

REGIONAL TRANSPORTATION AUTHORITY

ACTIVE TRANSIT STATION SIGNS
DEMONSTRATION
(INITIAL PHASE)

Specification

FINAL

21 February 2001

Table of Contents

[Section 01010 Project Description](#)01010-1

[Section 16010 Basic Electrical Requirements](#)..... 16010-1

[Section 16100 Basic Materials and Methods](#) 16100-1

[Section 16195 Electrical Identification](#)..... 16195-1

[Section 16450 Grounding](#) 16450-1

[Section 16470 Panelboards](#) 16470-1

[Section 16770 Central Control System](#)..... 16770-1

[Section 16771 Station Sign Controller](#)..... 16771-1

[Section 16772 Vehicle Proximity Sensors](#) 16772-1

[Section 16773 Station Consoles](#)..... 16773-1

[Section 16774 Variable Message Signs](#)..... 16774-1

**DIVISION 16
ELECTRICAL**

**SECTION 01010
PROJECT DESCRIPTION**

PART 1 - GENERAL

1.01 DESCRIPTION

- A. This Specification describes an instance of the regional Active Transit Station Signs (ATSS) system tailored to the specific site requirements of the Chicago Transit Authority (CTA) rail rapid transit stations included in this demonstration project.
- B. The work shall consist of the design, manufacture, provision, installation, test, training, and acceptance of a new ATSS system for demonstration purposes at two CTA rail rapid transit terminal stations (Midway Airport and O'Hare Airport) and two intermediate stations (Cumberland Avenue and Davis Street-Evanston).
- C. The ATSS shall be used to generate voice and text messages at each station. Text messages shall be displayed on Variable Message Signs (VMS) utilizing Light Emitting Diode (LED) technology. For the demonstration, a single train arrival voice announcement shall be made on the existing audio Public Address (PA) system at each intermediate station.
- D. It is intended that future enhancements of the ATSS system shall include integration and replacement of existing audio PA systems at each station. The design of control center hardware and software shall support future integration of the functions of the existing CTA PA system as an additive enhancement without duplication of hardware or software development efforts associated with the demonstration.
- E. The ATSS demonstration system shall form the first component of a regional Advanced Traveler Information System (ATIS) based on National Transportation Communications for ITS Protocol (NTCIP)-compliant communications protocols. This system will include a future Illinois Transit Hub (to be deployed by the Regional Transportation Authority (RTA)) and will be integrated with the Gary-Chicago-Milwaukee (GCM) Corridor Multi-Modal Traveler Information System (MMTIS). This integration is not considered part of this demonstration project, but the design of control center hardware and software shall support future integration as an additive enhancement without

duplication of hardware or software development efforts associated with the demonstration.

- F. For the demonstration, the ATSS system shall disseminate countdown messages and advisory messages for each station to CTA and Regional Transportation Authority (RTA) web sites in real-time.

1.02 RELATED DOCUMENTS

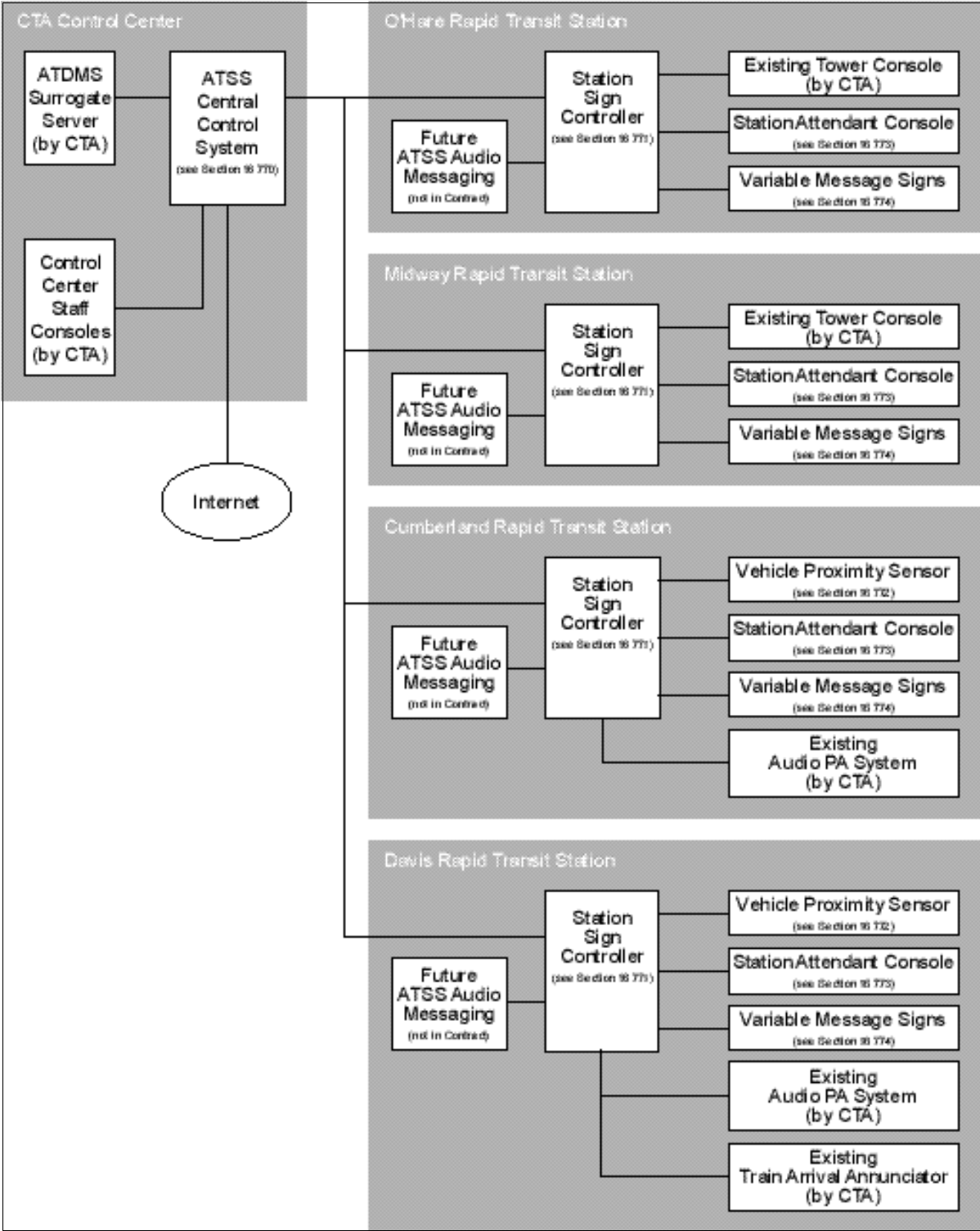
- A. The *ATSS General Specifications* Phase II Task 1 report (Draft 20 September 2000) and the *ATSS Functional, Messaging and Integration Requirements* Phase I Tasks 5-8 report (Draft 30 April 1999) provide background information on the design of the ultimate region-wide deployment of the ATSS, but are not considered components of the Contract Documents.
- B. Where system design provisions defined in this Specification conflict with provisions of the *ATSS General Specifications* or the *ATSS Functional, Messaging and Integration Requirements* reports, provisions of this Specification supersede all other specifications. The Contractor shall direct questions regarding any conflicts to the Authority before proceeding with system implementation.
- C. The CTA *Upgrade RT Stations ADA Standards Audio/Visual Public Address System* Procurement Specifications and Contract Documents (Spec No. CTA 806-98 dated October 1998) provide background information about the existing CTA PA system. The ATSS will interface with this system to announce audio train arrival messages. The ATSS demonstration project will also remove and replace some of the VMS associated with this system.
- D. The GCM Corridor Multi-Modal Traveler Information System will eventually be used to disseminate real-time transit service information. The design of the ATSS demonstration projects shall consider future interface with this system according to the requirements of this Specification. A partial list of relevant documents follows. The contractor shall be responsible for reviewing ALL relevant documents and coordinating with the GCM Corridor design team on system design issues.
 - 01. Gateway Project Glossary (Document # 2-8080), August 11, 1999
 - 02. Gateway System Definition (Document #2-8120.00), June 17, 1999
 - 03. Gateway External Interface User Guide (Document #2-8530.00), June 9, 1999

04. Gateway Interface Control Requirements (Document #2-8130.00), May 21, 1999
05. Gateway Graphical User Interface Design (Document #2-8230.01), May 21, 1999
06. Gateway System Hardware Design (Document #2-8220.03), May 23, 2000
07. Gateway Functional Requirements (Document #2-8140.02), May 23, 2000
08. Gateway External Interface User Guide (Document #2-8530.02), May 23, 2000
09. Location Reference Message Specification Migration Plan Guidelines, February, 2000
10. VMS/HAR Coordinated Policies and Guidelines Working Paper #19845.00, February 10, 1998
11. GCM MMTIS Strategic Plan, December 16, 1997

1.03 CONCEPTUAL SYSTEM ARCHITECTURE

- A. The ATSS consists of a Central Control System located at the CTA Control Center in Chicago, a Station Sign Controller at each station, multiple Variable Message Signs (VMS) at each station, NTCIP-compliant communications between these components, and related software and field devices.
- B. The conceptual System Architecture for the ATSS Demonstration Project is depicted in the figure on the following page.
- C. For more detailed information on each component, refer to the appropriate Section in this Specification.

Figure 01010-1: ATSS Demonstration Project System Architecture



END OF SECTION 01010

**DIVISION 16
ELECTRICAL**

**SECTION 16010
BASIC ELECTRICAL REQUIREMENTS**

PART 1 - GENERAL

1.01 DESCRIPTION

- A. This Section specifies general power and communications electrical work as necessary to support the Active Transit Station Signs Demonstration Project as detailed in the sections in Division 16. The work under this Section shall include furnishing all labor, materials, tools, equipment and incidentals necessary to provide and install the electrical work specified in Division 16 Electrical.
- B. Drawings and general provisions of the Contract, including General and Special Conditions and Division 1 Specification sections, are applicable to all Sections of Division 16. Additional general provisions applicable only to individual Sections are specified under each such Section.
- C. Drawings and Specifications are to be considered as supplemental to each other. Work specified but not shown, or shown but not specified, shall be performed or furnished as though mentioned in both Specifications and Drawings.
- D. Any incidental accessories, minor items, or devices reasonably inferable as necessary for completion and proper operation of any system or necessary to make the Work complete and ready for operation, whether or not explicitly specified or shown on the Drawings, shall be furnished and installed without additional expense to the Authority.
- E. Should there be any discrepancies or a question of intent, the Contractor shall refer the matter to the Authority for a decision before ordering any equipment, materials or before starting any related work.
- F. Work shall be scheduled so as not to interfere with CTA train operations. When necessary, CTA will provide flagmen to protect workers at the Contractor's expense. Flagmen will be assigned according to established CTA procedures and manpower availability.

1.02 TECHNICAL ABBREVIATIONS AND DEFINITIONS

- A. The following abbreviations, acronyms and their definitions are used throughout this Specification:

AA	Aluminum Association
AC	Alternating Current
ADA	Americans with Disabilities Act
AISC	American Institute of Steel Construction
ASCII	American Standard Code for Information Interchange
ASN.1	Abstract Syntax Notation One Protocol
ATDMS	Automatic Train Dispatching & Monitoring System
ATM	Asynchronous Transfer Mode
ATIS	Advanced Traveler Information System
ATSS	Active Transit Station Signs system
AVL	Automatic Vehicle Location
AWS	American Welding Society
bps	Bits per Second
°C	Degrees Celsius
CBMA	Certified Ballast Manufacturers Association
CCS	ATSS Central Control System
CD-ROM	Compact Disc – Read-Only Memory
CDPD	Cellular Digital Packet Data
CEC	City of Chicago Electrical Code
CECHA	Commonwealth Edison, Chicago Approved
CORBA	Common Object Request Broker Architecture
CRC	Cyclical Redundancy Check
CTA	Chicago Transit Authority
DATEX	DATa EXchange
DC	Direct Current
DDL	Data Definition Language
DFD	Data Flow Diagram
EJB	Enterprise Java Bean
ETA	Estimated Time of Arrival
ETL	Electrical Testing Laboratories, Inc.
°F	Degrees Fahrenheit
FCC	Federal Communications Commission
FSK	Frequency Shift Keying
GCM	Gary-Chicago-Milwaukee ITS Corridor
GUI	Graphical User Interface
HVAC	Heating, Ventilation, and Air Conditioning
IBEW	International Brotherhood of Electrical Workers
ICD	Interface Control Document
IDL	Interface Definition Language
ITS	Intelligent Transportation Systems
LAN	Local Area Network
LED	Light Emitting Diode

LRMS	Location Referencing Management System
MMTIS	Multi-Modal Traveler Information System
NAAMM	National Association of Architectural Metal Manufacturers
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NESC	National Electrical Safety Code
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
NTCIP	National Transportation Communication for ITS Protocol
OSHA	Occupational Safety and Health Administration
OSI	Open Systems Interconnection
PA	Public Address
PAHS	CTA Audio-Visual Paging System
PMS	Pantone Match System
PPMP	Point-to-MultiPoint Protocol
PPP	Point-to-Point Protocol
QAP	Quality Assurance Procedure
RTA	Regional Transportation Authority
SONET	Synchronous Optical Network
SSC	ATSS Station Sign Controller
TCIP	Transit Communications Interface Protocol
TCP/IP	Transmission Control Protocol / Internet Protocol
VAC	Volts Alternating Current
VDC	Volts Direct Current
VMS	Variable Message Sign
UL	Underwriters' Laboratories
WAN	Wide Area Network
XML	Extensible Markup Language
X-Window	UNIX-based Graphical User Interface

1.03 GENERAL REQUIREMENTS

- A. The Contractor shall carefully examine the Contract Documents, visit the site prior to submitting Bid, and become thoroughly familiar with all conditions relating to the Work.
- B. The Contractor shall carefully examine the entire site of the work. The Contractor shall make all investigations necessary to inform themselves thoroughly as to facilities for deliveries, placing and using the necessary equipment and materials, and as to all difficulties involved in completion of all work in accordance with the Specifications and Drawings. Failure to do so shall not relieve the Contractor of contractual obligations nor justify additional compensations.
- C. The existing conduit systems shall NOT be reused for any new wiring systems except as SPECIFICALLY indicated on the Contract

Drawings. All conduits shall be new, except as SPECIFICALLY indicated otherwise on the Contract Drawings.

