communications system. This communication port shall be configured as DTE. This communication port shall use a 25-pin socket connector (ITT DB-25S or equivalent). The communication port shall support dial-up modems, spread spectrum radio modems, cellular phone data port connections, fiber optic modems, and other communication devices that are compliant with the RS-232 standard. The communication port shall support a configurable transmission speed that may be 300, 1200, 2400, 4800, or 9600 bits per second. The communication port shall not be limited to these transmission speeds.

2. CMS Controller Type B

Provide the CMS controller unit with a 100Base-TX or 10Base-TX Ethernet port to allow connections between the controller and the CMS central control facility or hub via the field communications system. This communication port shall be configured as MDI. This communication port shall use standard RJ-45 female connector.

3. General

Use, at a minimum, a CMS controller unit that is based on a 16-bit microprocessor and that conforms to the requirements contained herein. Select a CMS controller and the CMS controller cabinet design that minimizes the number of components within the CMS housing. Normal diagnostics of the CMS shall be performed from the ground mounted controller cabinet. No operational programming can be required from within the sign housing except the initial set up required during installation of the equipment prior to acceptance testing.

Provide a watchdog timer for detecting controller failure and resetting the microprocessor. Functions such as plan storage and communications with the CMS central control facility software will be conducted by software resident in the controller unit. The unit shall be capable of providing electrical isolation, monitoring of sign status, detection of failed elements and other features particular to the sign design.

Base clock rate of greater than 4 MHz is required. Furnish a long life battery allowing for a minimum power outage of 24 hours to back up memory. The battery shall either be rechargeable when power returns or have an accumulated life of a minimum of 90 days when unpowered.

The CMS controller unit shall store a minimum of 32 two-phase messages of 63 characters per phase in RAM and a minimum of 32 two-phase messages of 63 characters per phase in non-volatile memory.

The CMS controller unit shall operate from a nominal 120 VAC, 60 Hz power supply.

The power consumption of the CMS controller unit, power supply and permanently connected equipment cannot exceed 250 watts total.

Include with the CMS controller unit a power on/off switch that controls the AC power to the controller unit. Mount the switch on the front face of the enclosure and mechanically protect it from accidental shut off.

Provide a CMS controller unit and its associated software that meet all of the functional requirements of the CMS Specification and fully support the NTCIP protocol stack defined in Appendix A of Section 631.

4. Communications

a. CMS Controller Type A and B

Provide the CMS controller unit with a second communication port. This second port shall be an EIA 232-C serial communication port to allow connections between the controller and a laptop computer. This communication port shall be located on the front of the CMS controller enclosure and it shall be configured as DCE. This communication port shall use a 25-pin socket connector (ITT DB-25S or equivalent). The communication port shall support dial-up modems, spread spectrum radio modems, cellular phone data port connections, fiber optic modems, and other communication devices that are compliant with the RS-232 standard. The communication port shall support a configurable transmission speed that may be 300, 1200, 2400, 4800, or 9600 bits per second. The communication port shall not be limited to these transmission speeds.

Provide the CMS controller unit with a fiber optic channel connection to allow connections between the controller and the changeable message sign. This communication port shall be compatible with the sign communication port. This communication port shall use a ST-type connector.

Provide a communication timer within each CMS controller for detecting failure of communications with the CMS central control facility. The timeout value shall be selectable between one (1) and sixty (60) minutes with one-minute resolution. The timeout shall be capable of keypad and laptop commanded disabling for use during periods of dialup or similar communication service where a periodic poll of the CMS within the 1 to 60 minute period is not normally made. The default shall be the last selection made of either timeout or non-timeout.

The communications protocol shall be the NTCIP protocol stack defined in Appendix A of Section 631 that specifies a variant of the NTCIP Class B profile.

5. Functionality

The functionality of the CMS is defined by the NTCIP protocol stack that has been defined for the CMS controller and the collection of data objects that exist in the MIB of the device. The following list constitutes an overview of the normal mode of operation of the CMS system. Normal mode of operation is defined as the state in which the controller is communicating with the CMS central control facility and processing requests from the central control facility. The major function of the controller is to change the message displayed at the CMS. Secondary functions of the controller may include the following: responding to status requests from the central control facility, storing new messages that have been sent to the controller from the central control facility, sending configuration data to or receiving and updating configuration data from the central control facility, and sending the currently displayed message to the central control facility. During normal operation, the controller unit will expect at least one successfully communicated message during a specified time period from the central control facility; a configurable master communication timer controls this time period. If no message is received, the controller unit shall take over in its communication loss mode. Furthermore, upon receipt of a message, the CMS controller shall respond to the message within five (5) seconds. Should the controller fail to respond within this time period, the entity that generated the request will assume that the request has failed.

- a. Data Objects for Type A Controllers: The SNMP/STMP Application Level protocol shall be used to access all of the data objects that have been defined at the Information Level of the NTCIP protocol stack defined in Appendix A. The value of some data objects may be updated, and the value of all data objects may be retrieved. The control mode of the CMS controller shall affect the accessibility of these objects, and a discussion of the various control modes has been given below.
- b. Data Objects for Type B Controllers: The SNMP Application Level protocol shall be used to access all of the data objects that have been defined at the Information Level of the NTCIP protocol stack defined in Appendix A. The value of some data objects may be updated, and the value of all data objects may be retrieved. The control mode of the CMS

controller shall affect the accessibility of these objects, and a discussion of the various control modes has been given below.

- c. Dwell Time: Dwell time is the time required for displaying and blanking the sign (or part of the sign for two phase signs) and for flashing or blinking lines and symbols (or parts of lines). Dwell times shall be in units of tenths of a second and shall range from 0 to 5 seconds. Various MULTI tags and default values provide this functionality (see the MULTI Configuration Group defined in Appendix A).
- d. Maximum Response Time: The Maximum Response Time defines the maximum amount of time that the CMS controller can take to respond to a particular SNMP or STMP request. The Maximum Response Time for the CMS controller shall be five (5) seconds. Should the controller fail to respond within this time period, the entity that generated the request shall assume that the request has failed.
- e. Master Communication Timer: The master communication timer keeps the time that has elapsed since the CMS local controller received a correctly formed SNMP or STMP request from the central control system, and it resets upon each request. The timer shall be in units of minutes, shall range from 1 to 60 minutes, and shall have a default value of 10 minutes (see dmsTimeCommLoss object of the Default Message Group defined in Appendix A).
- f. CMS Default Messages: Store two default messages in non-volatile memory. The stored default messages shall be used when there is a communication loss between the controller and the central control facility or when the CMS controller unit reboots after a power failure. The default message selected will be a result of the failure type.
- g. Blank Time: Blank time is the length of time the sign is blanked between changes in message display. Blank times shall be in units of tenths of a second and shall range from 0 to 10 seconds. Various MULTI tags and default values provide this functionality (see the MULTI Configuration Group defined in Appendix A).
- h. Message Display: The central control facility views the CMS as a line matrix and can request the CMS controller to display a stored message. In this case, the message is extracted from the storage of the CMS controller and displayed. If the command fails due to an error condition, then the controller shall return an error to the central control facility. The central control facility can also download a message to the CMS controller and command it to display this message. Again, the controller shall return an error if these commands fail (see the Message Table and Sign Control Groups defined in Appendix A).

The CMS controller shall store two (2) default fonts for use in message display (see the Font Definition Group defined in Appendix A). These fonts shall have a height of seven (7) pixels. The CMS controller shall be capable of storing four (4) graphic images and displaying one of these images at a time on the CMS.

The CMS controller unit shall be capable of displaying the longest possible one-phase message within two (2) seconds of the receipt of the complete SNMP or STMP request.

If both the primary and back-up lamps are not operational in a single module, the entire sign shall be turned off to prevent the display of an incomplete message. The CMS controller keypad shall provide a means to override this feature. The master communication timer shall be used to clear this override.

Messages shall be specified in the MULTI syntax. The presence of a tag in the message string shall override the default value that has been set if such a default has been configured. The following MULTI tags shall be supported:

- Field
- Flash
- Font
- Justification – Line
- Justification – Page
- Moving Text
- New Line
- New Page

- Page Time

- i. Controller States: A CMS can be in various states prior to the commands, which may affect how these functions are performed (see `dmsControlMode` object of the Sign Control Group defined in Appendix A). These modes are:

Power Loss Mode: This mode is reached when power has been lost to the CMS controller, and it has switched to its backup power source. If this mode is reached, then the controller shall display the default message that pertains to power loss if this message has been set.

Communication Loss Mode: This mode is reached after a communication timeout has occurred which may be a result of the central control facility being offline or a disruption of the communication channel. If this mode is reached, then the controller shall display the default message that pertains to communications loss if this message has been set, and the master communication timer shall be disabled.

Local Mode: This mode is reached when the CMS controller unit has been put under manual control in the field. Any SNMP or STMP update requests received from the central control facility shall be ignored.

Central Mode: This mode represents the normal operation of the CMS controller. On a user selectable time basis, the central control facility software shall poll the controller unit for status to receive any failure or recovery information.

Central Override Mode: This mode can be used to override a CMS controller that has been placed in Local Mode.

- j. Controller State Changes: The central control facility can change the operational state of the CMS controller. The Central control facility can send a local mode off command to the CMS controller unit.

The CMS controller shall be able to be put into Local Mode by field personnel at the CMS and shall be able to be controlled by the controller keypad or a laptop computer that has been attached to one of the serial interfaces. The message displayed on the sign shall not change when the CMS controller unit mode is changed to Local Mode. A CMS controller that has been switched into Local Mode shall ignore requests from the central control facility. The central control facility can override Local Mode by changing the operational state of the CMS controller to Central Override Mode.