- D. The Contractor shall furnish, erect, install, connect, clean, adjust, test and, condition all manufactured articles, materials and equipment, and place in service in accordance with the manufacturer's directions and recommendations except as otherwise specified herein.

1.04 CODES AND STANDARDS

- A. All work shall comply with codes, laws and ordinances of Federal, State and local governing bodies having jurisdiction. The construction requirements of State, County, City of Chicago, City of Evanston, or other political subdivision specifications exceeding the requirements of the codes, standards, and approving bodies referenced herein shall be met and complied with.
- B. In case of differences between Building Codes, State and Federal laws, local ordinances, utility companies regulations and the Contract Documents, the most stringent shall govern.
- C. All design, equipment and materials specified by design shall conform to any acts, laws, rules, and regulations of the following organizations:
 - 01. City of Chicago Electrical Code (CEC).
 - 02. Commonwealth Edison, Chicago Approved (CECHA).
 - 03. National Electrical Code (NEC-ANSI/NFPA 70).
 - 04. National Electrical Safety Code (NESC-ANSI C2).
 - 05. National Fire Protection Association (NFPA).
 - 06. Underwriters Laboratories Inc. (UL).
 - 07. Occupational Safety and Health Administration (OSHA).
 - 08. Life Safety Code (NFPA 101).
 - 09. Department of Aviation (DOA).
 - 10. Federal Aviation Administration (FAA).
- D. The electrical installation shall conform to all provisions and requirements of the following organizations and standards:
 - 01. National Electrical Code (NEC-ANSI/NFPA 70).

02. National Fire Protection Association (NFPA) 70 & 130.
 03. National Electrical Safety Code (NESC-ANSI C2).
 04. City of Chicago Electrical Code (CEC).
 05. Occupational Safety and Health Administration (OSHA).
- E. The electronic and telecommunications installation shall conform to all provisions and requirements of the following organizations and standards:
01. ANSI/EIA 310-D-1992: Racks, Panels and Associated Equipment.
 02. ANSI/EIA/TIA 232-E-1991: Interface between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
 03. ANSI/NFPA 130-1993: Fixed Guideway Transit Systems.
 04. EIA-422-A: Electrical Characteristics of Balanced Voltage Digital Circuits.
 05. EIA-485: Standard for Electrical Characteristics of Generators and Receivers for use in Balanced Digital Multipoint Systems.
 06. ANSI/TIA/ EIA 606: Administration Standard for the Telecommunications Infrastructure of Commercial Buildings.
 07. ANSI/TIA/EIA-607: Commercial Building Grounding and Bonding Requirements for Telecommunications.
 08. NTCIP 1101: NTCIP Simple Transportation Management Framework.
 09. NTCIP 1201: NTCIP Global Object (GO) Definitions.
 10. NTCIP 1203: NTCIP Object Definitions for Dynamic Message Signs.
 11. NTCIP 1209: NTCIP Object Definitions for Transportation Sensors.
 12. NTCIP 1400: TCIP Framework Standard.
 13. NTCIP 1401: TCIP Common Public Transportation (CPT) Objects.

14. NTCIP 1402: TCIP Incident Management (IM) Bus. Area Std.
15. NTCIP 1403: TCIP Passenger Information (PI) Bus. Area Std.
16. NTCIP 1404: TCIP Scheduling/Runcutting (SCH) Bus. Area Std.
17. NTCIP 1405: TCIP Spatial Representation (SP) Bus. Area Std.
18. NTCIP 1406: TCIP On-Board (OB) Objects.
19. NTCIP 1407: TCIP Control Center (CC) Objects.
20. NTCIP 2001: NTCIP Class B Profile.
21. NTCIP 2304: NTCIP DATEX-ASN Application Profile.
22. NTCIP 2305: NTCIP CORBA Application Profile.
23. TIA/EIA-568-A: Commercial Building Telecommunications Cabling Standard.

F. UL Labels: All electrical materials and equipment for which there are established Underwriters' Laboratories, Inc. (UL) standards shall bear the UL label.

G. Standards Publications: Standards publications of technical organizations and regulatory agencies are referenced herein, and unless stricter requirements are indicated, materials and equipment so specified shall be manufactured, tested and installed to conform, as a minimum, to the requirements of such reference standards and publications. The following list of organizations (with their identifying initials) involved in electrical standards is not intended to be all-inclusive:

- | | | |
|-----|------|--|
| 01. | AIA | American Insurance Association |
| 02. | ANSI | American National Standards Institute |
| 03. | ASTM | American Society for Testing and Materials |
| 04. | AEIC | Association of Edison Illuminating Companies |
| 05. | CEC | Chicago Electrical Code |
| 06. | IES | Illuminating Engineering Society |
| 07. | IEEE | Institute of Electrical and Electronic Engineers |

- 08. ICEA Insulated Cable Engineers Association Inc.
- 09. ISO International Standards Organization
- 10. NEC National Electric Code
- 11. NEMA National Electrical Manufacturers' Association
- 12. NFPA National Fire Protection Association
- 13. NTCIP National Transportation Communications for ITS Protocol
- 14. OSHA Occupational Safety and Health Administration
- 15. UL Underwriters' Laboratories, Inc.
- 16. EIA Electronic Industry Association
- 17. TCIP Transit Communications Interface Protocol
- 18. TIA Telecommunications Industry Association

- H. Should work be performed which does not comply with the requirements of the applicable building codes, State and Federal laws, local ordinances, industry standards and utility company regulations, changes for compliance shall be made by the Contractor at no additional cost to the Authority.
- I. The Contractor shall prepare and submit to governmental agencies and utility companies any drawings or other documents that may be required by these agencies for their approval.
- J. The Contractor shall notify the Authority of any materials or apparatus believed to be inadequate, unsuitable, or in violation of laws, ordinances, rules or regulations of authorities having jurisdiction.

1.05 PERMITS APPROVALS, AND FEES

- A. The Contractor shall obtain and pay for all electrical permits before commencement of related Work.
- B. The Contractor shall obtain approvals from the Fire Prevention Bureau and Department of Inspection Services, Electrical Inspection Section for electrical installations requiring specific approval. Any required drawings or wiring diagrams shall be provided and submitted for approval by the Contractor. Copies of the final approved drawings shall be delivered to the Authority. Permits and approvals shall be obtained before commencement of related work.

- C. Wherever the work requires the obtaining of permits from the City of Chicago, the City of Evanston, or other public authorities, it shall be the Contractor's responsibility to obtain the necessary permits and licenses and pay the associated fees. No work will be allowed to proceed before such permits are obtained.
- D. The Contractor shall pay fees and other charges incidental to the Work and obtain and pay for required insurance, licenses, inspections, and flagmen. The Contractor shall arrange for required inspections and deliver certificates and approval for same to the Authority as a requirement for final payment.
- E. The Contractor shall pay for CTA Safety Training of any personnel required to work in proximity to moving trains or at track level. The current rate is \$75.00 per day per employee. The Authority shall determine the necessity of such training. Training must be renewed annually.

1.06 QUALITY ASSURANCE

- A. Manufacturers of components installed for the Work shall be regularly engaged in the manufacture of products of the types listed in this Specification. Firms' products shall have been in satisfactory use in similar service for not less than five years.
- B. Installers of components shall have a minimum of five years of successful installation experience on projects involving work similar to that required for this project.
- C. System integrators and software developers shall have a minimum of five years of successful experience with custom development of transportation-related hardware and software systems.

1.07 CONTRACT DRAWINGS

- A. Contract Drawings show arrangements and sizes of principal apparatus and devices to be provided under this Contract and attachments thereto. These shall be followed as closely as actual building construction will permit and the Authority shall be consulted if discrepancies arise.
- B. Layout of equipment, as shown on the drawings, shall be checked and exact locations determined by dimensions of equipment approved by the Authority. Field verify dimensions, sizes of structural members, foundations, etc. Do not make final layouts until Shop Drawings are approved and job conditions verified.

- C. Consult Contract Documents to determine nature and extent of work of other Contractors which connects with work under this Contract, or to which this work connects. Cooperate with installer of such work as necessary to achieve a complete, workmanlike installation for each connection.

1.08 COORDINATION

- A. The Contractor shall coordinate all personnel as necessary to facilitate timely completion, avoid the necessity for rework, and ensure proper operation of all audio/visual public address system equipment.
- B. The Contractor shall furnish any drawings and instructions to appropriate installation or test personnel that are required to accommodate the requirements in this Specification.
- C. The Contractor shall obtain all wiring diagrams and other instructions required for proper electrical connection of equipment installed.

1.09 DOCUMENTATION REQUIREMENTS

- A. Within ten days after Contract award, the Contractor shall submit a Project Management Statement of Work that shall contain, at a minimum, the following:
 - 01. Tasks to be completed by the Contractor
 - 02. Tasks to be completed by the Authority
 - 03. Names and qualifications of Project Managers and Subcontractors
 - 04. A Schedule of system development and implementation activities including installation start and completion dates for major items, acceptance testing start and completion dates, final acceptance, and other milestones that are deemed appropriate.
 - 05. A Test Plan that conforms to the requirements of Subsection 3.05, including Factory Acceptance Test procedures and Local Acceptance Test procedures for each component, and a description of how each test will demonstrate that the equipment and software supplied under the Contract will meet the requirements of the Contract Documents.
 - 06. A Quality Plan describing the Contractor's quality-related policies, practices, procedures, and methods used to assure compliance with the Contract Documents.

- B. For all hardware, the Contractor shall submit Equipment Manufacturers' Product Information to the Authority prior to purchasing and installation. The data shall include but not be limited to Central Control System hardware, Station Sign Controllers, Vehicle Proximity Sensors, Station Consoles, Variable Message Signs, interface components with existing CTA Tower Consoles and PA systems, conduit, wiring, panelboards, cabinets and enclosures, and other components
01. Catalog cuts, including dimensions, physical properties, performance characteristics, ratings and capacities.
 02. Major electrical equipment manufacturer's drawings shall include, but is not limited to, relays, meters, current and potential transformers, disconnect switches, fuses, contactors, and lighting.
 03. The equipment manufacturer's schematic diagrams shall be "JIC" ladder type. Schematics shall identify all devices, wire codes, and terminal numbers.
 04. The equipment manufacturer's wiring diagrams shall show terminal blocks for external wiring. Wiring diagrams shall identify all devices, wire codes, and terminal numbers.
 05. The equipment manufacturer's internal point to point and external wiring diagrams between cubicles, panels and components within the equipment line up shall be provided.
- C. For all software, the Contractor shall submit the following before software coding begins.
01. A Software Design Plan, including a detailed system architecture diagram showing system components and interfaces, a detailed data flow diagram (DFD), data dictionary and metadata definitions, software component data flows and execution control.
 02. An Interface Control Document (ICD), including an interface specification, a data flow diagram, and a data description including data type, data source, data destination, data identification, etc. Each interface shall be described formally in Interface Definition Language (IDL).
- D. Shop Drawings
01. Within 30 days after award of Contract and before any material or equipment is purchased, the Contractor shall submit to the

Authority for approval all Shop Drawings to be incorporated in the work. All shop drawings shall be approved by the Authority before commencement of work. Signage shop drawings shall be approved by the CTA before work begins.

02. Shop Drawings shall show all mechanical parts and assemblies, including electrical components, a complete wiring diagram, and connection details, as well as a complete list of parts with full identification. Drawings shall include, but not be limited to:
 - a. Wires and cables, cable splices, and terminations
 - b. Raceways and fittings
 - c. Electrical components
 - d. Contactors and relays
 - e. Conduit hangers and other equipment support details
 - f. Items specified under Sections 16770, 16771, 16772, 16773, and 16774.
03. Shop Drawings shall include manufacturers' names, catalog numbers, cuts, capacities, diagrams, and other such descriptive data as may be required to identify and approve the equipment.
04. The types of drawings to be provided as part of this Contract shall include the following:
 - a. Drawings showing existing equipment to be interfaced with and/or replaced, and installation of new equipment,
 - b. Drawings showing the arrangement of distribution panels or frames, at station Electrical / Communications Rooms, the CTA Communications and Power Control Center, and terminal station rail operations control towers.
 - c. Drawings showing temporary work required that will not remain as part of the completed work.
 - d. Drawings that indicate cable routing and identify cable make-up. These drawings, when depicting internal cable routings within buildings, shall show building floor plans, identify conduit, duct or raceway locations and shall indicate the required sizes of all such conduit, ductwork and cables.

05. The Contractor shall design wiring diagrams and final circuit drawings for equipment being furnished by the Contractor and for any changes to existing equipment as required by the Contract Documents. The Contractor shall be solely responsible for the correctness of the wiring diagrams and final circuit drawings being designed and for the correctness of any existing drawings being reused as part of a complete working system.
06. The Contractor shall check drawings and final tracings for both form and content prior to submittal. Points to be checked shall include:
 - a. Conformance to the specifications.
 - b. Logical grouping and arrangement of subject matter.
 - c. Accuracy.
 - d. Legibility.
 - e. Neatness.
 - f. Line quality.
 - g. Lettering quality
 - h. Reproduction quality.
 - i. Inclusion of Contract-specified interfaces with related Work.
07. Approval of drawings and tracings will be at the discretion of the Authority's Authorized Representative. The Authority's Authorized Representative will consider the same points listed above.
08. Any listed materials, fixtures, apparatus, or equipment that are not in accordance with the Specification requirements can and will be rejected for use in this installation and construction.
09. Extended time for submitting special shop drawings may be requested; however, any extension of time approved does not relieve this Contractor of his responsibility of executing his work in accordance with the Contract.
10. Additional shop drawing requirements are described in individual sections of the Specifications.

11. The approved Shop Drawings shall be marked up by the Contractor during installation to reflect the final installation. The marked-up Shop Drawings shall be submitted as part of the final acceptance of the installation.
12. Any materials, fixtures, apparatus or equipment installed without stamped or written approval shall be removed by the Contractor and replaced with specified equipment at the direction of the Authority's Authorized Representative and without additional cost to the Authority.
13. Substitutions to listed acceptable manufacturers equipment and material will not be accepted until the Contractor has complied with the requirements of the Contract Documents.
14. The effective date and identification number, to be inscribed on the final tracings, will be furnished by the Authority prior to the time the tracings reach the as-built stage and are ready for final processing by the Contractor. This will only occur after Final Acceptance of the project by the Authority.

E. Installation Drawings

01. In addition to the preparation and submittal of Shop Drawings for manufactured electrical equipment and materials, the Contractor shall prepare and maintain in current status, a complete set of detailed, completely circuited, and dimensioned electrical construction drawings for all electrical work included under this Contract.
02. The Installation Drawings shall be made under the direction and supervision of the Contractor and shall show all electrical work including, but not limited to, conduit, wiring, electrical equipment and devices, signs, controllers, points where conduit enters or leaves structural slabs and walls, junction boxes, conduit supports and inserts.
 - a. The Contractor shall provide a single line diagram describing the power distribution system. This diagram shall include all circuiting and locations of all electrical equipment. This diagram shall include ratings for all equipment and cable sizes from the distribution panels to the Station Sign Controllers, Vehicle Proximity Sensors, Station Consoles, and Variable Message Signs. Symbol representation for home run circuits will not be acceptable.

- b. The Installation Drawings shall include floor plans and reflected ceiling plans with electrical layouts drawn at a scale (or scales) as required with a minimum scale of 1/8 inch equals one foot (1:96). It is intended that Installation Drawings of each trade be the same scale(s) in order to permit respective plans to be superimposed upon all others of each trade.
 - c. In addition to the floor plans, the layouts of all congested areas such as mechanical and/or electrical equipment rooms, and all functionally critical areas shall be drawn at a minimum scale of 1/4 inch equals 1 foot (1:48), and with all details of construction shown. The Authority may request additional Installation Drawings if in its opinion they are required to properly coordinate the project.
 - d. The minimum drafting letter size shall be 1/8 inch in height and shall be block type lettering.
03. All Installation Drawings shall be made at the Contractor's expense on 3 mil Mylar sheets of the same size and with the same border lines and title blocks as the Chicago Transit Authority drawings, with the Contractor's name added, as applicable.
04. The initial version of all Installation Drawings shall be submitted to the Authority for review. These submittals shall be considered as Shop Drawings and shall be subject to the Shop Drawing approval process. No work shall begin until these Installation Drawings are accepted by the Authority.
05. Upon final approval by the Authority, the initial Installation Drawings, and all revised Installation Drawings thereafter, shall be dated and certified by the Contractor as having been fully coordinated by him. It shall then be understood that the work shown thereupon is ready for construction.
06. All Installation Drawings shall be prepared by the Contractor in accordance with an approved schedule, and arranged to coincide with actual construction in such a manner as to allow the latter work to proceed without delay.
07. The Contractor shall be responsible for the coordination of power and communications electrical work with the work of all other trades and shall, in preparing the Installation Drawings, continually check the work of all other trades (inclusive of that indicated by Shop Drawings) in order to avoid possible

installation conflicts arising therefrom. It shall be understood that the work shown on the Installation Drawings has been so coordinated. In the event of conflicts or interferences that cannot be resolved in the field, the Contractor shall request a written clarification from the Authority.

08. The Contractor shall make provisions to ensure uninterrupted power and communications to all station and terminal operations. Additionally, work shall be staged so as not to interfere with passenger flow. Work is prohibited during rush periods and on certain “special events” days specified by the Authority.
09. The Installation Drawings shall indicate the entire installation exactly as constructed and therefore shall be periodically revised to reflect all changes inclusive of those required by the Authority, those which are or have been found necessary in the field, those which may be suggested by the Contractor and approved by the Authority, etc.
 - a. Conduits shall be shown on the Installation Drawings as installed.
 - b. Revisions shall be performed when considered necessary by the Authority’s Authorized Representative or the Contractor in order to facilitate proper coordination.
10. Subsequent revised copies shall be issued to the Authority as requested. It shall be clearly understood that these installation drawings are for installation coordination purposes only and cannot in any way alter the requirements of the Contract. Therefore, the Contract Documents, and authorized revisions thereto, shall remain the only determinants of the Contract requirements.
11. If, in the opinion of the Authority’s Authorized Representative, the Installation Drawings are in acceptable condition after each has been finally revised and accepted, the Contractor may submit same as the Field Record (“As-Built”) Drawings called for elsewhere in the Specifications.

F. Field Record Drawings

01. Provide “As Built” drawings on the entire installation to support maintenance operations and engineering records of the Authority. If approved by the Authority, the revised Shop Drawings and Installation Drawings described in Subsection

1.09, paragraphs D 12 and E 10, may serve as Field Record Drawings.

G. Test Documentation

01. The Contractor shall provide procedures and test results to the Authority for Factory Acceptance Testing, Installation Testing Local Acceptance Testing, and Performance Testing according to the requirements of Subsection 3.05.

H. Instruction Books, Operations and Maintenance Manuals

01. The Contractor shall provide as part of the project binder set described in Subsection 3.06 all instruction books, operations and maintenance manuals, and other literature provided by the manufacturer of each component.
02. The Contractor shall provide Operations and Maintenance Manuals for the Central Control System, Station Sign Controllers, Vehicle Proximity Sensors, Station Consoles, and Variable Message Signs according to the requirements of Subsection 3.07.
03. The Contractor shall also provide User Manuals for Control Center Console software, Station Sign Controller firmware, and Station Consoles according to the requirements of Subsection 3.07.

1.10 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Equipment and materials shall be delivered to the site and stored in original unopened, protective packaging, suitably sheltered from the elements and mechanical injury, but readily accessible for inspection until installed.
 01. Items shall be stored in dry spaces.
 02. Manufacturer's directions shall be followed in the delivery, storage, protection, installation and operation of all equipment and materials.
- B. The Contractor shall coordinate with the Authority the movement of heavy machinery, equipment, or components thereof brought into or onto the structure.
- C. The Contractor shall protect all fixtures, material, equipment and apparatus as required to shield them against dirt, water, chemical or mechanical damage before, during and after installation. The

Contractor shall handle all material in a manner to prevent damage to finished surfaces. Stored material shall not be accessible to CTA customers.

- D. Where possible, the Contractor shall maintain protective coverings until installation is complete and remove such covers as part of final clean-up.
- E. The Contractor shall touch-up any damage to finishes to match adjacent surfaces or replace damaged equipment to the satisfaction of the Authority's Authorized Representative at no additional cost to the Authority.

1.11 EXECUTION, CORRELATION, AND INTENT OF DOCUMENTS

- A. In the event that conflicts, if any, cannot be settled rapidly and amicably between the affected trades, with the Work proceeding in a workmanlike manner, then the Authority's Authorized Representative shall decide which Work is to be adjusted and his judgment shall be final and binding to the Contractor.
- B. No measurements of a Drawing by scale shall be used as a definite dimension to work by.

PART 2 - PRODUCTS

2.01 MATERIALS AND EQUIPMENT

- A. Materials and equipment shall be new and shall bear the manufacturer's name, model number and other identification markings.
- B. Materials and equipment shall be the manufacturer's latest design with published properties. Manufacturers shall meet the experience requirements of Subsection 1.06.
- C. Equipment and materials of the same general type shall be of the same manufacturer throughout the project to provide uniform appearance, operation and maintenance.
- D. Dissimilar Metals
 - 01. Dissimilar metals as defined herein shall be those which are incompatible in the presence of moisture as determined from their position in the electrochemical series or from test data.
 - 02. Where dissimilar metals come in contact, paint the joint both inside and out with approved paint so as to exclude moisture

from the joint, or provide a suitable barrier separating the metals.

2.02 SOFTWARE

- A. Scalability: The ATSS software shall be designed to accommodate, not only the requirements of the demonstration project, but also plans under consideration by the Authority at the time of development for the following initiatives. Additional ATSS hardware associated with these initiatives is not considered part of this Contract. However, the design of control center hardware and software shall support future integration of the functions associated with these initiatives as an additive enhancement without duplication of hardware or software development efforts associated with this Demonstration Project.
01. Integration of audio messaging capabilities with ATSS,
 02. ATSS system expansion to include all CTA passenger facilities,
 03. ATSS system expansion to include all RTA Service Boards (CTA, Metra, and Pace).
 04. CTA vehicle fleet expansion, and
 05. CTA route network expansion.
- B. The ATSS system and software shall operate at the same high level of performance during both peak hours and non-peak hours as defined in Section 16770, Section 16771, and elsewhere in this Specification.
- C. In general, system security will be implemented using standard UNIX user privileges that grant access to files and applications.
- D. Principles of human factors engineering shall be used in the design of graphical user interfaces to simplify and minimize the steps required to monitor and control the system.
- E. The Contractor shall provide the final, delivered version of all software source code, related compilers, and software development tools to the Authority as a condition of acceptance of the system. These items shall be provided on one or more appropriately labeled CD-ROM(s) with the project binder described in Subsection 3.06.

PART 3 - EXECUTION

3.01 INSTALLATION OF WORK

- A. All Work shall be scheduled so as not to interfere with CTA train, station, or terminal operations.
- B. All Firms installing the Work shall meet the experience requirements of Subsection 1.06.
- C. The Contractor shall perform all Work with trained mechanics in a neat and workmanlike manner as approved by the Authority. Only Contractor personnel who have completed CTA Safety Training shall be allowed on the right-of-way. Personnel on the right-of-way shall carry their safety card at all times and produce it on request.
- D. The Contractor shall perform all Work in cooperation with other trades and the schedule prepared for this Work to allow timely and efficient completion of the Project.
- E. The Contractor shall furnish other trades with advance information regarding necessary service disconnections to permit trades affected to perform their work properly and without delay.
- F. Work installed before coordinating with other trades so as to cause interferences with the work of other such trades shall be changed by the Contractor to correct such condition, as directed by the Authority's Authorized Representative, without additional cost to the Authority.
- G. Minor changes in the locations of components and equipment shall be made prior to rough-in at the direction of the Authority's Authorized Representative and at no additional cost to the Authority. "Minor changes" shall be considered as up to 15 (fifteen) feet.
- H. The Contractor shall protect the materials and work of other trades from damage during installation of the Work provided under this Contract.
- I. Cutting or drilling of any structural members will NOT be permitted unless written approval is obtained from the Authority.
- J. When necessary, the CTA will provide flagmen to protect workers at the Contractor's expense. Flagmen will be assigned according to established CTA procedures and manpower availability.

3.02 TEMPORARY POWER

- A. The Contractor may utilize CTA-supplied single-phase power for portable power tools and temporary lighting, only to the extent of the available circuits and their capacity in the project area and subject to approval by the Authority. The Contractor shall check with the CTA to make sure that the power at a given station is reliable. If no suitable source of power is available, the Contractor shall supply such power as required at no additional cost to the Authority.
- B. The Contractor shall inform CTA of its intended use of CTA-supplied power at a specific project location, 48 hours prior to commencing use of such power. The Authority shall inform the Contractor if the use of said power is permissible. If the Authority deems that the use of said power is not permissible, the Contractor shall supply such power as required at no additional cost to the Authority.
- C. Work performed by the Contractor shall not interrupt power to any CTA operations, including the station, the fare collection system, rail signals, etc.

3.03 PROTECTION

- A. The Contractor shall protect conduit openings against the entrance of moisture, water, debris or other foreign matter.
- B. The Contractor shall cover fixtures, materials, equipment and devices furnished or installed under this Specification or otherwise protect against damage, before, during, and after installation.
- C. Fixtures, materials, equipment, or devices damaged prior to final acceptance of the Work shall be restored to their original condition or replaced at the option of the Authority's Authorized Representative at no additional cost to the Authority.

3.04 REMOVAL OF MATERIAL

- A. The Authority will have right of first refusal for removed items, including existing VMS to be removed. If the Authority declines to exercise this right, any remaining material being removed shall become the property of the Contractor and shall be removed from the site and properly disposed of off site by the Contractor.