- k. Diagnostic Functions: Diagnostic functions shall allow the user to diagnose errors on a CMS controller unit. Ensure that the central control facility or a laptop computer is able to command the following:

Software Reset: Ensure that the reset request will cause the CMS controller unit to restart the control program (see `dmsSWReset` object of the Sign Control Group defined in Appendix A). This is similar to a complete bootstrap of the CMS controller unit and shall be non-destructive of library messages stored in volatile memory. The following steps shall make up the reset process:

- Any temporary variables and the message displayed on the CMS shall be lost as the control program restarts and reinitializes such variables. The CRC of each message stored in the memory of the controller shall be recalculated and compared with the stored value. If the CRC comparison for a particular message fails, then the message shall be invalidated, and that storage slot shall be made available.
- If a default message has been defined for a reset, then it shall be displayed; otherwise, the sign shall be blanked.

Test Pattern: On command, the CMS controller shall display a test pattern on the CMS. The test patterns shall cycle through turning banks of display elements on and off. The pixels shall remain in each particular pattern for sufficient time for a user to validate the pattern. The requirement of this test pattern is to exercise each display element and allow the validation of the operation of all display elements. The preferred test pattern consists of a "checkerboard" of alternating modules (7X5 pixels) that are on or off for a length of time and then reverse their polarity. Other test patterns of similar function, but not distracting to motorists, may be used subject to the approval of the Engineer.

Blank the CMS: On command, the CMS controller shall change all the display elements to the off position. The CMS display shall stay in this format until the next display command is received. During period of a blank display, all fiber optic display lamps shall be off.

CMS Element Status: On command the CMS controller shall exercise the full diagnostics of the CMS including a report of any failed elements, condition bits set (e.g., power off, comm. failure, reset), etc.

Configuration Parameter Retrieval: On command, the CMS controller shall return the value of a particular parameter.

Message Retrieval: On command, the CMS controller shall return a particular message from its storage.

l. Regular Checks by the CMS Controller

Message Library: Each individual messages shall have a CRC stored with it when it is downloaded. The CMS controller unit shall recalculate the CRC of a particular message and compare it with the value stored whenever it attempts to display that message. Any difference shall cause a library error to be stored for reporting to the central control facility.

Failed Display Elements: The CMS controller unit shall verify all display elements on a regular basis. The CMS shall detect and report any display elements that are not controllable. Whenever a message is displayed, all elements that are to be enabled shall be checked immediately after the display is completed.

Major Component Checks: The CMS controller unit shall monitor the major components of the sign such as lamps, pixels, the controller, photocells, fans, or temperature sensors. If any of these components fail or become uncontrollable, the CMS controller unit shall record this for reporting to the central control facility. This monitoring shall be on each change of message displayed and at regular intervals.

Watchdog: The CMS controller unit shall keep a hardware watchdog on the sign's own operation. During normal processing, the processor shall reset this watchdog every few seconds. If this watchdog is not reset for a period, there shall be a hardware switch that will reset the CMS controller.

Controller Bootstrap: During the bootstrap process, the CMS controller unit (usually after a power failure) shall carry out the following steps:

- Any temporary variables, and the message displayed on the CMS, shall be reset as the control program starts and reinitializes such variables.
- The CMS controller unit shall recalculate the CRC of each message in its storage and compare it with the corresponding stored value.
- If a default message has been defined for a controller boot, then it shall be displayed; otherwise, the sign shall be blanked.

m. Controller Keypad: Provide a keypad on the controller face to input programming and CMS configuration data. The keypad shall allow full access to the CMS operating parameters and commands. A laptop computer or central computer system cannot be required to set up or operate the CMS.

n. Control of Sign Luminance

Illumination Control: The CMS controller shall provide two levels of illumination control (see `dmsIllumControl` object of the Illumination/Brightness Group defined in Appendix A).

- Photocell Control: The luminance level of the CMS shall be determined by the values of the three photocells that are attached to the CMS.
- Manual Control: The luminance level of the CMS shall be determined by the value set by the central control agency

Luminance Levels: The luminance of a light emitting pixel shall have a minimum of three levels selected in accordance with the ambient illumination level as read by the photosensor system and the software control (see the `dmsIllumNumBrightLevels` of the Illumination/Brightness Group defined in Appendix A). Typical ranges are:

- overbright range, level 3
- daylight range, level 2
- night range, level 1

Equip the CMS controller unit with dimming circuitry that will allow selection of the light intensity levels between 0.4 to 35 candelas for each range to best suit the sign location. The dimming scheme used cannot reduce the rated life of the light source. There can be no observable flicker or difference in consistency between pixels at any of the intensity ranges specified above.

Incorporate sufficient hysteresis in the sensor or control circuit to ensure that no rapid or erratic changes are implemented when the environmental lighting level fluctuates around the threshold (see dmsIllumBrightnessValues object of the Illumination/Brightness Control Group defined in Appendix A).

Photocell Failure: In case of the photosensor system failure, the light output of the sign display elements shall be defaulted to the night range setting.

E. CMS Controller Cabinet

The cabinet shall house all of the CMS equipment required to control, monitor, and communicate to the CMS and all of the equipment required to communicate with the communications hub or central facility as shown on the Plans. Include with the equipment housed within the cabinet, as a minimum, the rack mounted CMS controller unit, the communication interface between the CMS and the CMS controller, the interface between the CMS controller and the fiber optic communication equipment and interconnection panel, the laptop computer interface, all power supplies and power termination and distribution equipment, all wiring, cables and jumpers, and all environmental protection material and equipment.

Provide the CMS controller cabinet with the necessary louvered vents positioned such that vehicle exhaust fume intrusion into the cabinet is minimized while the housing is provided with sufficient ventilation to maintain the thermostat temperature settings. Provide fans, thermostatically and parallel timer switch controlled, to pull warm air out of the cabinet to support the venting of the heat within the cabinet to the extent that an interior temperature of no more than 130 °F (54 °C) is reached with a 120 °F (49 °C) direct sunlight generated ambient temperature with the cabinet door closed and locked. Provide documentation of the design calculations to support the performance of the ventilation and heating systems as specified in Subsection 631.1.03.

Use replaceable waterproof washable dust filters across all vents and position them such that when in place a secure dust tight joint exists between the filter and the cabinet. Install fans in protected fan openings within the cabinet such that moisture, dust, vehicle exhaust fumes, or insects or birds will not enter the fan opening.

Control the ventilation fan and heater by thermostats adjustable to operate the fan between the range of 70 °F to 130 °F (20 °C to 54 °C) and a separate heater thermostat adjustable between the range 30 °F to 80 °F (-1 °C to 27 °C). The on-off temperature delta of the thermostats shall be nominally 3 °F (1.7 °C). Verify that the current rating of the thermostats is no less than 200 percent of the respective controlled equipment. Install Quencharc or other suitable devices across the thermostat and switch contacts that will prevent electromagnetic interference being generated with the opening or closing of the thermostat contacts under electrical load.

Identify different components of the controller equipment including all the wires, connectors, control leads, switches, etc., with labels of engraved lamanoid or with permanent transfers. The identifiers shall correspond to the labels used in the equipment documentation and maintenance material.

Mount all protective devices such as lightning arrestors and surge protectors external to the CMS controller unit enclosure but within the cabinet.

All mounting hardware and wire connections shall be easily accessible and removable with hand tools.

Ensure that the driver circuitry installed in the controller cabinet meets or exceeds the electrical and environmental specifications of the CMS.

F. Interconnection Cables

1. Power Cables

Use bundled multi-conductor power cables connecting 120 volt circuits between the CMS controller unit and the CMS housing equipment power distribution area. Size the power cables as required by the load and distance.

2. Signal or Communications Cables

Use bundled, shielded, jacketed multi-conductor signal or communications cables to connect circuits of 50 volts or less (including fiber optic cable) between the CMS controller unit and the CMS housing. Size the cables as required by load and distance. If a parallel (non-multiplexed) means of interconnection is used between the controller unit and the sign, carry out

tests approved by the Engineer to ensure that no significant signal deterioration occurs. Design the communication channels for acceptable noise margin limits specified by the logic family or drivers/receivers used.

3. Tape

Use electrical insulating tape rated for 600 volts from 150 °F (65 °C) to 1950 °F (1066 °C) working temperature.

4. Protective Devices

Provide all cables entering the cabinet with surge protective devices installed inside the controller cabinet equal to or exceeding the requirements of GDOT Specification Section 925. The protective devices shall be encapsulated hybrid suppressers and shall be bayonet mounted such that replacement can be done without removal of the housing or other equipment.

631.3.05 Construction

A. Wiring, Cabling and Harnesses

Make all harnesses neat and firm, and route them to minimize crosstalk and electrical interference.

Separately bundle or shield wiring containing AC from all DC logic control circuits.

Route wiring to prevent conductors from being in contact with metal edges. Arrange wiring so that any removable assembly may be removed without disturbing conductors not associated with that assembly.

Install all wiring as a part of the CMS assembly and controller including power, communication, and fiber optic control cables between cables necessary to operate the changeable message signs. Install the cables in liquid tight conduit in inconspicuous locations, between the nipples on the sign support and the housing. Install the cables to use the sign support beams and legs as raceways and install them in continuous, unspliced lengths between the housing and the CMS controller cabinet unit. Coil sufficient slack neatly in the base of the CMS controller cabinet to ensure that the connections to the housing and the power source will be possible without the need to add or splice any cables. At vertical transitions, support the cable by integral hooks or other methods that assure that the stress placed on the wiring or fiber optic cable is minimized and in no case violates the cable or wire manufacturers maximum static, pulling, or dynamic tension, or bend radius.