3.05 TESTING REQUIREMENTS

- A. The Contractor shall conduct tests to insure that all work has been done correctly and completely, and to demonstrate that all systems, subsystems, assemblies, subassemblies, software and components

supplied under this contract are in compliance with the specifications. The Contractor shall give the Authority's Authorized Representative 48 hours advance notice of such tests.

- B. The Contractor shall provide a schedule of all testing activities described within this Section, including submittal of draft test procedures for Authority approval and performance of test activities. This schedule shall be provided 60 days prior to the time of initial Factory Acceptance Testing.
- C. When a device or system does not meet the Specification requirements, the contractor shall be responsible for the cost of additional tests and work required to prove compliance, at no additional cost to the Authority.
- D. After completion of Active Transit Station Signs system installation and before final Acceptance Testing, the Contractor shall thoroughly clean and touch up damaged finishes of all equipment installed under Division 16.
- E. Factory Acceptance Testing: All equipment including the ATSS Central Control System and related materials shall be tested at the manufacturing location using the production inspection and testing procedures in normal use by the Manufacturer. Certification of the successful completion of the factory acceptance tests and compliance with the specifications shall be provided to the Authority.
- F. Installation Testing: The Contractor shall perform the following field test in the presence of the Authority's Authorized Representative to demonstrate the reliability of the electrical installation and the full function of each component.

At least 30 days prior to Installation Testing, written Installation Testing procedures shall be submitted to the Authority for review and approval. The Contractor shall revise the written Installation Testing procedures based upon this review to the satisfaction of the Authority.

- 01. Operate all electrical equipment for a period of 24 hours, unless in the opinion of the Authority's Authorized Representative, a different test period is required, to prove the operation and performance of the equipment.
- 02. Should the foregoing test reveal any defects, promptly correct such defects and rerun the test until the entire installation is satisfactory in all respects. The duration of a rerun test shall be 24 hours each time or such a period as the Authority's Authorized Representative deems appropriate.

- G. Local Acceptance Testing: The Contractor shall test the ATSS system in each station after installation is complete and the Authority's Authorized Representative has approved the inspection certification. The Contractor shall provide certification for each installation showing satisfactory operation and performance to meet specifications to the Authority's Authorized Representative.

At least 30 days prior to Local Acceptance Testing, the Contractor shall submit written Local Acceptance Testing procedures to the Authority for review and approval. The Contractor shall revise the written Local Acceptance Testing procedures based upon this review to the satisfaction of the Authority.

Local Acceptance Testing shall address at minimum:

01. Functional testing of each equipment item installed.
 02. Demonstration of all system control functions available at the Control Center, including time synchronization, station schedule updates, station schedule overrides, schedule adherence monitoring and countdown estimation, creation and distribution of text messages, and health monitoring.
 03. Demonstration of all system control functions available at the station, including text messages initiated from the Station Console and Departure Mode messages initiated from the interface (by Contractor) with the existing CTA Tower Console (by CTA).
 04. Demonstration of countdown messaging on VMS signs, including use of Vehicle Proximity Sensors to force start of Arrival Mode, and recording of countdown error for at least a 24-hour weekday period.
 05. Demonstration of integration of Arrival Mode text messaging with audio messaging at station, including verification that audio message volume is equal to the volume associated with other audio messages typically announced at station.
 06. Exercising the overall ATSS system from the Control Center as well as from local control points to verify all interlocks, panel-lamp indications, console display indications, and priority definitions.
- H. Performance Testing: Following Local Acceptance Testing, a 30-day Performance Testing Period shall commence. All error messages, warnings, and other troubleshooting messages shall be recorded

during this period. The Performance Testing Period will be determined to have expired and Final Acceptance will occur when the ATSS system has operated to the satisfaction of the Authority for a full 30-day period without any malfunction or interruption.

- I. Test Support: The Contractor shall provide test support upon request by the Authority's Authorized Representative to assist in additional testing of the ATSS system or equipment after its Final Acceptance by the Authority. During the Warranty Period, the Authority may conduct additional performance tests to measure the accuracy of the system or collect customer responses to the system. The Contractor shall be responsible for making any adjustments or changes to the configuration of the system based on these tests at the request of the Authority during the Warranty Period defined in Subsection 3.08.

3.06 OPERATIONS AND MAINTENANCE MANUAL

- A. General: The Contractor shall assemble manuals to include definite and specific information and instructions on materials, apparatus, equipment and systems provided under the Contract. The Contractor shall coordinate production of manuals with the actual needs of the Authority's staff.
- B. Contents: The Contractor shall include for each item the following data, as applicable, edited to include only items specific to this Contract or other items requested by the Authority. All data, including notations, shall be completely legible - typewritten or printed.
 01. Manufacturer's original operating instructions, maintenance and repair manuals which set forth the manner of operation, precautions, care to be followed, recommended maintenance and cleaning procedures, methods and materials for maintaining exposed finishes, and periodic preventive maintenance requirements.
 02. Final accepted Shop Drawings, Installation Drawings, and Product Information, including final comments and responses.
 03. Complete and detailed material list and manufacturer's parts list with catalog names, numbers and illustrations.
 04. An exploded view of the Central Control System, each Station Sign Controller, each Station Console, the Vehicle Proximity Sensors, and each Variable Message Sign with part designations.

05. Recommended inventory of spare parts and emergency parts, sources of purchase, and quantities and prices for 5 years of operation.
06. Test Documentation, including manufacturer test certificates, permits and inspection reports, insurance inspections and approvals, and Factory Acceptance Test, Installation Test, Local Acceptance Test, and Performance Test certificates as required by the Contract Documents.
07. Manufacturer's Guarantee or Warranty as normally provided and as specifically required by the Contract Documents.
08. Contact Information including:
 - a. Name, address, and telephone numbers of Contractor, suppliers, and installers.
 - b. Name, address and telephone number of manufacturer's nearest service representatives.
 - c. Name, address and telephone number of nearest parts vendor and service agency.
09. Anticipated date on which the Authority assumes responsibility for maintenance.
10. Operating Procedures, including:
 - a. Pre-operation check or inspection list.
 - b. Procedures for starting, operating, and stopping equipment.
 - c. Post-operation check or shut down list.
 - d. Inspection and adjustment procedures.
 - e. Emergency operating instructions.
 - f. List of special tools and test equipment required for the operation, maintenance, adjustment, testings, and repair of the equipment, instruments, and components.
11. Maintenance Procedures and Schedules, including:
 - a. Recommended maintenance and cleaning procedures,
 - b. Methods and materials for maintaining exposed finishes,

- c. Periodic preventive maintenance requirements
 - d. Scale and corrosion control procedures.
 - 12. Troubleshooting and Repair Instructions, including.
 - a. Dismantling and re-assembly instructions.
 - b. Calibration procedures.
 - c. Vendor and ordering information.
 - 13. Software User Manual according to the requirements of Subsection 3.07.
 - 14. Software source code, related compilers, and software development tools on CD-ROM.
- C. Binding: Assemble each group of documents for materials, apparatus, equipment or systems in binders identified for the items covered. Organize the contents in binders as follows:
 - 01. Group documents for each item in the order listed above for contents.
 - 02. Index group of documents for each item in accordance with the filing system of CSI Masterformat.
 - 03. Fold drawings and other documents larger than 8-1/2" x 11" to properly fit in binders and so that they can be fully unfolded without removal from the binder. Reinforce edges of large drawings.
 - 04. Provide each binder with a table of contents and an index of volumes in each volume of multiple volume systems.
- D. Binders:
 - 01. General: Hard-cover, three-hole, D-ring, loose leaf binders of size using standard 8-1/2" x 11" sheets. Binding is subject to the approval of the Authority.
 - 02. Quantity: Provide at least 20 copies of each set of binders to the Authority.
 - 03. Flysheets: Separate each portion of the manual with colored, neatly prepared flysheets briefly describing contents of the ensuing portion.

04. Cover: Clearly identify the manual on the cover, not on the spine, with at least the following information:

OPERATION AND MAINTENANCE INSTRUCTIONS
Chicago Transit Authority
Active Transit Station Signs
Project Number

05. The Contractor shall also provide the Maintenance Procedures and Schedules section (see Subsection 3.06 B.11) and the Software User Manual section (see Subsection 3.06 B.13) of the Operation and Maintenance Instructions in Adobe Acrobat Portable Document Format (.pdf) on CD-ROM.

3.07 TRAINING OF AUTHORITY'S PERSONNEL:

- A. The Contractor shall conduct Operation and Maintenance courses for RTA and CTA personnel at one or more CTA facilities at time of system installation. The courses shall be designed to provide CTA personnel with the knowledge and technical expertise to operate, perform maintenance, and instruct others in the operation of the ATSS. Training materials shall be submitted to the Authority and approved prior to instruction, and should include the following:
 01. Instructor's Guide
 02. Student Manual
 03. Copies of relevant sections of the Operating and Maintenance Manuals, and software User Manuals
 04. Audio/Visual aids as required
 05. Training Aids
- B. All material shall be delivered in reproducible form, with no copyright restrictions for internal use by the Authority. The Authority retains the right to record sessions for internal use using either audio or video means.
- C. The Contractor shall conduct three types of training courses for CTA personnel. A "day" of training shall consist of 7 hours. The attendance of each session shall be limited to no more than 6 people.
 01. User training for up to 12 CTA Communications and Power Control Center employees. This shall be a lengthy, detailed course including theory of operation, software use, troubleshooting, and safety procedures using software User

Manuals and hands-on training with actual ATSS software lasting approximately 1 day in duration.

02. User training for up to 24 CTA Rail Instructors. This shall be a brief course in the theory and operation of the overall ATSS with specific emphasis on the use of the Station Consoles. The duration shall be approximately 1/2 day in duration.
 03. Technical maintenance training for up to 12 CTA Engineering and Maintenance department personnel. This shall be a lengthy, detailed course including theory of operation, component installation and removal, testing, troubleshooting, repair, vehicle proximity sensor operation and maintenance, and safety procedures using Operations and Maintenance Manuals and hands-on training with actual ATSS equipment lasting approximately 2 days in duration. Training equipment supplied by the Contractor shall allow instructors to demonstrate testing of equipment installed at both the CTA Communications and Power Control Center and at the stations.
- D. Provide three (3) repetitions of each instruction session at various times of the day to allow the Authority's personnel from different shifts to attend at least one session. The Contractor shall schedule training sessions through the Authority at the Authority's and Contractor's mutual convenience.
 - E. The Contractor shall provide all maintenance and operations training prior to any equipment being made operational in the field.
 - F. Training shall be provided by personnel thoroughly familiar with the equipment operation. This may be the Contractor's personnel, equipment manufacturer's representatives, or a combination of the two. Include instructions by the manufacturers' representatives where installers are not expert in the procedures. A complete course outline and summary of the experience and qualifications of the instructional personnel shall be submitted to the Authority for approval prior to the start of training. Training sessions may be combined and/or shortened with the agreement of the CTA and the Contractor.
 - G. Recommended test equipment, literature, drawings, and training manuals for the classes shall be furnished by the Contractor. At the conclusion of classes, all items furnished, which are not currently owned by the CTA, shall become the property of the CTA.

3.08 WARRANTY

- A. Following successful completion of the Performance Test, Final Acceptance shall occur. This represents the Base Date for the Warranty Period.
- B. The Warranty Period shall be 365 days in duration. The purpose of this period is to ensure that all components of the ATSS system function in accordance with the Specifications over an extended length of time, and to provide continuing assistance to the Authority in all phases of system operation as required.
- C. For the Warranty Period, beginning at Final Acceptance, the Contractor shall be responsible for the proper performance of all equipment, and the repair and/or replacement of defective equipment within 24 hours of being notified.
- D. The Contractor shall also be responsible for obtaining technical assistance from the equipment manufacturers and/or suppliers in cases where programming, operational or adjustment difficulties are encountered. The Contractor shall be responsible for providing training to the CTA on any communications equipment if new or unusual problems/repairs are discovered during the Warranty Period. The Contractor shall be responsible for correcting any problems attributable to poor workmanship and/or equipment.
- E. Maintenance requirements beyond those required during the Warranty Period are optional and will be negotiated separately from this Contract.

END OF SECTION 16010

**DIVISION 16
ELECTRICAL**

**SECTION 16100
BASIC MATERIALS AND METHODS**

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. General: The work under this section is subject to the requirements of the Contract Documents.
- B. Furnish and Install: All electrical work, materials and accessories indicated schematically by drawings, schedules and specified herein which include, but is not limited to, the following:
 - 01. Rigid Galvanized Steel Conduit (RGSC)
 - 02. Liquid-tight flexible metal conduit (LTFMC)
 - 03. Supports
 - 04. Bushings
 - 05. Fittings
 - 06. Boxes and Conduit Bodies
 - 07. Wire and Cable
 - 08. Disconnect Switches
 - 09. Wiring Devices
 - 10. Fuses

PART 2 - PRODUCTS

2.01 MATERIALS AND EQUIPMENT

- A. Lump sum cost shall be based on the furnishing of all materials and equipment as specified, which in every case shall be new and, where not specifically referred to by manufacturer's name, of the best grade and quality available.
- B. Equipment and materials shall be without blemish or defect.

- C. Where two or more makes or kinds of materials or equipment are specified, indicate which of these choices will be used. This information shall be included with the list of manufacturers for equipment and materials to be submitted to the Authority as specified elsewhere.

2.02 MANUFACTURERS' NAMEPLATES

- A. Each major electrical component shall have the manufacturer's name and address, catalog number, and rating on a plate or label located inside the cover or in any other inconspicuous but readily accessible place. Distributor's nameplates will not be acceptable.

2.03 EQUIPMENT IDENTIFICATION

- A. Provide approved nameplates on the front of each electrical equipment enclosure and rack.
- B. Unless otherwise indicated, fabricate nameplates from an approved type plastic with letters engraved on the plate in white on black background. Where letter sizes are not specified, use one inch (1") high letters for panelboards and one—quarter inch (1/4") high elsewhere. Nomenclature shall be according to a schedule submitted by the Contractor and approved by the Authority.
- C. Secure nameplates on equipment or racks with brass screws.

2.04 RIGID HEAVYWALL GALVANIZED STEEL CONDUIT (RGSC)

- A. Rigid heavywall galvanized steel conduit and fittings shall be hot-dipped galvanized, standard weight, rigid mild steel with threaded connections as manufactured by Allied, Steelduct or Wheatland. Fittings shall be Appleton, Thomas & Betts or O.Z. Gedney.
 - 01. RGS conduit and couplings shall be threaded, rigid steel, hot-dipped galvanized after fabrication and shall be in accordance with UL6.
 - 02. Split couplings, set screw or compression couplings and connectors are NOT acceptable.
 - 03. The minimum size conduit shall be 3/4 inch, unless otherwise indicated.

2.05 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LTFMC)

- A. Liquidtight flexible conduit shall be moistureproof and oilproof, flexible metal conduit with PVC outer jacket as manufactured by Anamet. Inc.,

Alflex or Electri-Flex Company. Provide a separate ground conductor in each length.

- B. Liquidtight flexible conduit shall be installed in such a manner that liquids tend to run off the surfaces and not drain toward the fittings.
- C. All runs of flexible conduit shall be as short as practicable, of the same size as the conduit it extends and with enough slack to reduce the effects of expansion and vibration to a minimum.
- D. Liquid-tight flexible conduit shall be U.L. or C.S.A. listed, suitable for use in a -20°F atmosphere.
- E. LTFMC shall be minimum 3/4 inch.
- F. Connectors shall be malleable iron or steel with insulated throat, squeeze-type, with annular gripping rib. Particular attention shall be given to maintaining ground bond and firm support through flexible connections. Liquid-tight connections shall have insulated throats.

2.06 BUSHINGS

- A. Bushings for rigid conduit shall be malleable iron body rated 105°C and with 150°C insulation ring. Insulator material shall be molded in place and shall be non-removable.
- B. Acceptable manufacturers shall be Appleton Catalog Series BU75I, O.Z. Gedney Catalog Series IBC-125.
- C. Grounding bushings for RGSC shall be Appleton Series GIB-75L or O.Z. Gedney Series HBLG0722. Bushings shall be hot-dipped galvanized or triple coated with an insulating ring molded into the bushing with a 150°C rating. Insulating ring shall be non-removable.
- D. All bushings shall be of the threaded type. Set screw or compression type bushings are NOT acceptable.

2.07 CONDUIT SEALS

- A. Conduit seals shall be Crouse-Hinds Type EYS or EZS, Appleton ESUF or ESUM, or O.Z. Gedney, and filled with compound after first damming with proper fiber per the manufacturer's instructions. The fiber and compound shall be from the same manufacturer as the fitting.
- B. Fittings and sealing compound shall be designed for application in locations indicated on the Drawings. Fittings shall be of the malleable type.

- C. Combination seal and drain fittings may be used in lieu of two separate fittings.

2.08 PULL AND JUNCTION BOXES

- A. Pull and junction boxes in non-hazardous environments, on the exterior of the structure, in interior wet areas, and in environments where chemicals are stored or mixed with liquids shall be NEMA Type 4X, 10 gauge minimum, type 316 stainless steel with type 316 stainless steel hinge and cover, and stainless steel fasteners and hardware.
- B. Pull and junction boxes in non-hazardous and dry environment shall be NEMA Type 12 gasketed, 12-gauge, seam welded, galvanized, with a rust inhibitive primer, screwed type or hinged covers as required by job conditions. All screws and hinges shall be stainless steel.
- C. Covers for non-hazardous boxes shall be secured with round or flat head machine screws. Where required, screws shall be of the tamper-proof type.
- D. Where required by building construction, special junction or pull boxes shall be provided in sizes and shapes determined from field measurements as required to make a neat and workmanlike installation. Special size and/or shaped boxes shall be sized in accordance with the Chicago Electrical Code.
- E. Where required, boxes with metal barriers or separators for grouping of dissimilar conductors for voltage and insulation or system separation shall be provided in compliance with the City of Chicago Electrical Code.
- F. Where required by the drawings or job site conditions special finishes shall be provided. These may be hot-dipped galvanized, PVC coated, etc. The Contractor shall take extreme precaution when working these areas to insure that proper finishes are provided.
- G. Acceptable manufacturers shall be Appleton Electric, Crouse-Hinds, Hoffman, Keystone, Circle A.W., Raco, Steel City, Chicago Switchboard, or IEC.

2.09 OUTLET BOXES

- A. Outlet boxes shall be cast, of sizes and types to accommodate structural conditions, size and number of conductors contained, and the device or fixture for which required. Outlet boxes and accessories shall be Appleton, Crouse-Hinds, or O.Z. Gedney.

- B. Outlet boxes and covers for use with PVC-coated rigid conduit shall be PVC-coated threaded hub type boxes with gaskets.
- C. All outlet boxes shall have adequate supports.
- D. Furnish and install extension rings on outlet boxes where required to comply with Code requirements for maximum wire fill, or where necessary to intercept existing wiring.
- E. Provide proper covers with gaskets on boxes.
- F. The Contractor shall orient outlet boxes for duplex receptacles for horizontal mounting of devices.
- G. An outlet box shall be provided at each location where one is required.
- H. There shall be no more openings made in any box than are required for the conduits entering same. Depths of boxes shall be as to allow for easy wire pulling and proper installation of wiring devices in accordance with Code requirements.

2.10 EXPANSION JOINTS

- A. Each building expansion joint and each straight uninterrupted run of surface mounted conduit, and vertical risers in excess of 100 feet shall be provided with appropriate expansion fitting. The distance between fittings as installed shall not exceed 200 linear feet.
- B. The Contractor shall furnish and install expansion couplings and bonding jumpers for metallic conduit system where conduits cross buildings, expansion joints, or where conduits transfer between structurally independent pipes, poles, or supports.
- C. The Contractor shall provide expansion fittings with 8-inch movement and with bonding jumpers in all conduits crossing building and structure expansion joints.
- D. Expansion fittings shall be Appleton XJ with XJB jumpers, Crouse-Hinds, or O.Z. Gedney.

2.11 WIRE AND CABLE - 600 VOLT

- A. Wire and cable shall be soft copper, properly refined and shall have minimum conductivity to 98 percent. Aluminum conductors are NOT acceptable.
 - 01. Conductors for power and lighting shall have 600-volt insulation, shall be not less than No. 10 AWG, shall conform to the latest

Chicago Electrical Code and shall bear Underwriters Laboratories Inc. label.

02. Wire for signal and control systems shall be minimum No. 14 AWG, unless otherwise indicated on the Drawings or elsewhere in these Specifications.
 03. Factory wired equipment of a manufacturer's standard product line, shall be wired with the manufacturer's standard wire size and type provided that the wiring meets all applicable Code requirements. This does not apply to custom-built equipment as defined elsewhere in these Specifications.
- B. Wire and cable shall be delivered to the job site in original packing or on factory reels. All wire and cable shall bear tagging or marking on the finish at regular intervals, consisting of manufacturers' name or code number, as well as the insulation type, voltage rating and UL listing.
- C. Wire and cable shall have factory color-coded insulation and shall be as follows:
01. Color coding for voltage system of 250 volts and less shall be:
 - a. "A" Phase - Black
 - b. "B" Phase - Red
 - c. "C" Phase - Blue
 - d. Neutral - White
 - e. Ground - Green
 02. Green shall be used for grounding only.
 03. Other colors shall be used for identification when more than one conductor of the same phase is installed in the same raceway system.
 04. For wire and cable sizes No. 6 and larger where colors other than black are not available, provide Scotch brand 33+ or equivalent by Plymouth or Permacel color-coded vinyl tape wrapped around the cable at each junction box, splice box, termination and splice for a minimum overlapping length of 4 inches at each end. Color of tape shall comply with color coding specified above.

- D. The insulation shall be applied tightly to the conductor and shall be free stripping.
- E. Wire No. 10 AWG and larger shall be stranded copper.
- F. Wire and cables shall be 600-volt, 90°C rated, with type XHHW-2 insulation.
- G. If any of the cable types are modified by the Drawings, the Drawings shall be followed.
- H. The 600-volt insulated wires and cables shall be factory tested prior to shipment in accordance with the latest ICEA standards for the insulation specified.
- I. Samples and reports on the results of shop tests for all wire and cables, and descriptive literature for splices and terminations shall be submitted.
- J. Acceptable cable manufacturers for 600-volt rated cable shall be American Insulated Wire Corp., Rome, Southwire, General Cable, or Triangle.

2.12 CONNECTORS

- A. Copper compression connectors shall be crimp type. All connectors shall be copper. Copper compression connectors shall be long barrel, tin plated, closed end compression type. The barrel for each cable lug shall be size for the exact cable size specified. Copper-Aluminum connectors are not acceptable.
- B. Mechanical or set screw types are not acceptable. The cables shall be terminated with die type compression tools.
- C. Acceptable connector manufacturers shall be Burndy Type YA, Anderson Type VHCL, Thomas & Betts Co. Series 54800 and 54900, or Panduit Series LCB.

2.13 TAPE

- A. Splices shall be made with UL approved, black, self-fusing jacketing tape, resistant to weather, oils, water and chemicals. Tape shall meet or exceed Scotch 33+.
- B. Acceptable manufacturers shall be Amazon, Permacel, or 3M.

2.14 WIRE-PULLING LUBRICANT

- A. Where necessary to use a lubricant for pulling wires, the compound shall be listed by Underwriters Laboratories Inc. Cable pulling lubricant shall be biodegradable, non-flammable, non-toxic compound with a solid residue of not more than 1.5 percent and a viscosity of at least 50,000 C.P.S.
- B. Cleaning agents or lubricants that have a deleterious effect on conductors covering shall not be used. Cable lubricant shall contain no waxes, greases, silicones, or polyalkylene glycol oils.
- C. Lubricant shall be rated to match temperature conditions at the time of installation.
- D. Acceptable manufacturers are Polywater J. High Performance Cable Lubricant, or Ideal Aqua-Jel 2.

2.15 FIRE STOPPING

- A. All conduits which penetrate fire-rated or time-rated slabs or walls shall be sealed to comply with ASTM E814 and UL 1479 requirements, and Chicago Building Code requirements.

2.16 CAULKING

- A. Caulk with a caulking sealant where indicated on the Drawings or as called for in these Specifications.
- B. Caulking sealant shall be silicone construction sealant as manufactured by General Electric or equal or two-part polysulfide conforming to the requirements of the Thiokol Chemical Corp.
- C. Caulking sealant shall contain no acid or ingredients which will stain stone, corrode metal, or have injurious effect on painting. It shall be colored as required to match adjacent surroundings.
- D. Caulking shall be performed by tradespeople skilled at such work.

2.17 PAINTING

- A. Touch-up any shop primed or factory finish marred in shipping or installation with matching paint in a neat and workmanlike manner.
- B. Repair to the satisfaction of the Authority's Authorized Representative, any finish marred or damaged by the installation of the Work.

2.18 DISCONNECT SWITCHES

- A. Disconnect switches shall be rated at 600 volts for 480 VAC, and 250 VAC for 208 VAC and 120 VAC circuits.
- B. All disconnect switches shall be quick-make, quick-break with visible blades and dual horsepower ratings. Switch handles shall physically indicate "ON" and "OFF" positions. Switches shall be lockable only in the "OFF" position and accept three padlocks. Switch covers and handles shall be interlocked to prevent opening in the "ON" position. A means shall be provided to permit authorized personnel to release the interlock for inspection purposes.
- C. Each disconnect switch shall be heavy duty, fused or non-fused as required. NEMA classification shall be of the type required for the area in which they are to be installed.
- D. Acceptable disconnect switch manufacturers shall be Siemens/ITE, Cutler-Hammer/Westinghouse, General Electric, or Square D.

2.19 FUSES

- A. Furnish and install all fuses including fuses for equipment furnished by other trades.
- B. Fuses shall not be installed in the equipment until the installation is complete, tested and ready to be energized. Paralleling of fuses will not be permitted.
- C. All fuses shall be of the same manufacture to insure retention of selective coordination as designed.
- D. Spare fuses shall be furnished in the ratio of 10% of each rating and type installed, but not less than three of each type and rating for each fused disconnect switch and panelboard. Spare fuses shall be turned over to the Authority upon completion of the Work.
- E. All fuses shall be sized as indicated on the Drawings. Where fuse ratings are not indicated for fuses used to provide short circuit protection, such fuses shall be sized in accordance with the heavy service recommendations of the fuse manufacturer.