Route all wiring within the sign in properly supported cable trays.

B. CMS

1. General

The following section provides a description of a permanent changeable message sign (CMS) assembly using LED or shuttered fiber optic display technology. Ensure that the various subassemblies are interchangeable between the same type of sign and 100 percent compatible with NTCIP protocol stack defined in Appendix A of Section 631.

2. Timing of Work

Ensure that CMS controller units are installed, tested, and ready for operation before installing the changeable message signs. Do not install changeable message signs until 14 calendar days or less, prior to beginning the proof of performance testing. Install the CMS during restricted times, as designated by the Department, and control all traffic using the GDOT approved pacing method. Proceed with installation only upon approval of the pre-installation tests results. Notify the Engineer 96 hours prior to installation.

3. Installation

Maintain full responsibility for the sign housing mounting to the support structure and confirm that the sign can be properly mounted on the sign support structure prior to installation. Provide complete structural shop drawings and calculations of the sign mounting to the support structure to the Department as part of the submittal data requirements in Section 631.1.03. Securely mount the sign on the sign support structure. Initially set the housing at a 3 degree tilt **forward** toward traffic and

adjust the housing under both day and night conditions to optimize the view of the sign from the roadway by a motorist and eliminate random reflections as directed by the Engineer. Alternatively, the housing may be constructed at a 3 degree tilt toward traffic, if approved by the Engineer, but shall be adjusted to obtain the same optimization of the viewing of the sign from the roadway.

Attach and secure all mechanical hardware for initial attachment prior to the reopening of lanes to traffic. Complete attachment of hardware prior to the release of crane cables. Install and connect the CMS sign wiring and communications cables to the ground cabinet and disconnect switch in the controller cabinet only after attaching and securing the sign to the sign structure. During the proof of performance testing, the Engineer will evaluate the initial setting of the sign and direct the Contractor to adjust the sign tilt if necessary. Use nylon stop washers with mounting attachments. For all structural aspects, stainless lock washers and nuts are unacceptable; use stainless steel nuts with nylon inserts for locking.

Lift and install the CMS housing and display in place on the overhead structure only with prior approval of, and in the presence of the Engineer. Do not lift and install the CMS housing and display until all equipment, materials, and labor are available such that the CMS can be operated with messages from the local CMS controller within 72 hours of installation on the overhead structure. Program message displays on the CMS at the direction of the Engineer. Make sight alignment adjustments to the CMS housing and display as directed by the Engineer.

Securely install mounting hardware to the torque recommended by the overhead sign support manufacturer.

4. Wire Connectors

Perform all connector crimping using a ratchet installation tool with a compatible crimp jaw sized for the connector used. Strip wire in accordance with the connector manufacturer's recommendations.

Use multi conductor connectors that are commercially available and properly sized within the manufacturers rating of the wire size used and the voltage/current limitations ratings.

5. Controller Unit to CMS Interconnection

Install all interconnecting cables between the equipment in the CMS controller cabinet and the sign inside two (2) 2" (50.8 mm) diameter ducts, which are installed between the sign footing and the concrete pad of the controller cabinet. If additional 2" (50.8 mm) ducts are required to accommodate the sign manufacturers interconnect requirements, add additional ducts in multiples of two (2) each, 2" (50.8 mm) ducts. Provide all communications between the ground mounted CMS controller cabinet and the above ground mounted sign in the form of fiber optic cable and signaling.

6. Cabinet Equipment

- a. **Wiring and Connections:** Make all connections to terminal boards or screw-type equipment terminals with insulated fork-tongue compression connectors only when using stranded cable. Make all wiring to bulkhead connectors on equipment housings with MS bayonet-type connectors. Solder connector joints for use with extra-low voltage systems, with the joint metals preheated to the flow temperature of the solder or crimped using ratchet-type positive crimp tools and a double crimp (conductor and jacket) connector.

Remove the outer jacket of data and communications cables to expose approximately 6 in. (150 mm) of the shielding or drain wire. Twist together and solder the shielding or drain wire for all cables serving a similar function with a #10 AWG minimum insulated (green) ground lead securely connected to the cabinet ground bus. Make the ground lead routing as short as possible. Cut the shield off and leave it isolated at the other end.

Upon completion of wiring and connections, bundle all incoming cables and hold in place with nylon cable ties. Connect the front panel and chassis to the cabinet ground bus from a single point only.

The controller will be powered from the power distribution assembly provided in the field cabinet. Bond the shields of all extra-low voltage cables to the ground bus inside the cabinet. The shield inside the sign enclosure shall be unconnected and insulated. Route low voltage cables and extra-low voltage cables installed in the cabinet on opposite sides of the cabinet. Group similar extra-low voltage cables in the controller cabinets, between common locations, together with cable ties. Install cables and connectors so that the manufacturer's rated minimum bending radius and pulling tension are not exceeded. Take proper care to prevent abrasions to the cable jacket during installation.

- b. **Controller Cabinet Installation:** Install the CMS controller unit in the designated space of the field cabinet. Install the cabinet at locations as indicated on the Contract drawings or as designated by the Engineer. Mount all cabinet assemblies to the support pole at a height of 4 ft +/- 3 in (1.2 m +/- 76 mm) from ground level to the centerline of the cabinet housing. Where the Plans show base-mounted cabinets, install the cabinets in accordance with the Department's Standard Specification for Traffic Signal Equipment installations.

7. Photosensor System

Aim one sensor in the northerly direction (away from nearby lights) and scale it for a reading of up to 100 lux (horizon type). Aim the other two sensors in opposite directions and perpendicular to the sign face. Scale these two sensors for a reading of up to 100,000 lux. Mount the sensors on the top of the housing near the right side for ease of maintenance. The aiming angle of the sensors shall be adjustable. Aim the photosensors and calibrate the dimming system consistent with field conditions found for each sign as a part of the installation process. Perform this work prior to any proof of performance acceptance test.

8. Support Material

Test the support equipment components specified in Subsection 631.4.A as per the appropriate pre-installation procedures as defined in the Specifications. Deliver the components prior to final acceptance of the Contract and beginning of the CMS support period.

631.3.06 Quality Acceptance

A. Use and Operations Prior To Final Acceptance

The Department will approve or control any and all CMS displays at all times that a display is in potential public view. When potential public view exists, no message or graphical display of any kind or activation of any CMS display component is permitted without prior approval of the Engineer. At such time as the Engineer determines that any given CMS is ready for Department control, the Department will exercise complete and total control of that CMS display and all central and local communications with that local CMS controller. Prior to any action, coordinate with the Engineer any remaining work or any testing or maintenance that may affect that CMS display. Do not interpret such CMS display control as acceptance of the project in whole or in part. Do not construe such action as a waiver by the Engineer of any provision of this Specification. Do not consider such use part of the burn-in period.

B. Utility Coordination

This Specification includes provisions whereby the Contractor furnishes or installs equipment and materials that will become part of the regional utility facility. Coordinate all such work with the utility representatives, and furnish all equipment and materials and perform all work in accordance with the Contract Documents and all applicable utility agency standards and procedures.

Meet all standards required by utility companies as related to CMS equipment, materials, and installation associated with attachment to related power service feeds or leased communication connections. Test the power and telephone utility service to confirm proper voltage and current capacity and the serviceability of any telephone circuit connected to CMS equipment.

Power utility or telephone utility representatives are not authorized to revoke, alter, or waive any requirements or design of materials or facilities provided under this Specification. The inspection of any of the Contractor's work by the utility providers or the failure to inspect any of the Contractor's work by the utility provider representatives will not relieve the Contractor of any requirements of this Specification.

Coordinate work with the utility providers to permit inspection of said work. Notify the Engineer and the utility providers' representatives of planned work.

C. Control of Work

Maintain all work under this Contract from the date of award of Contract to the date of final acceptance of the project by the Engineer. Maintain responsibility for making all trouble calls, diagnosis, repair, and replacement, supplying all equipment and materials; providing maintenance of traffic, and performing any other work necessary to maintain all work as required above. Within one (1) hour of notice from the Engineer or after your own identification of a problem, make an on-site trouble call. Complete all work necessary to correct the problem within twelve (12) hours unless otherwise directed by the Engineer.

Within 24 hours of having completed a trouble call or repair, provide a written report to the Engineer fully describing the problem, its cause, all action taken, and all equipment and materials repaired or replaced.

The Department will not be liable for any equipment or material purchased, work done, or delay incurred, prior to the Department's approval of said equipment or material through the materials submittal data process. Any failure of the Department to discover or note any unsatisfactory material will not relieve the Contractor of his responsibility for providing a complete operable CMS installation as called for under the terms of the Contract. Specifically describe any deviation from the Contract requirements and Specifications in the submittal documents along with a detailed description of the reason for the deviation.

D. CMS Environmental Operating Conditions

Ensure that the equipment and materials defined within this Specification functions in accordance with these specifications. The equipment, materials, and systems will be installed in harsh environmental conditions and shall perform without failure to the performance levels defined within these Specifications. The normal AC power input, ambient air temperature, and ambient humidity are expected to be:

AC power input voltage 120 VAC, 60 Hz

Air temperature -20 °F (-28 °C) to 105 °F (40.0 °C)

Humidity 20 to 100 percent

It is further expected that under extreme conditions these values may deviate substantially from those normally experienced. As such, the equipment, materials, and systems shall perform to the level of performance or functionality defined within these Specifications without noticeable degradation under conditions outside of that normally experienced.