- F. All low voltage fuses are sized based on Bussman's System 300 Level of Protection, to provide selective coordination and "no damage" protection of equipment. Fuses shall be as manufactured by Bussman Manufacturing Company, and shall be of the following types:
 - 01. 601 amperes and larger shall be KRP-C Low Peak, unless otherwise indicated on the Drawings.
 - 02. 600 amperes and smaller shall be Low Peak Class RK-1, unless otherwise indicated on the Drawings.
- G. The Contractor shall affix to the inside of the door of each fuse enclosure a label or sticker indicating the proper type and rating of fuse. The fuse manufacturer's labels shall be used where such are furnished with fuses.

2.20 FASTENERS

- A. Provide inserts, expansion shield lugs, anchors, bolts with nuts and washers, shims or any other type of fastening devices required to fasten panels, racks, or other equipment to foundations, floors, walls or ceilings. Unless otherwise specified herein or shown on the Contract Drawings, all fasteners shall be stainless steel and of sizes and types recommended by the equipment manufacturer and as approved by the Authority.
 - 01. Steel Fasteners: Fastening of equipment, devices or supports to structural steel shall be by welded studs, or drilled and tapped holes less than 5/16" inch in size. No holes shall be allowed greater than five-sixteenths inch (5/16") diameter in structural steel members. No cutting or drilling of structural members will be allowed without the written consent of the Authority.
 - 02. Bolts and Accessories: Bolts, screws, rods, nuts, lockwashers, threaded washers, flat washers, and similar hardware shall be furnished and installed by the Contractor. Unless otherwise stated on the Contractor's Drawings, all hardware provided shall be stainless steel.

2.21 SUPPORTS

- A. Unless otherwise specified in other Sections of Division 16 of these Specifications, or indicated on the Drawings, provide mounting supports, fasteners, stainless steel hardware and related components required to securely attach all electrical items to the structure, including but not limited to boxes, conduits and signs. All supports and components used with galvanized steel conduits shall be hot dipped galvanized steel.

- B. Subject to compliance with Code requirements and these Specifications, main support equipment shall be as fabricated by one of the following manufacturers, as applicable:
 - 01. Unistrut
 - 02. Power Strut
 - 03. B-Line
 - 04. Elcen
 - 05. Appleton
 - 06. Ackerman/Johnson
 - 07. Erico/Caddy
- C. Shop- or field-fabricated supports or manufactured supports shall be assembled from hot-dipped galvanized steel U-channel components after all manufacturing operations are completed.
- D. Steel brackets shall be fabricated of hot-dipped galvanized steel angles, channels and other standard structural shapes. Connect with welds and stainless steel machine bolts to form rigid supports.
- E. U-channel systems shall be 12 gauge hot-dipped galvanized steel channels, PVC-coated where used with PVC-coated conduits, with 9/16inch-diameter holes, at a minimum of six (6) inches on center, in top surface. Field-cut ends shall be suitably coated with matching material to maintain the integrity of the coating. Provide fittings and accessories that mate and match with U-channel and are of the same manufacture and with the same coating.
- F. Fastener types, materials and construction features shall be as follows:
 - 01. Powder-activated driven threaded studs will NOT be permitted.
 - 02. Hardware shall be stainless steel.
- G. Where conduits are supported with one-hole straps, spacers shall be used to provide 1/4 inch minimum clearance between the conduits and supporting surfaces. All hangers, racks and straps shall be galvanized steel.
- H. Perforated strap hangers are NOT acceptable. The use of tie wire is NOT acceptable.

- I. Hanger rods for trapeze-type hangers shall be made from high tensile strength 316 stainless steel not less than 3/8 inch diameter. The rods shall have free-running, burr-free Unified National Coarse threads.
- J. Conduit supports for trapeze hangers shall be made from U-shaped steel components which are galvanized. Minimum material thickness shall be 12 gauge. Supports shall be hot dipped galvanized for interior use. For areas exposed to the elements, PVC coated components shall be provided. The use of painted components is prohibited. The miscellaneous components which are required to complete the support materials, except the threaded rod, shall have the same finish as the U-shaped channel. Conduit supports shall be as manufactured by Unistrut Corp., Kindorf, Powerstrut, or B-line.
- K. When conditions exceed the structural capabilities of U-shaped strut the Contractor shall submit for review detailed drawings indicating the proposed method of support. The submittal shall contain complete details of fabrication, calculations, materials and finishes.
- L. All field cut ends shall be treated in a manner which will insure the integrity of the support system. The repair shall be done with materials which are compatible with the factory finish. In no case shall spray on galvanizing be acceptable for PVC or other special finishes.

2.22 SPLICES

- A. No splicing will be permitted except in junction boxes. The tools used shall provide a UL certified connection. Indenter type compression fittings will not be acceptable. Lugs shall be one or two-hole and color keyed. Lug bolting shall include a flat washer, a Belleville washer and a locknut.
- B. Outdoor splices shall be made using heat shrink products which, when properly installed, will produce a completely sealed covering over the connectors or lugs. The tube or jacket shall be completely coated with mastic to insure a 100 percent seal to the conductor jacket. The splice, when completed, shall be watertight. An acceptable manufacturer of this type product is Raychem Inc.
- C. All splices and pigtail connections in boxes and receptacles wiring No. 8 AWG and smaller shall be made up with the pre-insulated spring connectors. Splices and terminations in wire/cable larger than No. 8 AWG shall be made with compression type connectors and lugs. Acceptable products are Buchanan, Ideal Wingnut or Scotch Lock 2.
- D. All splices shall be taped over.

PART 3 - EXECUTION

3.01 CUTTING AND PATCHING:

- A. All cutting and patching shall be done by the Contractor, entirely at the Contractor's own expense, in order that the Contractor's work may be properly installed. All disturbed construction, or finish, shall be repaired or replaced by the Contractor using skilled craftsmen of the trade required. Such work requires approval of the Authority's Authorized Representative. Any such work shall be scheduled so as to have no impact on station or train operations or passenger flow.
- B. Under no conditions shall structural work be cut except upon written approval of the Authority's Authorized Representative. In general, cutting through ceilings, floors, walls and partitions shall be avoided, and only where absolutely necessary will it be permitted with the written pre-approval of the Authority's Authorized Representative. When necessary and after written approval is obtained, the work shall be done by the Contractor in a careful manner, and the openings filled about pipes as directed by the Authority's Authorized Representative, using skilled craftsmen of the appropriate trade.
- C. The Contractor is cautioned to do no cutting or disturbing of any finished walls, partitions, ceilings, etc. or similar work unless absolutely necessary and with written pre-approval of the Authority's Authorized Representative.

3.02 INSTALLATION - GENERAL

- A. Interferences:
 - 01. Locations of conduits, fixtures and equipment shall be adjusted and supported to accommodate the Work in accordance with field conditions encountered, anticipating potential interferences.
 - 02. The Contractor shall determine the exact route and location of each conduit prior to fabrication in order to avoid interferences.
- B. Accessibility:
 - 01. The Work shall be installed to permit removal (without damage to or removal of other parts) of parts requiring periodic replacement or maintenance.
 - 02. Conduits and equipment shall be arranged to permit ready access to components and to clear the openings of doors.

3.03 CONDUIT INSTALLATION

A. General:

01. All conduits shall be new rigid heavywall galvanized steel as indicated hereinafter. The re-use of any existing conduits will NOT BE PERMITTED except where SPECIFICALLY indicated on Contract Drawings.
02. Double locknuts shall be used at terminations of conduit in knock-out openings for connections to NEMA 1 enclosures.
03. Conduit connections to enclosures other than NEMA 1 shall terminate in a threaded hub with an insulated throat to provide a positive seal, an electrical ground, and a water tight connection. Each hub shall be manufactured by Meyers or O.Z. Gedney, Type CH-T.
04. All conduits shall be installed as required. The conduit system shall be installed complete with all accessories, fittings, boxes and supports in an approved and workmanlike manner to provide proper raceways for electrical conductors.
05. All conduit runs shown on the Contract Drawings are shown diagrammatically for the purpose of outlining the general method of routing the conduits to avoid interferences.
06. Conduit systems shall be run exposed as shown.
07. Exposed conduit runs shall be installed as inconspicuously as possible. Conduit runs shall be true, plumb, parallel with or at right angles to adjacent building members, and must present an orderly, neat and workmanlike appearance.
08. Exposed conduit runs shall be painted to match the existing structure. The paint shall be exterior latex semigloss, Sherwin-Williams Metallux or equal.
09. Field bends shall be carefully made to prevent conduit damage or reduction in internal areas. All bends shall be made with equipment specifically made for the purpose of bending conduit. The bending radius shall not be less than six times the nominal diameters of the conduit, with carefully matched bends on parallel runs to present a neat appearance. The number of crossovers shall be kept to a minimum. Where larger radii are required to meet utility company requirements, etc., they shall be provided. Hickey bends are not acceptable.

10. Conduits which are crushed or deformed in any way shall not be installed.
11. All conduits cut on the job shall be carefully reamed inside and out to remove burrs. All field cut ends of conduits shall be cut square and shall be done with the proper tools. The use of tubing or pipe cutters is strictly prohibited. Conduits not properly cut shall be replaced at no cost to the Authority.
12. All threads shall be tapered. No running threads will be permitted. Threads on steel conduit shall be given a coat of zinc duct in oil, or other approved compound. All joints shall be properly tightened and shall be watertight and insure a low resistance ground path in the conduit system.
13. All conduits shall be carefully cleaned before and after installation and all inside surfaces shall be free of imperfections likely to injure the cable. After installation of complete runs, all conduit shall be snaked with an approved tube cleaner equipped with an approved cylindrical mandrel of a diameter not less than 85 percent of the nominal diameter of the conduit. Any conduits through which the mandrel will not pass shall be removed and replaced. After snaking, the ends of the conduits shall be protected with standard products acceptable to the Authority to prevent the entrance of water and other foreign matter. The use of such items as plastic bags, tape, paper, rags, etc. shall not be used under any circumstances.
14. Lines of nylon, polyolefin or polypropelene, propelled by carbon dioxide, vacuum or compressed air, shall be used to snake or pull wire and cable into conduits. Flat steel tapes or "sparks" type tapes can only be used in conduit runs of 50 feet or less. They shall not be used in PVC or PVC coated conduits. Metal cables are expressly forbidden for pulling wire/cable.
15. Where conduits are connected to boxes or equipment enclosures, drilled holes or full size knockout openings shall provide electrical continuity for grounding and shall be assured by the use of bonding type locknuts. Where connections are at slightly eccentric openings, jumper type grounding bushings and wire jumpers shall be installed. Should the openings become excessively eccentric, as determined by the Authority's Authorized Representative, the box or equipment shall be replaced at no cost to the Authority.

16. Conduit systems shall be installed, with fittings, couplings, connectors, double locknuts, bushings, etc., made up tight to insure ground continuity throughout the system.
 17. All conduit fittings shall be threaded type. Set screw or other type fittings will NOT be acceptable.
 18. All wiring systems shall be "pullable". The use of "BX" or angle fittings for scaltite, except as whip, is prohibited.
 19. Ends of conduit shall be equipped with insulated metallic bushings. Ends of conduits shall be temporarily capped prior to installation and during construction to exclude foreign material. Conduits shall be closed using a threaded cap.
 20. Conduit risers shall be rigidly supported from the structure using appropriate supports.
 21. Screws for exposed work shall be stainless steel.
 22. Rigid heavywall galvanized steel conduit which is not PVC-coated may be used in all other locations.
 23. Rigid heavywall aluminum conduit will NOT be permitted.
 24. Intermediate metal conduit (IMC) will NOT be permitted.
 25. Electrical metallic tubing (EMT) will NOT be permitted.
 26. Flexible metal conduit which is not liquid tight will NOT be permitted.
 27. Conduits will not be permitted to run horizontally across the recess of "waffle" construction from joist to joist. Where conditions require conduits to extend from joist to joist, the use of conduit bodies (Appleton or equal type LB, LL, LR or LRL, as applicable) will be required to route the conduits up the face of one joist to the top of the recess, across the slab to the next joist and down the face of that joist. Provide unions where necessary to thread conduits into fittings.
- B. As far as practicable, conduit shall be pitched slightly to drain to the outlet boxes, or otherwise installed to avoid trapping of condensate. Where necessary to secure drainage, a breather-drain fitting shall be installed in the boxes or trapped conduit at low points. Each breather drain fitting shall be manufactured by Crouse-Hinds Co., Appleton Electric Co., or O.Z. Gedney. Conduit shall not run through columns or

beams unless so specifically detailed, submitted to and approved by the Authority.

- C. Each building expansion joint and each straight uninterrupted run of surface mounted conduit, and vertical risers in excess of 100 feet shall be provided with appropriate expansion fitting. The distance between fittings as installed shall not exceed 200 linear feet.
- D. The Contractor shall furnish and install expansion couplings and bonding jumpers for metallic conduit systems where conduits cross building expansion joints, or where conduits transfer between structurally independent pipes, poles or supports.
- E. Conduits crossing building-expansion joints shall be provided with expansion fittings and flexible grounding bonds bypassing the fittings to ensure ground continuity.
- F. Conduits installed in locations requiring a flexible connection for adjustment or vibration isolation, such as for transformers, shall be provided with an 18-inch minimum length of LTFMC.
- G. Flexible conduit installed in all areas shall be liquid-tight type (LTFMC).
- H. The number of 90 degree bends shall be limited to four or a total of 360 degrees including all off sets, sweeps, kicks, etc. This shall be between any pull points. The maximum run without pull boxes shall be 300 feet.
- I. The Contractor shall be aware that the conduits are sized for cables installed in exposed rigid steel conduits, as indicated on the Contract Drawings.
- J. Conduits entering unit substations, etc. shall be fitted with jumper-type insulated grounding bushings, bonded together and to the structure of the enclosure by a continuous bonding wire.
- K. There shall be no more openings made in any box than are required for the conduits entering same. Depths of boxes shall be as to allow for easy wire pulling and proper installation of wiring devices.
- L. All boxes shall be supported independent of the conduit system. The boxes shall be supported from the building structure.