Conduct performance testing, in the presence of the Engineer, to demonstrate that the performance requirements and the CMS functionality are met. Ensure that all CMS assemblies and components are designed and tested to perform without degradation of performance or functionality within the environmental conditions defined within NEMA TS-2-1992 with supplemental TS-2-1994 requirements. Demonstration of compliance is required under testing laboratory conditions to the extent of these NEMA standards and within the following nominal operating environments:

- Input power voltage and frequency soak/power interruption and high voltage shock:
 - 95 to 135 VAC 57 to 63 Hz.
 - 0.01 to 2.0 seconds power interruption
 - Slow and wide range variations in AC power from 0 to 115 to 0 volts
 - AC power 0.5 seconds off then 0.5 second on cycles, for two minutes
 - 300, 600, and 1,000 volt noise spikes, up to 19 joules
- Ambient Air Temperature/humidity soak:
 - -30 °F (-34 °C) to 130 °F (54 °C)
 - near 0 percent to 95 percent relative humidity
- Vibration soak: At resonate frequency for 1 hour and 10 g shock on all axes

While environmentally testing the CMS equipment, subassembly, and system, demonstrate any combination of these three operating environments for up to two hours for each combination of CMS performance and functionality, in addition to those tests defined within the NEMA TS-2 test requirements.

E. Component Minimum Design Criteria

1. General

Ensure that all electrical, electronic, or electromagnetic components used in any CMS assembly have a minimum design life of not less than 10 years operating 24 hours per day under the environmental conditions defined under the acceptance test described within these Specifications. Use only components de-rated by 50 percent with regard to applied voltage and power dissipation unless otherwise specified so that material shortening of life or shift in values is minimized. All electrolytic capacitors used to filter circuits shall be de-rated by at least 150 percent of their normally operating voltage. All components shall be second sourced with the exception of specialty items for which the Contractor demonstrates that no commercially available second source component will meet the design or performance requirements of the CMS Specification.

All components, residing inside the CMS housing, including the display elements and all components residing in the CMS controller cabinet shall be rated for and shall properly operate within the following limits:

- Ambient temperature: -30 °F (-34 °C) to 130 °F (54 °C)
- Humidity: 0 percent to 95 percent, non-condensing.
- AC input voltage: 90 to 135 VAC, 55 to 65 Hz
- AC input voltage interruption of 0.1 second to 2.0 seconds in 0.1 second intervals for 2 minutes each interval.
- AC input voltage interruptions of 0.5 seconds on then 0.5 seconds off cycles, for 2 minutes.
- 300 volt spikes across all communications lines and across the AC power input lines sine wave 10 times a second for two minutes.
- 600 volt spikes at 10 joules once every 10 seconds for 2 minutes
- 1000 volt spike across the AC power input with AC power unapplied.

All CMS assemblies and subassemblies shall be tested under these conditions during the acceptance tests. The acceptance tests are described in detail in another section of these Specifications.

2. CMS Pixels

Use only materials for the fabrication of the pixel display modules that will not be damaged by direct exposure to sunlight.

F. Acceptance Testing

1. General

This section describes Contract acceptance procedures for permanent CMS installations.

Unless otherwise noted in this Contract, develop, provide all equipment for, and perform all acceptance testing for all permanent changeable message sign installations. Develop detailed and thorough test procedures with full test plan descriptions, test and measurement equipment listings, and test results data sheets based upon the testing requirements defined within these Specifications. As part of the submittal requirements specified in Subsection 631.1.03, provide the following test plans for Engineer approval:

- Pre-Installation Test Plan
- Proof of Performance Test Plan
- Acceptance Test Plan

Use only test plans approved by the Engineer. Provide all necessary testing equipment, facilities, communications, transportation between test sites, and test documentation. Have a complete copy of all materials and equipment submissions and all documentary items on hand at all acceptance testing sessions.

At the conclusion of a test for a given CMS or for the CMS system, provide a thorough and detailed test report that documents the test process and the results of each portion of the testing. Provide a complete listing of test results. Deliver seven (7) copies of this report to the Engineer within ten (10) calendar days after conclusion of that test.

Perform all testing in the presence of the Engineer and/or his representatives. Upon receipt of the Contractor's test report for a given CMS or system acceptance test, the Engineer will provide a written acceptance or rejection of that test within ten (10) calendar days.

If the results of a given test are rejected, the Contractor will be notified of the specific reasons for rejection. Make all necessary corrections and revisions to the subject materials and/or equipment and any accompanying documentary items. Upon completion of all necessary corrections and revisions, request a retest in writing. Include in the request for a retest a complete written summary of all corrections and revisions performed and, if applicable, revised documentary items. Do not commence with retesting without the Engineer's prior approval. Conduct all retests in accordance with all requirements of the initial test. The successful completion of any phase of the testing will not relieve the Contractor of his obligation to fulfill any of the requirements of the Specifications.

2. Pre-Installation Testing

Perform pre-installation testing on each type and size changeable message sign in accordance with the Specifications. The pre-installation testing will be used to verify compliance with the Specifications and to ensure the operation, serviceability, and reliability of each sign prior to installation. Successful completion of the pre-installation testing is required prior to installation of any CMS assembly.

Develop a Pre-Installation Test Plan that includes all of the requirements of the NEMA TS-2-1992, the TS-2-1994 supplemental, and those additional requirements specifically defined within these Specifications.

During all pre-installation testing, test a complete CMS assembly for each sign type. A complete CMS assembly is defined as all elements included within the controller cabinet and the cabinet, and all elements included within the sign housing and the sign housing, as well as the interconnection cables and connectors. Configure and connect each CMS assembly as in the final field installation configuration. First perform the vibration and physical shock portions of the NEMA testing for each sign assembly. The vibration and physical shock (g-loads) portion of the tests need not be applied to the entire sign housing but representative assemblies of the display, display driver, power supply and distribution, and communication subassemblies mounted in the sign housing may be assembled as a representation of a complete CMS. Include at least one of each CMS assembly in the representative CMS subjected to the vibration and g-load shock test. Expose a complete CMS controller and controller cabinet assembly to the full NEMA tests described herein as well as the other tests parameters described within these Specifications. Expose a complete sign housing and display of each type and size to the temperature, humidity, and electrical shock tests defined within the NEMA tests.

Develop software and supply a laptop test computer for the pre-installation testing which communicates with the CMS using the NTCIP protocol stack defined in Appendix A of Section 631. Demonstrate all commands to and all responses from the CMS, available in the protocol, using the test computer. Monitor all commands and responses through the use of a recording data analyzer.

Supply an environmental test chamber to perform environmental testing. The test chamber shall be capable of containing the CMS controller cabinet and an operational representation of the sign assembly that includes at least one of each type of operational assembly installed in the sign housing and provide a display capable of displaying at least one character in each sign row. The minimal display configuration shall be such that a test message containing text and graphics is viewable during the testing. During ambient temperature and humidity environmental testing, configure a complete CMS assembly. Provide an environmental chamber capable of achieving and sustaining, with the equipment and material placed in the chamber to be tested, temperatures of -30 °F (-34 °C), +70 °F (20 °C), and +130 °F (54 °C). During these temperatures, apply humidity levels to the maximum non condensing values obtainable, consistent with the temperature, to the equipment under test. Input power and signal lines shall have transient voltages applied as well as power interruption during the environmental testing sessions. Alternately, the entire sign, controller, and controller cabinet may be mounted in a modified refrigerated trailer that is capable of exposing the CMS assembly to the temperature and humidity extremes defined within the NEMA tests.

Commence with Pre-Installation Testing only after meeting all of the following requirements:

- All equipment and materials submissions associated with the CMS controller and housing have been approved by the Engineer.
- All documentary items as specified have been approved by the Engineer.
- The Engineer has approved the Pre-Installation Test Plan, testing schedule, and travel arrangements

Do not perform testing during any State or Federal holiday. Complete any given pre-installation testing session within five (5) consecutive GDOT working days unless otherwise approved by the Engineer. Successfully complete all pre-installation testing prior to installation of a CMS in the field.

If conducting any Pre-Installation Acceptance Test at a facility more than 100 miles (160 km) from the GDOT Transportation Management Center in Atlanta, Georgia, pay for all travel costs of the Engineer and up to three additional Department representatives. Travel costs shall include all transportation, hotel, rental car, and per diem costs consistent with GDOT travel regulations. The Department reserves the right to pay for these travel costs from monies due the Contractor under this Contract.

3. Proof of Performance Testing

Perform Proof of Performance Testing on each permanent changeable message sign in accordance with the Specifications. The Proof of Performance Testing will be used to verify compliance with the Specifications and to ensure the proper installation and operation of each changeable message sign after all of the equipment and materials are placed in the field and all of the signs are made operational.

Perform the following functional testing using the test software and the laptop computer provided for testing:

- Demonstrate 100 percent compliance with the NTCIP protocol stack (see Appendix A of Section 631) operating within an automated poll-response environment.
- Demonstrate every feature of the CMS controller and sign display assembly via direct connect and modem communications.
- Demonstrate fault-free operation of the CMS assembly under test when subject to 500 cycles of status request command and response operations between the CMS and the test software.
- Demonstrate fault-free operation of the CMS assembly under test when subjected to 1000 cycles of message download command, message download response, message display command, message display response, CMS status command, and CMS status response. Perform one complete cycle in 20 seconds or less with a CMS message constructed such that a character message fills every available character space on a two phase message. Set the phase time on to three seconds for each phase and the off time to zero seconds.

Record all communication between the test software and the CMS under test using an HP 4952A or equal protocol analyzer. Record serial data captured by the protocol analyzer on media printable from the protocol analyzer to an ANSI character printer. Provide the test results to the Department as part of the Proof of Performance test results.

Commence with Proof of Performance Testing at a given CMS location only after meeting all of the following requirements:

- All work required in the Plans and Specifications for that CMS location is completed.
- All Pre-Installation Testing for all CMS in the project has been successfully completed. All communications between the given CMS location and the central control facility has been established and tested as functional.
- The Proof of Performance Test Plan and testing schedule have been approved by the Engineer

Do not conduct testing during any State or Federal holiday. Complete any given Proof of Performance Testing session within five (5) consecutive GDOT working days unless otherwise approved by the Engineer.

4. Acceptance Testing

Perform Acceptance Testing on the entire CMS system in accordance with the Specifications. The Acceptance Testing will be used to verify that the entire CMS system was designed, constructed, installed, and operates as a complete system per the Plans and Specifications.

Perform the following operational performance testing using NaviGator software:

- Demonstrate 100 percent compliance with the NTCIP protocol stack (see Appendix A of Section 631) operating within an automated poll-response environment.

- Demonstrate every feature of the CMS controller and sign display assembly via direct connect and modem communications.
- Demonstrate fault-free operation of the CMS assembly under test when subject to 500 cycles of status request command and response operations between the CMS and NaviGator software.
- Demonstrate fault-free operation of the CMS assembly under test when subjected to 1000 cycles of message download command, message download response, message display command, message display response, CMS status command, and CMS status response. Perform one complete cycle in 20 seconds or less with a CMS message constructed such that a character message fills every available character space on a two phase message. Set the phase time on to three seconds for each phase and the off time to zero seconds.

Record all communication between NaviGator software and the CMS under test using an HP 4952A or equal protocol analyzer. Record serial data captured by the protocol analyzer on media printable from the protocol analyzer to an ANSI character printer. Provide the test results to the Department as part of the Acceptance Test results.

Commence with Acceptance Testing only after meeting all of the following requirements:

- Complete all work required in the Plans and Specifications for the entire Contract, including the Contractor's adjustment of the sign alignment on the sign support system, dimming system, test messages, communications, and test software.
- Successfully complete all Proof of Performance Testing for all CMS in the project.
- The Engineer has approved the Acceptance Test Plan and testing schedule.

Conduct no testing during any State or Federal holiday. Complete the Acceptance Testing session within five (5) consecutive GDOT working days unless otherwise approved by the Engineer.

G. Burn-In Period

1. General Requirements

Provide a 30-day burn-in period for all work and equipment included in the Contract. The burn-in period shall consist of the field operation of the changeable message sign system in a manner that is in full accordance with the changeable message sign system requirements of the Plans and Specifications. An acceptance test procedure is not required for the system burn-in.

Conduct only one (1) burn-in period on the entire Contract. Commence with the burn-in period only after meeting all of the following requirements:

- All work required in all Contract documents for CMS (may be combined with construction contract) (except this burn-in period) has been completed and inspected by the Engineer.
- Successfully complete all Acceptance Testing.

Commence with the burn-in period upon written authorization by the Department to commence. Terminate the burn-in period 30 consecutive days thereafter unless an equipment malfunction occurs. Stop the burn-in period for the length of time any equipment is defective. After repairing the equipment so that it functions properly, resume the burn-in period at the point it was stopped.

Successful completion and acceptance of the burn-in period will be granted on the 30th day unless any equipment has malfunctioned during the 15th through 30th day of the burn-in period. If any equipment has failed during the 15th through 30th day, final acceptance will be withheld until all the equipment is functioning properly for 15 days after repair.

When a specific piece of equipment has malfunctioned more than three times during the 30 day burn-in period, replace that equipment with a new unit and repeat the 30 day burn-in period.

2. Contractor Responsibilities

During the burn-in period, maintain all work under this Contract in accordance with the Specifications. Restore any work or equipment to proper operating condition within 12 hours after notification.

3. Department Responsibilities

Department responsibilities during the burn-in period will be as follows:

- Expedient notification of Contractor upon failure or malfunction of equipment
- In the event that the Contractor does not provide the services enumerated above under his Contract responsibilities, the Department or its authorized agents may in the interest of public safety take emergency action to provide for adequate traffic control. Pay any costs incurred as a result of these emergency actions. Such action by the Department will not void any warranties or warranties or other obligations set forth in the Contract.

4. Burn-In Period Acceptance

The Department will make burn-in period acceptance after satisfactory completion of the required burn-in period and on the basis of a comprehensive field inspection of the complete CMS system in accordance with the Specifications. Upon burn-in period acceptance but prior to Final Acceptance of the entire Contract, maintain the complete CMS system in accordance with the requirements of Subsection 631.3.07.

H. CMS Controller

Provide a CMS controller unit with a design mean time between failures (MTBF) of a minimum of five years of continuous operation in the outdoor environment as calculated by a means approved by the Engineer.

631.3.07 Contractor Warranty and Maintenance

A. General

Provide a Manufacturer support (usual and customary warranties) period for all equipment and materials furnished and installed as part of the pay item for CMS equipment and materials. Include in warranty and support, all contractor or manufacturer activities related to maintenance, removal and replacement of parts and materials during the period of support. Begin the Manufacturer support upon successful completion of the Proof of Performance Testing, as outlined in Subsection 631.3.06.F. All Manufacturer warranties shall be continuous throughout the period and state that they are subject to transfer to the Department.

B. Support

Provide full support (for both parts and labor) for the period from the installation of all of the CMS in this contract until final acceptance of the contract for all Contractor supplied CMS components.

Provide support that covers maintenance and any defects in materials and workmanship for all system components. Make any replacements required during the support period without additional charge for labor, equipment and system components and other materials required. Support all system components notwithstanding any supplier's warranties whether written or implied.

During the support period, enter a precise description of repair work performed into the log book (supplied by the Department and located in the CMS controller cabinet and at the central control facility).

C. Response and Notification

Clearly identify in writing the designated contact person and alternate for liaison with the Department. The Department will designate representatives and alternates as contact persons for the control center and the field equipment and provide this information to the Contractor. Communicate with the Department's designated representative, or alternate, prior to undertaking any maintenance or emergency repairs. Allow the Department's staff the option to accompany the Contractor's staff during the performance of component failure identification and corrective action, during maintenance activities, and during emergency repairs performance. Record all repair and maintenance activity log entries into field cabinet documents and at the control center in the log books provided by the Department.

Respond to emergency repair calls by the Department's coordinator of maintenance or the designated alternate. The Department's coordinator of maintenance or alternate will enter the time of the call and the time of arrival of the Contractor in an emergency repairs log book at the control center. This log book will be made available to the Contractor for his inspection

upon request. Response time to reach the site of the malfunction shall be no more than three hours between 0900 hours and 1800 hours Monday to Friday, excluding State or Federal holidays; and six hours at any other time. Take no more than 24 hours from time of receiving notification to have the sign repaired to full functionality, meeting all requirements of the Specifications and confirmed by the Department representative, exclusive of requirements for the coordination of lane closure.

631.3.08 Training

A. General

Prepare and conduct training courses on the system for Department personnel and persons designated by the Engineer. A total of up to 20 GDOT designated personnel will attend the training sessions.

Conduct two types of training courses. The first type is for the engineering and operator personnel (one-day course). The second is for the maintenance personnel (five-day course).

Carry out training on dates mutually agreeable to the Engineer and to the Contractor. Notify the Engineer by giving 30 days notice of intent to carry out the training so that arrangements for attendance can be made. Develop the courses specifically for the system, assuming no prior knowledge of the communications, electronic or changeable message sign technology used. Provide a location to hold the courses that is an acceptable indoor and comfortable location near the project area. If requesting that the training be conducted away from the project area, pay all costs associated with travel and accommodation of all the students. A member of the Contractors staff with intimate experience with this Contract shall attend the courses and provide answers to any inquires.

Provide a draft of the course material to the Engineer as specified in Subsection 631.1.03.Q. Allow adequate time for reviews and revisions to ensure that the courses are held within the designated dates.

B. Training Content

Include an introductory level briefing to familiarize attendees with the CMS subsystem prior to the conduct of any acceptance testing of the CMS. A separate operator and engineering course shall include an overview of subsystem elements, the theory of operation of components, operating procedures and capabilities, and software applications. Involve "hands-on" use of all CMS equipment installed in the control center. Provide a separate technician level course to include relevant topics in electronics and communications interfaces. Provide a detailed description and explanation of the theory of operation of major CMS components; operation, test and installation procedures; troubleshooting, diagnostics and maintenance to the replaceable module level, including the use of test equipment and diagnostic tools, installation and alignment techniques during training. The technicians' level course shall also show how to use the system documentation to operate, diagnose, maintain, and expand the system. The technician level course shall also involve the "hands-on" use of the system, laptop computer and software, system test equipment, and any other Contractor supplied equipment.