3.04 CONDUIT CONNECTIONS TO EQUIPMENT

- A. The conduit system shall terminate at the terminal box or at the conduit connection points of electric devices and equipment. Terminations of

conduit at such locations shall permit direct wire connections to the electrical devices or other equipment.

- B. Conduit connections shall be made with rigid conduit if the equipment is fixed and not subject to adjustment, mechanical movement or vibration. A union type fitting shall be provided when RGSC or PVC-coated RGSC is terminated at each enclosure or piece of equipment which contains a threaded termination for the conduit. This may be a threaded hub or through a fitting such as Meyers type hub. Conduit terminations using double locknuts do not require union type fittings.

3.05 PULL BOX INSTALLATION

- A. Pull boxes shall be installed where shown and where necessary to insure that the installed cable will not be damaged.
- B. The Contractor shall add pull boxes where needed or required by Code whether or not shown on the Drawings at no additional cost to the Authority.
- C. Junction boxes and pull boxes of the proper size and shape shall be provided.
- D. Pull boxes and junction boxes shall be supported from the building structure and shall not be supported by the conduit. Pull/junction box supports shall comply with the applicable requirements for supports as contained in these Specifications.

3.06 WIRING INSTALLATION

- A. All cable and wire shall be installed in conduit.
- B. No splices will be permitted between terminals, except at approved junction or terminal box points. Cable and wire runs shall be looped through pull boxes without cutting and splicing where possible. Boxes shall be sized to allow cable and wire installation without splices.
- C. All hardware, such as cable stanchions, racks, insulators, brackets, structural supports, wall inserts, cable and junction boxes, bolts, connectors, clamps, fittings and other accessories for the installation of wires and cables in the structure and outdoors shall be furnished and installed complete to provide a satisfactory operating installation.
- D. All wiring system shall be "pullable" and use of "BX" is prohibited.
- E. Branch circuit wiring for single phase applications shall be sized for a voltage drop in accordance with the City of Chicago Electrical Code.

- F. Feeders shall be installed with the sizes as indicated on the Drawings and shall be connected as required for the proper operation of the equipment they serve.
- G. Home runs and branch circuits shall not be grouped more than what is indicated on the Drawings.
 - 01. A home run is that part of a circuit between the panel and the first outlet or device to which a current carrying service is connected.
 - 02. Circuit numbers as indicated on the Drawings are provided for the proper connection to multi-wire circuits at the panels. The Contractor shall not alter the circuiting without prior written acceptance of the Authority.
- H. It shall be the responsibility to the Contractor to see that the circuiting work for field changes fulfills the following conditions:
 - 01. Loads on panel bus shall be as evenly balanced on all phases as possible.
 - 02. No neutral conductor shall be common to more than one multi-wire circuit (the same network) of the supply system.
- I. Feeders shall be installed with wire sizes as indicated on the Drawings and shall be connected as required for the proper operation of the equipment they serve.
- J. Proper termination of conduits and wires at panels or other equipment items shall be provided.
- K. Where conduit and wire sizes are increased beyond the equipment manufacturer's normal provisions for conduit and wire terminations, due to voltage-drop or other considerations in branch-circuit designs, the Contractor shall provide necessary auxiliary termination facilities with adequate boxes, lugs, terminals, knock-outs, etc., as may be required.
- L. Training of wire and cable on the ground or concrete slabs will not be permitted. Wire and cable shall be installed directly from factory reels or packaging.

3.07 SPLICES AND TERMINATIONS - 600-VOLT CABLE

- A. Splices and terminations shall be carefully taped and covered, when required, using material recommended by the cable manufacturer, to provide insulation equal to that of the conductors.

- B. Splices shall be made in proper splice or junction boxes. Splices shall not be made in any panels. Splices shall not be pulled into any conduit. Splices shall not be made in any fitting.
- C. Splices:
 - 01. Splices shall be performed only by experienced and qualified cable splicers regularly engaged in this type of work.
 - 02. All cable runs shall be given an insulation resistance test and continuity check at the completion of each splice throughout the length of the cable run.
 - 03. Where a cable is cut preparatory to splicing, the work shall proceed without delay. When an unavoidable delay is encountered in completing a splice, the opened cable shall be protected to prevent the entrance of moisture and foreign matter with a heat shrink cap.

3.08 WIRING METHODS

- A. Spare conductors shall have the ends taped and they shall be neatly coiled and tied and left in the bottom of the enclosure. They shall be marked as spare conductors.

3.09 ELECTRICAL HARDWARE INSTALLATION

- A. Locations:
 - 01. Anchor bolts, sleeves, inserts, hangers and supports required for the work shall be furnished and installed by the Contractor.
 - 02. Any expense resulting from improper location or installation shall be paid for by the Contractor at no additional cost to the Authority.
 - 03. Conform to manufacturer's recommendations for selection and installation of supports.
 - 04. Strength of each support shall be adequate to carry present and future load multiplied by a safety factor of at least four. Where this determination results in a safety allowance of less than 200 lbs., provide additional strength until there is a minimum of 200 lbs. allowance in the strength of each support.
 - 05. Anchors are not to penetrate more than one and one-quarter (1 1/4) inches into any concrete joists, nor more than one and one half (1 1/2) Inches into any concrete beams. They shall not

be installed closer than one and one half inches (1 1/2) from the edges of the beams or joists. Adjust routing of conduits and locations of boxes accordingly.

- 06. Conduits, boxes, signs, etc. mounted to or supported from concrete columns, beams, joists or slabs shall be attached with drilled holes and concrete anchors. If resistance is detected while drilling, anchor locations shall be moved to avoid damage to steel reinforcing. Powder-activated driven studs will not be permitted.
- 07. The load applied to fasteners shall not exceed one-fourth the proof test load of the fasteners or hangers.
- 08. Fasteners attached to concrete shall be vibration and shock resistant.

B. Hangers:

- 01. The Contractor shall provide adequate supports for all conduits and equipment, either suspended from the construction above, or by means of struts to the construction below. When the weight of the support system, including the completed electrical assembly, exceeds 100 pounds per hanger the Contractor shall design a suitable support system and submit the design along with associated sketches and calculations to the Authority for review and approval before construction.
- 02. Hangers for support of conduit shall be of the fabricated type, but not of the perforated iron type, and shall conform to the requirements of the Contract Documents.
- 03. Hangers shall be suitable for the weight of the conduit(s) supported. This shall include any and all pulling loads, as well as the load of the conductors, which the support may be subject to.
- 04. Trapeze type hangers may be used where several conduits are to be installed at the same elevation.
- 05. The Contractor shall provide straps, clamps, threaded rods, turnbuckles and anchors and all miscellaneous specialties for the attachment of hangers and supports to the structure.
- 06. Vertical conduits shall be supported by heavy metal clamps or collars anchored in or to the construction at each floor.

C. Conduit Supports:

01. Exposed conduits shall be supported in an approved manner. Conduits shall not be fastened to or come in contact with any mechanical system pipes, ducts or equipment of other trades, except as approved by the Authority. In all conduit work, acceptable hangers, racks or a combination thereof shall be used as supports.
02. Conduit trapeze supports shall be located at intervals not exceeding 5 feet. Single conduits shall be supported as required by the Chicago Electrical Code.
03. Conduits shall be securely fastened to each trapeze with U-bolts, straps or clamps.
04. When the conduit supports must be attached to the structural concrete, proper anchors shall be installed. The use of anchors containing lead, plastic or wood is strictly prohibited.
05. Field cut ends are to be treated as soon as they are cut.

D. Sleeves:

01. The Contractor shall provide sleeves in fire rated walls and floors, and when penetrating CMU walls.
02. Sleeves shall be not less than 1 inch larger than outside diameter of the conduit.
03. Floor sleeves shall be galvanized steel pipe, as approved by the NEC, 3 inches above floor, and shall be watertight.
04. Where conduit passes through floors or walls, the Contractor shall caulk sleeves with an appropriate system to insure the complete sealing of the opening to prevent passage of water, dirt or air and to insure the fire rating of the structure penetrated.
05. Sleeves shall be set true to line, plumb, and position, and shall be so maintained during construction.

3.10 PAINTING

A. Prime Coat:

01. Shop fabricated and factory built equipment without a primer shall be galvanized or protected by plating. Before delivery to

the site, the equipment shall be cleaned and given one shop coat of zinc-chromate primer.

02. Any portions of the shop coats damaged in delivery or during construction shall be recoated.
03. Nameplates, labels, tags, stainless steel or chromium-plated items such as levers, handles, trim strips, etc. shall not be painted.

B. Finish Coat:

01. All equipment, panelboards, etc. shall be factory finished in baked enamel or lacquer, or as specified. Standard finishes shall be approved. All scratches shall be neatly touched-up by the Contractor.
02. All metal work installed by the Contractor that will be exposed to weather and is not factory finished shall be painted with one coat of rust inhibitive primer and two coats of oil based paint of a color selected by the Authority.

3.11 CUTTING AND PATCHING

- A. The Contractor shall provide all cutting and patching of building materials required for the installation of the work herein specified:
 01. No structural members shall be cut without the written approval of the Authority.
 02. Roof deck is considered a structural member.
 03. Approved cutting shall be done with concrete saws or core drills.
- B. Patching shall be provided by skilled craftsmen of the particular trade involved and done in a neat and workmanlike manner.
- C. Slots, chases, openings, and recesses through floors, walls, ceilings and roofs shall be cut by the Contractor. The Contractor shall verify that they are properly located.
- D. The Contractor shall patch and repair as required. Where patching or repair becomes excessive at a location, as determined by the Authority's Authorized Representative, the Contractor shall use skilled technicians of the appropriate trade to make the repairs or patching.

3.12 CLEANING

- A. Open ends of conduit and equipment shall be properly capped or plugged to keep dirt and other foreign matter from entering.
- B. Each length of conduit shall remain capped until the conduit connections are required.
- C. When work is not in progress, open ends of conduit and fittings shall be securely closed so that no water, earth, or other substances will enter. Tape is NOT allowed.

3.13 ROUTING OF NEW CONDUITS

- A. The Contractor shall field-verify routing of new conduits and make adjustments to suit actual existing conditions at no additional cost to the Authority.

END OF SECTION 16100

**DIVISION 16
ELECTRICAL**

**SECTION 16195
ELECTRICAL IDENTIFICATION**

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. The Work under this Section is subject to the requirements of the Contract Documents.
- B. The Contractor shall furnish and install all technical work, materials and accessories indicated schematically by drawings, schedules and specified herein, which include, but are not limited to, the following:
 - 01. Conduit markers.
 - 02. Wire/Cable Markers.
 - 03. Warning Tape.
 - 04. Danger Signs.
 - 05. Equipment Identification.
- C. For the purpose of this Specification, the term "Cable" shall apply to any type of conductor mentioned in the Contract Documents.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide electrical identification products of one of the following (for each type marker):
 - 01. Alarm Supply Co., Inc.
 - 02. Brady, W.H. Co.
 - 03. Calpico Inc.
 - 04. Cole-Flex Corp.
 - 05. Direct Safety Co.

06. George-Ingraham Corp.
07. Griffolyn Company
08. Ideal Industries, Inc.
09. LEN Products, Inc.
10. Markal Company
11. National Band and Tag Co.
12. Panduit Corp.
13. Seton Name Plate Co.

2.02 INTERIOR CABLE/WIRE MARKERS

- A. Cable markers shall be installed on both ends of all conductors. Self-adhesive, self-laminating, or heat shrink tubing shall be used. All markers shall be mechanically printed. Cable markers shall be rated for the environment in which they are placed. Acceptable manufacturers shall be Brady, 3M, or Panduit.
- B. Circuit identification shall be per the Contract Drawings. Should the Drawings not specify the circuit identification the following system shall be used:
 01. For branch circuit wiring from receptacle/lighting panels the circuit identification shall be the panel number and the circuit number.
 02. For circuiting from distribution panels the circuit identification shall be the panel number and the circuit number.
- C. Conductor color coding shall be done using tape as specified elsewhere in the Contract Documents. Provide color coding for all conductors which do not come with factory applied colors.

2.03 CONDUIT MARKERS

- A. Conduit tags shall be either stainless steel, grade 316 minimum, or BHMA606 brass. Tags shall have the identification either stamped in or embossed in the material. Tags shall be fastened to the conduit with either stainless steel wire or with nylon, self-locking tie wraps. For dry interior locations, nylon tags which are mechanically printed may be used.

2.04 WARNING / DANGER SIGNS

- A. The Contractor shall provide manufacturer's standard "DANGER" signs of rigid polyethylene; of standard, red, black and white graphic; 14" x 10" size except where 10" x 7" is the largest size which can be applied where needed and except where larger size is needed for adequate vision; with recognized standard explanation wording, e.g., HIGH VOLTAGE, KEEP AWAY, DO NOT TOUCH SWITCH.
- B. The Contractor shall provide "Warning" signs as required, of rigid polyethylene, colors as required by OSHA.
- C. Signs shall be attached with stainless steel screws. "Warning" / "Danger" signs shall not be of the adhesive type for attachment to doors or walls.