631.4 Measurement

A. CMS

CMSs are measured for payment by the number actually installed, complete, functional and accepted. Unless otherwise specified in the Plans, include with a CMS installation, at a minimum, furnishing and installing the following:

- Type A or Type B controllers.
- All electrical, electronic, or electromagnetic components used in any CMS assembly, including but not limited to capacitors, potentiometers, resistors, semiconductor devices, transformers, inductors, circuit breakers, switches, terminal blocks, wiring, cabling, harnesses, indicators, electromechanical shutter units, light emitting modules, lamps, driver boards, sign control logic boards, opto-isolation cards, photosensors, sign electronics power supply, pin and socket connectors, PCB connectors, wire connectors, PCB assemblies, fans, and filters.
- All CMS housing components including, but not limited to, the housing assembly and mounting hardware, CMS platform and housing door, and maintenance safety eyebolts.
- Cabinet equipment, including but not limited wiring, conductors, terminal blocks, surge suppression

- Power cables to connect 120V circuits between the CMS controller unit and CMS housing equipment power distribution area.
- Signal or communication cables with phone line surge protectors for dial-up CMS assembly as shown in the Plans.
- All weather heads, vertical conduit risers and conduit hardware on the CMS support pole for power service, grounding, and communications.
- All hardware and materials necessary to provide electrical power service to the CMS field location as shown in the Plans, including, but not limited to, vertical sections of conduit, conduit hardware, wire, circuit breakers, disconnect enclosures, and grounding. The Department will pay for horizontal runs of conduit separately.
- All cables, connectors, hardware, interfaces, supplies, and any other items necessary for the proper operation and function of any CMS system component with any other CMS system component.
- Development, installation, testing, and documentation of all software associated with the CMS controller unit.

Supply the following components as support material for all fiber optic shutter (FOS) sign projects:

- Electromechanical shutter units 1 each, per sign
- Light emitting modules 1 each, per sign
- Lamp driver boards 3 each, per sign
- Shutter Driver boards 3 each, per sign
- Sign control logic boards 1 each, per sign
- Opto-isolation cards 14 each, per sign
- Photo cells 2 each, per sign
- Sign electronics power supply 2 each, per sign
- Fans 1 each, per sign

Supply the following components as support material for all light emitting diode (LED) sign projects:

- LED modules 3 each, per sign
- LED drivers 3 each, per sign
- Power supplies 1 each, per sign
- Photocell assembly 3 each, per sign
- Sign control logic boards 1 each, per sign
- Fans 1 of each type, per sign

In addition for projects installing:

- One to nine CMS signs using the same controller type, provide one full CMS controller unit of like type for ground cabinet and one CMS controller for sign housing
- Ten to fifteen CMS signs using the same controller type, provide two full CMS controller units of like type for ground cabinet and two CMS controllers for sign housing
- More than fifteen CMS signs using the same controller type, provide three full CMS controller units of like type for ground cabinet and three CMS controllers for sign housing

Include any miscellaneous labor, material, equipment, or services not specifically mentioned but required to make a complete and operational CMS installation within the CMS sign pay item as no separate payment will be made for same.

B. Pixel Unit (Furnish Only)

Pixel units are measured for payment by the number actually furnished and accepted.

C. Light Emitting Module (Furnish Only)

Light emitting modules are measured for payment by the number actually furnished and accepted.

D. Lamp (Furnish Only)

Lamps are measured for payment by the number actually furnished and accepted.

E. Driver Board (Furnish Only)

Driver boards are measured for payment by the number actually furnished and accepted.

F. Sign Control Logic Board (Furnish Only)

Sign control logic boards are measured for payment by the number actually furnished and accepted.

G. Opto-Isolation Card (Furnish Only)

Opto-isolation cards are measured for payment by the number actually furnished and accepted.

H. Photosensor (Furnish Only)

Photosensors are measured for payment by the number actually furnished and accepted.

I. Sign Electronics Power Supply (Furnish Only)

Sign electronics power supplies are measured for payment by the number actually furnished and accepted.

J. Fan (Furnish Only)

Fans are measured for payment by the number actually furnished and accepted.

K. Filter (Furnish Only)

Filters are measured for payment by the number actually furnished and accepted.

L. CMS Controller Type A (Furnish Only)

CMS controllers Type A are measured for payment by the number actually furnished and accepted.

M. CMS Controller Type B (Furnish Only)

CMS controllers Type B are measured for payment by the number actually furnished and accepted.

N. Laptop Computer (Furnish Only)

Laptop computers are measured for payment by the number actually furnished and accepted.

O. Testing

Testing is measured as a lump sum for full delivery of testing and acceptance requirements of all CMS included in the Contract.

P. Training

Training is measured as a lump sum for all supplies, equipment, materials, handouts, travel, and subsistence necessary to conduct the training.

631.4.01 Limits

Not applicable

631.5 Payment

A. CMS

CMSs are paid for at the Contract Unit Price. Payment is full compensation for furnishing and installing the CMS.

CMS components are paid for at the Contract Unit Price. Payment is full compensation for furnishing each component.

Payment at 100 percent of the Contractor and vendor certified invoice price of materials to be permanently incorporated into the work will be allowed provided the Engineer determines that all requirements of the specifications have been met. All partial payments shall be subject to the maximum Contract pay item increments defined for the particular Contract and subject to the Department’s retainage requirements.

For all CMS materials and equipment, payment at 100 percent of the material or equipment invoice price up to a maximum of 75 percent of the Contract pay item bid price will be allowed on a per each basis provided the Engineer determines that the following requirements have been met per each:

- Successfully complete all Pre-installation testing.
- Deliver all CMS housing, display, wiring equipment and materials to the designated project area.
- Place the CMS in proper temporary storage.
- Submit a complete draft documentation package to the Engineer for review and approval for all of the CMS equipment, systems, controller and laptop software, and proof of performance testing.

For all CMS controller materials and equipment, payment of 85 percent of the Contract pay item bid price will be allowed on a per unit basis provided the Engineer determines that all Proof of Performance Testing is successfully completed.

For all communications materials and equipment, payment of 95 percent of the Contract pay item bid price will be allowed on a per unit basis provided the Engineer determines that the 30 days of the burn-in period have been successfully completed.

For all CMS System materials and equipment, payment of 100 percent of the Contract pay item bid price will be allowed on a per unit basis provided the Engineer approves Final Acceptance of the contract.

Payment for CMSs is made under:

Item No. 631	CMS	Per Each
Item No. 631	Pixel Unit	Per Each
Item No. 631	Light Emitting Module	Per Each
Item No. 631	Lamp	Per Each
Item No. 631	Driver Board	Per Each
Item No. 631	Sign Control Logic Board	Per Each
Item No. 631	Opto-Isolation Card	Per Each
Item No. 631	Photosensor	Per Each
Item No. 631	Sign Electronics Power Supply	Per Each
Item No. 631	Fan	Per Each
Item No. 631	Filter	Per Each
Item No. 631	CMS Controller Type A	Per Each
Item No. 631	CMS Controller Type B	Per Each
Item No. 631	Laptop Computer	Per Each

B. Testing

The Department will pay for testing performed as prescribed by this Item, measured as provided under Measurement at the Lump Sum Contract Bid Price.

Payment for testing is made under:

Item No. 631	Testing	Lump Sum
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C. Training

The Department will pay twenty-five (25%) of the total contract bid amount for training upon approval of the Training Plan. The Department will pay the remaining seventy-five (75%) after completion of all training as described in Subsections 631.3.08. The total sum of all payments cannot exceed the original contract amount for this item.

Payment is made under:

Item No. 631	Training	Lump Sum
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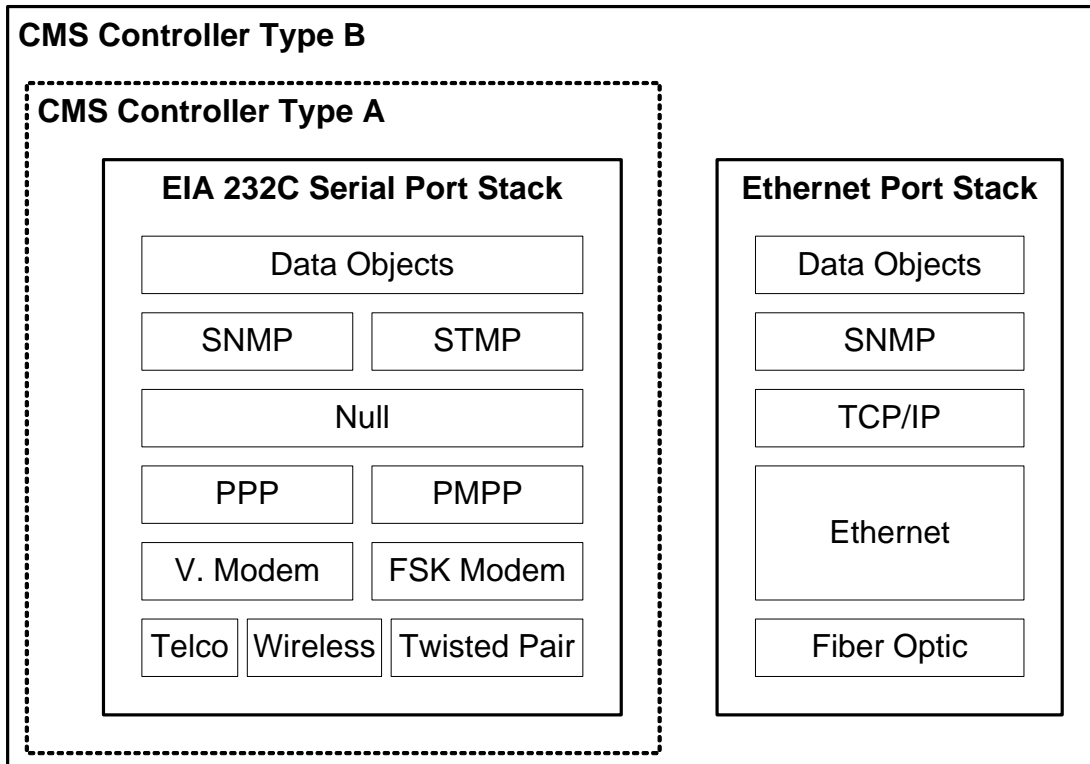
631.5.01 Adjustments

Not applicable

APPENDIX A - NTCIP PROTOCOL STACK

CMS controller Type A and B shall implement a NTCIP protocol stack according to the port type. For EIA 232 serial port, the protocol stack shall be based on the NTCIP Class B profile (NTCIP 2001:1996, NTCIP 2101, NTCIP 2103, NTCIP 2201, and NTCIP 2301). For Ethernet port, the protocol stack shall be based on the following NTCIP standards: 1201, 1203, 2104, 2202, and 2301

All communication will be made using either SNMP or STMP to retrieve and/or update the configuration of the CMS controller. Furthermore, if the CMS controller is required to generate a response to the SNMP/STMP request, then it should send the response to the requestor within five (5) seconds of receiving the request. The following is a diagram of the communication stack per port type and controller type.



A.1 INFORMATION LEVEL

The CMS controller shall support the following NTCIP Data Objects and the values within the specified range:

A Configuration Conformance Group (NTCIP 1201 [1996])

Section Number	Data Object	Range
2.2.1	globalSetIDParameter	Entire Range
2.2.2	globalMaxModules	{2...255}
2.2.3	globalModuleTable	
2.2.3.1	moduleNumber	Entire Range
2.2.3.2	moduleDeviceNode	Entire Range
2.2.3.3	moduleMake	Not Null
2.2.3.4	moduleModel	Not Null
2.2.3.5	moduleVersion	Entire Range

2.2.3.6	moduleType	Entire Range
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Note: At a minimum, the module table should contain information pertaining to the hardware and firmware of the CMS controller.

B Time Management Conformance Group (NTCIP 1201 [1996])

Section Number	Data Object	Range
2.4.1	globalTime	Entire Range
2.4.2	globalDaylightSaving	Entire Range

C Timebase Event Schedule Conformance Group (NTCIP 1201 [1996])

Section Number	Data Object	Range
2.4.3.1	maxTimeBaseScheduleEntries	{12...65535}
2.4.3.2	timeBaseScheduleTable	
2.4.3.2.1	timeBaseScheduleNumber	Entire Range
2.4.3.2.2	timeBaseScheduleMonth	Entire Range
2.4.3.2.3	timeBaseScheduleDay	Entire Range
2.4.3.2.4	timeBaseScheduleDate	Entire Range
2.4.3.2.5	timeBaseScheduleDayPlan	Entire Range
2.4.4.1	maxDayPlans	{12...255}
2.4.4.2	MaxDayPlanEvents	{12...255}
2.4.4.3	timeBaseDayPlanTable	
2.4.4.3.1	dayPlanNumber	Entire Range
2.4.4.3.2	dayPlanEventNumber	Entire Range
2.4.4.3.3	dayPlanHour	Entire Range
2.4.4.3.4	dayPlanMinute	Entire Range
2.4.4.3.5	dayPlanActionNumberOID	Entire Range
2.4.4.4	dayPlanStatus	Entire Range

D Report Conformance Group (NTCIP 1201 [1996])

Section Number	Data Object	Range
2.5.1	maxEventLogConfigs	{50...65535}
2.5.2	eventLogConfigTable	
2.5.2.1	eventConfigID	Entire Range
2.5.2.2	eventConfigClass	Entire Range
2.5.2.3	eventConfigMode	Entire Range

2.5.2.4	eventConfigCompareValue	Entire Range
2.5.2.5	eventConfigCompareValue2	Entire Range
2.5.2.6	eventConfigCompareOID	Entire Range
2.5.2.7	eventConfigLogOID	Entire Range
2.5.2.8	eventConfigAction	Entire Range
2.5.3	maxEventLogSize	{200...65535}
2.5.4	eventLogTable	
2.5.4.1	eventLogClass	Entire Range
2.5.4.2	eventLogNumber	Entire Range
2.5.4.3	eventLogID	Entire Range
2.5.4.4	eventLogTime	Entire Range
2.5.4.5	eventLogValue	Entire Range
2.5.5	maxEventClasses	{15...255}
2.5.6	eventClassTable	
2.5.6.1	eventClassNumber	Entire Range
2.5.6.2	eventClassLimit	Entire Range
2.5.6.3	eventClassClearTime	Entire Range
2.5.6.4	eventClassDescription	Entire Range
2.5.6.5	eventClassNumRowsInLog	Entire Range

E STMP Conformance Group (NTCIP 1201 [1996])

Section Number	Data Object	Range
2.6.1	dynamicObjectPersistence	{0...65535}

F PMPP Conformance Group (NTCIP 1201 [1996])

Section Number	Data Object	Range
2.7.1	maxGroupAddresses	{10...255}
2.7.2	hdlcGroupAddressTable	
2.7.2.1	hdlcGroupAddressIndex	Entire Range
2.7.2.2	hdlcGroupAddress	Entire Range

G Sign Configuration & Capability Conformance Group (1203 [1997])

Section Number	Data Object	Range
2.2.1.1.1.2	dmsSignType	Entire Range

2.2.1.1.1.8	dmsBeaconType	Entire Range
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Note: The values for the Sign Configuration Group should reflect the correct information for the particular sign and cannot be given random values.

H GUI Appearance Conformance Group (1203 [1997])

Section Number	Data Object	Range
2.2.1.1.1.1	dmsSignAccess	Entire Range
2.2.1.1.1.3	dmsSignHeight	Entire Range
2.2.1.1.1.4	dmsSignWidth	Entire Range
2.2.1.1.1.5	dmsHorizontalBorder	Entire Range
2.2.1.1.1.6	dmsVerticalBorder	Entire Range
2.2.1.1.1.7	dmsLegend	Entire Range
2.2.1.1.1.9	dmsSignTechnology	Entire Range

Note: The values for the GUI Appearance Group should reflect the correct information for the particular sign and cannot be given random values.

I Font Configuration Conformance Group (NTCIP 1203 [1997])

Section Number	Data Object	Range
2.4.1.1.1.1	numFonts	{2...255}
2.4.1.1.1.2	fontTable	
2.4.1.1.1.2.1	fontIndex	Entire Range
2.4.1.1.1.2.2	fontNumber	Entire Range
2.4.1.1.1.2.3	fontName	Entire Range
2.4.1.1.1.2.4	fontHeight	Entire Range
2.4.1.1.1.2.5	fontCharSpacing	Entire Range
2.4.1.1.1.2.6	fontLineSpacing	Entire Range
2.4.1.1.1.2.7	fontVersionID	Entire Range
2.4.1.1.1.3	maxFontCharacters	Entire Range
2.4.1.1.1.4	characterTable	
2.4.1.1.1.4.1	characterNumber	Entire Range
2.4.1.1.1.4.2	characterWidth	Entire Range
2.4.1.1.1.4.3	characterBitmap	Entire Range

J VMS Sign Configuration Conformance Group (NTCIP 1203 [1997])

Section Number	Data Object	Range
2.3.1.1.1.1	vmsCharacterHeightPixels	Entire Range
2.3.1.1.1.2	vmsCharacterWidthPixels	Entire Range

2.3.1.1.1.3	vmsSignHeightPixels	Entire Range
2.3.1.1.1.4	vmsSignWidthPixels	Entire Range
2.3.1.1.1.5	vmsHorizontalPitch	Entire Range
2.3.1.1.1.6	vmsVerticalPitch	Entire Range

Note: The values for the VMS Sign Configuration Group should reflect the correct information for the particular sign and cannot be given random values.

K MULTI Configuration Conformance Group (NTCIP 1203 [1997])

Section Number	Data Object	Range
2.5.1.1.1.1	defaultBackgroundColor	{0 }
2.5.1.1.1.2	defaultForegroundColor	{7}
2.5.1.1.1.3	defaultFlashOn	Entire Range
2.5.1.1.1.4	defaultFlashOff	Entire Range
2.5.1.1.1.5	defaultFont	Entire Range
2.5.1.1.1.6	defaultJustificationLine	{2, 3, 4}
2.5.1.1.1.7	defaultJustificationPage	{2, 3, 4}
2.5.1.1.1.8	defaultPageOnTime	Entire Range
2.5.1.1.1.9	defaultPageOffTime	Entire Range
2.5.1.1.1.10	defaultCharacterSet	{2}

L Message Table Conformance Group (NTCIP 1203 [1997])

Section Number	Data Object	Range
2.6.1.1.1.1	dmsNumPermanentMsg	{10...65535}
2.6.1.1.1.2	dmsNumChangeableMsg	Entire Range
2.6.1.1.1.3	dmsMaxChangeableMsg	{32...65535}
2.6.1.1.1.4	dmsFreeChangeableMemory	Entire Range
2.6.1.1.1.5	dmsNumVolatileMsg	Entire Range
2.6.1.1.1.6	dmsMaxVolatileMsg	{32...65535}
2.6.1.1.1.7	dmsFreeVolatileMemory	Entire Range
2.6.1.1.1.8	dmsMessageTable	
2.6.1.1.1.8.1	dmsMessageMemoryType	Entire Range
2.6.1.1.1.8.2	dmsMessageNumber	Entire Range
2.6.1.1.1.8.3	dmsMessageMultiString	Entire Range
2.6.1.1.1.8.4	dmsMessageOwner	Entire Range
2.6.1.1.1.8.5	dmsMessageCRC	Entire Range
2.6.1.1.1.8.6	dmsMessageBeacon	Entire Range

2.6.1.1.1.8.7	dmsMessagePixelService	Entire Range
2.6.1.1.1.8.8	dmsMessageRunTimePriority	Entire Range
2.6.1.1.1.8.9	dmsMessageStatus	Entire Range
2.6.1.1.2	dmsValidateMessageError	Entire Range

M Sign Control Conformance Group (NTCIP 1203 [1997])

Section Number	Data Object	Range
2.7.1.1.1.1	dmsControlMode	Entire Range
2.7.1.1.1.2	dmsSWReset	Entire Range
2.7.1.1.1.3	dmsActivateMessage	Entire Range
2.7.1.1.1.4	dmsMessageTimeRemaining	Entire Range
2.7.1.1.1.5	dmsMsgTableSource	Entire Range
2.7.1.1.1.6	dmsMsgRequesterID	Entire Range
2.7.1.1.1.7	dmsMsgSourceMode	Entire Range
2.7.1.1.1.16	dmsMemoryMgmt	{2, 3, 4}
2.7.1.1.1.17	dmsActivateMsgError	Entire Range

N Default Message Conformance Group (NTCIP 1203 [1997])

Section Number	Data Object	Range
2.7.1.1.1.8	dmsShortPowerRecoveryMessage	Entire Range
2.7.1.1.1.9	dmsLongPowerRecoveryMessage	Entire Range
2.7.1.1.1.10	dmsShortPowerLossTime	Entire Range
2.7.1.1.1.11	dmsResetMessage	Entire Range
2.7.1.1.1.12	dmsCommunicationsLossMessage	Entire Range
2.7.1.1.1.13	dmsTimeCommLoss	{1..60}
2.7.1.1.1.14	dmsPowerLossMessage	Entire Range
2.7.1.1.1.15	dmsEndDurationMessage	Entire Range
2.7.1.1.1.17	dmsActivateMsgError	Entire Range
2.7.1.1.1.18	dmsMultiSyntaxError	Entire Range
2.7.1.1.1.19	dmsMultiSyntaxErrorPosition	Entire Range
2.7.1.1.1.20	dmsMultiOtherErrorDescription	Entire Range
2.7.1.1.1.21	vmsPixelServiceDuration	Entire Range
2.7.1.1.1.22	vmsPixelServiceFrequency	Entire Range
2.7.1.1.1.23	vmsPixelServiceTime	Entire Range

O Pixel Service Conformance Group (NTCIP 1203 [1997])

Section Number	Data Object	Range
2.7.1.1.1.21	vmsPixelServiceDuration	Entire Range
2.7.1.1.1.22	vmsPixelServiceFrequency	Entire Range
2.7.1.1.1.23	vmsPixelServiceTime	Entire Range

P MULTI Error Conformance Group (NTCIP 1203 [1997])

Section Number	Data Object	Range
2.7.1.1.1.18	dmsMultiSyntaxError	Entire Range
2.7.1.1.1.19	dmsMultiSyntaxErrorPosition	Entire Range
2.7.1.1.1.20	dmsMultiOtherErrorDescription	Entire Range

Q Illumination/Brightness Control Conformance Group (NTCIP 1203 [1997])

Section Number	Data Object	Range
2.8.1.1.1.1	dmsIllumControl	{2, 3, 4}
2.8.1.1.1.2	dmsIllumMaxPhotocellLevel	Entire Range
2.8.1.1.1.3	dmsIllumPhotocellLevelStatus	Entire Range
2.8.1.1.1.4	dmsIllumNumBrightLevels	{3...255}
2.8.1.1.1.5	dmsIllumBrightLevelStatus	Entire Range
2.8.1.1.1.6	dmsIllumManLevel	Entire Range
2.8.1.1.1.7	dmsIllumBrightnessValues	Entire Range
2.8.1.1.1.8	dmsIllumBrightnessValuesError	Entire Range
2.8.1.1.1.9	dmsIllumLightOutputStatus	Entire Range

R Scheduling Conformance Group (NTCIP 1203 [1997])

Section Number	Data Object	Range
2.9.1.1.1.1	numActionTableEntries	{15...255}
2.9.1.1.1.2	dmsActionTable	
2.9.1.1.1.2.1	dmsActionIndex	Entire Range
2.9.1.1.1.2.2	dmsActionMsgCode	Entire Range

S Auxiliary I/O Conformance Group (NTCIP 1203 [1997])

Section Number	Data Object	Range
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2.10.1.1.1.1	maxAuxIODigital	{8}
2.10.1.1.1.2	maxAuxIOAnalog	{8}
2.10.1.1.1.3	auxIOTable	
2.10.1.1.1.3.1	auxIOPortType	Entire Range
2.10.1.1.1.3.2	auxIOPortNumber	Entire Range
2.10.1.1.1.3.3	auxIODescription	Entire Range
2.10.1.1.1.3.4	auxIOResolution	Entire Range
2.10.1.1.1.3.5	auxIOValue	Entire Range
2.10.1.1.1.3.6	auxIOPortDirection	Entire Range

T Sign Status Conformance Group (NTCIP 1203 [1997])

Section Number	Data Object	Range
2.11.1.1.1.1	statMultiFieldRows	{0..255}
2.11.1.1.1.2	statMultiFieldTable	
2.11.1.1.1.2.1	statMultiFieldIndex	Entire Range
2.11.1.1.1.2.2	statMultiFieldCode	Entire Range
2.11.1.1.1.2.3	statMultiCurrentFieldValue	Entire Range
2.11.1.1.1.3	dmsCurrentSpeed	Entire Range
2.11.1.1.1.4	dmsCurrentSpeedLimit	Entire Range
2.11.1.1.1.5	watchdogFailureCount	Entire Range
2.11.1.1.1.6	dmsStatDoorOpen	Entire Range

U Status Error Subconformance Group (NTCIP 1203 [1997])

Section Number	Data Object	Range
2.11.2.1.1.1	shortErrorStatus	Entire Range
2.11.2.1.1.10	controllerErrorStatus	Entire Range

V Pixel Error Status Subconformance Group (NTCIP 1203 [1997])

Section Number	Data Object	Range
2.11.2.1.1.2	pixelFailureTableNumRows	Entire Range
2.11.2.1.1.3	pixelFailureTable	
2.11.2.1.1.3.1	pixelFailureDetectionType	Entire Range
2.11.2.1.1.3.2	pixelFailureIndex	Entire Range
2.11.2.1.1.3.3	pixelFailureXLocation	Entire Range

2.11.2.1.1.3.4	pixelFailureYLocation	Entire Range
2.11.2.1.1.3.5	pixelFailureStatus	Entire Range
2.11.2.1.1.4	pixelTestActivation	Entire Range

W Lamp Error Status Subconformance Group (NTCIP 1203 [1997])

Section Number	Data Object	Range
2.11.2.1.1.5	lampFailureStuckOn	Entire Range
2.11.2.1.1.6	lampFailureStuckOff	Entire Range
2.11.2.1.1.7	lampTestActivation	Entire Range

X Fan Error Status Subconformance Group (NTCIP 1203 [1997])

Section Number	Data Object	Range
2.11.2.1.1.8	fanFailures	Entire Range
2.11.2.1.1.9	fanTestActivation	Entire Range

Y Power Status Subconformance Group (NTCIP 1203 [1997])

Section Number	Data Object	Range
2.11.3.1.1.1	signVolts	Entire Range
2.11.3.1.1.2	lowFuelThreshold	Entire Range
2.11.3.1.1.3	fuelLevel	Entire Range
2.11.3.1.1.4	engineRPM	Entire Range
2.11.3.1.1.5	lineVolts	Entire Range
2.11.3.1.1.6	powerSource	Entire Range

Note: The values for the Power Status Group should reflect the correct information for the particular sign and cannot be a random value.

Z Temperature Status Subconformance Group (NTCIP 1203 [1997])

Section Number	Data Object	Range
2.11.4.1.1.1	TempMinCtrlCabinet	Entire Range
2.11.4.1.1.2	TempMaxCtrlCabinet	Entire Range
2.11.4.1.1.3	TempMinAmbient	Entire Range
2.11.4.1.1.4	TempMaxAmbient	Entire Range
2.11.4.1.1.5	TempMinSignHousing	Entire Range
2.11.4.1.1.6	TempMaxSignHousing	Entire Range

A.2 APPLICATION LEVEL

The CMS controller shall support the Simple Transportation Management Protocol (STMP) at the Application Level.

A.3 TRANSPORT LEVEL

CMS controller serial ports shall implement the NULL Protocol at the Transport Level.

CMS controller Ethernet port shall implement TCP/IP Protocols at the Transport Level.

A.4 SUBNETWORK LEVEL

CMS controller EIA 232 serial ports shall support the Point-to-Point Protocol (PPP) if it communicates using dialup modem at the Subnetwork Level.

CMS controller EIA 232 serial ports shall support the Point-to-Multi-Point Protocol (PMPP) if it communicates in a multidrop wireless network. Single byte addressing will be employed.

CMS controller Ethernet port shall support the Ethernet protocol.

A.5 PLANT LEVEL

The CMS controller shall support the serial interface specification defined in Section 631.3.04.D.1.

The CMS controller shall support the Ethernet interface specification defined in Section 631.3.04.D.2.