2.05 EQUIPMENT IDENTIFICATION

- A. After finish painting is completed, the Contractor shall provide white with black core laminated phenolic nameplates with 1/4 inch minimum lettering etched through the outer covering. Inscription shall be made with all capital letters and shall be the same inscriptions as shown on the Drawings or as directed by the Authority.
 - 01. Embossed self-adhering plastic tape labels will NOT be accepted.
 - 02. The Contractor shall use stainless steel screws, except where contact-type permanent adhesive may be required when screws cannot or should not penetrate substrate.
 - 03. The Contractor shall take care when attaching the identification so that the NEMA or UL rating of the equipment is not violated.

2.06 LETTERING AND GRAPHICS

- A. The Contractor shall coordinate names, abbreviations and other designations used in electrical identification work, with corresponding designations shown, specified or schedules. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by the manufacturer or as required for proper identification and operation / maintenance of electrical systems and equipment. Comply with ANSI A13.1 pertaining to minimum sizes for letters and numbers
- B. Identification markings on signs and markers shall NOT be done with pens, pencils, crayons, magic markers, paint, Dymo-labels, etc.

- C. Identification on small boxes, i.e. cast boxes or other boxes less than 5" square, may be done with a permanent marker in neat and legible block printing. Black markers shall be used for this purpose.

2.07 TERMINAL IDENTIFICATION

- A. Terminal strips shall be identified by using markers supplied by the terminal manufacturers. Wherever possible they shall be mechanically printed. When this is not possible the strips shall be marked in neat and legible block lettering using a permanent marking system acceptable to the terminal strip manufacturer. The terminal marking shall be the wire number attached to that terminal.

2.08 BOX IDENTIFICATION

- A. Identification markers for pull boxes, splice boxes, junction boxes, etc. shall be of the polyester film type, self adhesive and pre-printed. The marker shall contain the voltage level(s) contained within the box. The marker shall be yellow with black letters and the lettering shall be visible from the floor.
- B. The box shall have a phenolic nameplate, white with black letters, affixed to the box with stainless steel screws with the box identification. Each box shall have a identifying designation that will be shown on the drawings.

2.09 CABLE TIES

- A. Cable ties shall be fungus-inert, self-extinguishing, one-piece, self-locking nylon cable ties, 0.18 inch minimum width, 50 lb. Minimum tensile strength, and suitable for a temperature range from minus 50°F to 350°F. Provide ties in specified colors when used for color coding.
- B. Acceptable manufacturers shall be Thomas & Betts Co., Brady Co., and Panduit.

PART 3 - EXECUTION

3.01 APPLICATION AND INSTALLATION

- A. The Contractor shall install electrical identification products as indicated, in accordance with manufacturer's written instructions, requirements of the Chicago Electrical Code, and the Contract Documents.
 - 01. Where identification is to be applied to surfaces which require finish, install identification after completion of painting.

02. The Contractor shall comply with governing regulations and requests of governing authorities for identification of electrical work.

B. The Contractor shall provide a typewritten directory of circuits in lighting and power panels. The Contractor shall clearly indicate the purpose of each circuit, i.e. lighting, receptacles, etc. and shall indicate the location of the supplied equipment.

3.02 CONDUIT, WIRE, CABLE AND BUS IDENTIFICATION

A. Each cable shall be labeled at all terminals and at all accessible points in equipment, panelboards and pull boxes, etc. Labels shall be as specified herein.

B. All wires and feeder cables shall be labeled wire markers in all junction boxes, pull boxes, control panels, substations, panelboards, etc. All conductors shall be tagged in cabinets at the time wires are pulled in the tested and markers shall not be removed for any reason.

C. Markers approved by the Authority shall be attached to all cables where entering or leaving from conduit runs. The cable designation and circuit use from the cable schedule shall appear on the tag. Where a cable schedule is not provided, the designation shall be the circuit number and the panel from which the circuit originates.

D. The Contractor shall apply colored, pressure sensitive tape in half-lapped turns for a distance of 2 inches from the cable marker and in all boxes. Provide color coding at all splices and taps on each side of the splice or tap. Apply the last two laps of tape with no tension to prevent possible unwinding. Do not obliterate cable tag with the tape.

E. All conduit runs shall be identified by means of non-corrosive metals tag with stamped identification thereon, as shown on Contractor's Installation Drawings and attached at all conduit terminations, including junction boxes.

F. Conduit identification tags shall be fastened to the conduit near the point of termination where conduits enter substations, panelboards, terminal cabinets, outlet boxes, junction boxes, pull boxes and other items. The tag shall be held in place by a tie wrap.

G. Conduits in miscellaneous pull boxes in runs where the system identity cannot be clearly seen shall have identifying tags indicating the name of the system. Such tags shall be installed as described above. Miscellaneous systems shall include, but not be limited to, lighting, etc.

- H. Conduits terminating at lighting fixtures, wall switches, panelboards, receptacle outlets and similar items need not be tagged where their system identification is obvious, except as noted above for clarity.
- I. Exterior installed conduits, except branch lighting circuit conduits, shall be tagged at the ends and in intermediate boxes, and other enclosures in accordance with the same inscriptions as shown on the Drawings.
- J. Tags shall be fastened as specified except that where this method is not practicable, they shall be fastened to the adjacent masonry by means of expansion bolts.
- K. Phase identification letters shall be 1 inch high in readily visible locations, and shall be stamped into the main bus bars of all panel boards .

3.03 OPERATIONAL IDENTIFICATION AND WARNING

- A. Wherever reasonably required to ensure safe and efficient operation and maintenance of electrical systems, electrically connected mechanical systems and general systems and equipment, including prevention of misuse of electrical facilities by unauthorized personnel, install self-adhesive plastic signs of similar equivalent identification, instruction or warnings on switches, outlets and other controls, devices and covers of electrical enclosures. Where detailed instructions or explanations are needed, provide plasticized tags with clearly written messages adequate for intended purposes.
- B. In addition to installation of danger signs required by governing regulations and authorities, the Contractor shall install appropriate danger signs at locations indicated and at locations subsequently identified by installer of electrical work as constituting similar dangers for persons in or about project.
 - 01. The Contractor shall install "Danger" signs wherever it is possible, under any circumstances, for persons to come into contact with electrical power of voltages higher than nominal 120 volts.
 - 02. The Contractor shall install "Danger" signs on switches and similar controls, regardless of whether concealed or locked up, when untimely or inadvertent operation (by anyone) could result in significant danger to persons, or damage to or loss of property.

3.04 EQUIPMENT/SYSTEM IDENTIFICATION

- A. The Contractor shall install engraved plastic-laminate signs on each unit of electrical equipment in the structure unless unit is specified with its own self-explanatory identification or signal system. Provide text matching terminology and numbering of the Contract Documents and Shop Drawings. Provide signs for each unit, but not limited to, the following categories of electrical work.
 - 01. Panelboards, electrical cabinets and enclosures
 - 02. Access panel/doors to electrical facilities
 - 03. Transformers
 - 04. Disconnect Switches
- B. The Contractor shall install signs at locations indicated or, where not otherwise indicated, at location for best convenience of viewing without interference with operation and maintenance of equipment. Secure to substrate with fasteners, except use adhesive where fasteners should not or cannot penetrate substrate.
- C. Provide identification on all pull junction, splice or terminal boxes. Identification shall consist of the voltage contained within the enclosure and the enclosure identification.

END OF SECTION 16195

**DIVISION 16
ELECTRICAL**

**SECTION 16450
GROUNDING**

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. The work under this Section is subject to the requirements of the Contract Documents.
- B. The Contractor shall furnish and install all technical work, materials, and accessories indicated schematically, in schedules, and as specified herein which include, but are not limited to, the following:
 - 01. Electrical power systems
 - 02. Ground electrodes
 - 03. Separately derived systems
 - 04. Raceways
 - 05. Service equipment
 - 06. Enclosures
 - 07. Equipment
- C. Requirements of this Section apply to electrical grounding and bonding work specified elsewhere in these Specifications.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Subject to compliance with requirements, the Contractor shall provide grounding and bonding products of one of the following (for each type of product):
 - 01. Adalet-PLM Div.; Scott Fetzer Co.
 - 02. Burndy Corporation.
 - 03. Cadweld Div.; Erico Products Inc.

04. Crouse-Hinds Div.; Cooper Industries
05. Eagle Electric Mfg. Co.
06. Ideal Industries, Inc.
07. Joslyn Corporation
08. Okonite Company
09. O-Z/Gedney Div.; General Signal Corp.
10. Thomas and Betts Corp.

2.02 GROUNDING AND BONDING

- A. Except as otherwise indicated, the Contractor shall provide electrical grounding and bonding systems indicated; with assembly of materials, including, but not limited to, cables/wires, connectors, solderless lug terminals, grounding electrodes and plate electrodes, bonding jumper braid, surge arresters and additional accessories needed for a complete installation. Where more than one type component product meets indicated requirements, selection of the component product is at the Contractor's option.
- B. Unless otherwise indicated, the Contractor shall provide electrical grounding conductors for grounding system connections per Specification Section 16100 which are sized according to Chicago Electrical Code. In no case shall bare conductors be installed in the earth.
- C. The Contractor shall provide electrical bonding plates, connectors, terminals, lugs and clamps as recommended by bonding plate, connector, terminal and clamp manufacturers for indicated applications.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. The Contractor shall examine areas and conditions under which electrical grounding and bonding connections are to be made and notify Authority in writing of conditions detrimental to proper completion of work. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to the Authority.

3.02 INSTALLATION OF ELECTRICAL GROUNDING AND BONDING SYSTEM

- A. The Contractor shall install electrical grounding and bonding systems as indicated and specified and in accordance with manufacturer's instructions and applicable portions of Chicago Electrical Code, NECA's "Standard of Installation" and in accordance with recognized industry practices to ensure that products comply with requirements. EXCEPTION: No ground connection shall be made to water lines.
- B. The Contractor shall coordinate with other electrical work as necessary to interface installation of electrical grounding and bonding system work.
- C. The Contractor shall ground the electrical service system neutral at the service entrance equipment to the grounding system.
- D. The Contractor shall ground each separately-derived system neutral to the grounding system.
- E. The Contractor shall connect system neutral, service equipment enclosures, exposed noncurrent carrying metal parts of electrical equipment, metal raceway systems, grounding conductors in raceways and cables and wiring device ground connectors.
- F. The Contractor shall terminate feeder and branch circuit insulated equipment grounding conductors with a grounding lug, bus, or bushing.
- G. The Contractor shall tighten grounding and bonding connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values for connectors and bolts. Where manufacturer's torquing requirements are not indicated, tighten connections to comply with tightening torque values specified in UL 486A to assure permanent and effective grounding.
- H. The Contractor shall route grounding connections and conductors to ground and protective devices in the shortest and straightest paths possible to minimize transient voltage rises.
- I. The Contractor shall apply corrosion-resistant finish to field-connections, buried metallic grounding and bonding products, and places where factory applied protective coatings have been destroyed, which are subject to corrosive action.
- J. The Contractor shall install clamp-on connectors on clean metal contact surfaces, to ensure electrical conductivity and circuit integrity.
- K. All conduits shall contain a ground wire.

3.03 FIELD QUALITY CONTROL

- A. Upon completion of installation of electrical grounding and bonding systems, the Contractor shall test existing ground resistances with ground resistance testing. These tests shall be witnessed by the Authority's Authorized Representative. Where tests show resistance-to-ground is over the required ohms, take appropriate action to reduce resistance to the required ohms, or less, by driving additional ground rods; then retest to demonstrate compliance.

END OF SECTION 16450

**DIVISION 16
ELECTRICAL**

**SECTION 16470
PANELBOARDS**

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. The work under this section is subject to the requirements of the Contract Documents.
- B. The Contractor shall furnish and install: All electrical work, materials, and accessories indicated schematically by drawings, in schedules, and as specified herein which include, but are not limited to, the following:
 - 01. Electrical power systems
 - 02. Panelboards
 - 03. Circuit breakers
 - 04. Separately derived systems
 - 05. Enclosures
 - 06. Equipment

1.02 QUALITY ASSURANCE

- A. Assembled panelboards shall be UL and IBEW labeled, and meet the requirements of Specification Section 16010 and Section 16100.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. General:
 - 01. Panelboards shall be of the circuit breaker or fusible switch type, of dead front construction, with the voltage characteristics, bus size, main lugs only or main protective device, and number and size of branch circuits as shown on the Drawings.

02. Panelboards shall be recessed or surface mounted as shown on the Drawings, enclosed in a 12 gauge steel cabinet with steel trim, and door with continuous stainless steel piano concealed hinges and cylinder type locks.
03. Panelboards shall be fully rated, labeled with their UL short circuit rating, and shall have a Service entrance label when required by the application.
04. Circuit breakers shall be of the industrial, bolt-on type, of the number of poles and rating as shown on the Drawings.
05. Fusible switch units for sizes 30 amperes through 400 amperes shall be quick-make, quick-break design, with rejection type fuse clips. Switch units that are 600 amperes and larger shall be of the bolted pressure type with Class L fuses.
06. Panelboards shall be designed for sequence phase connection of branch circuit devices to allow for complete flexibility of circuit arrangement to evenly balance the electrical load on each phase.

B. Cabinets:

01. Cabinets shall be fabricated from a minimum of 12 gauge stretcher level steel and shall provide not less than 6 inches clear space for wiring gutters at top, bottom and sides, as measured from the panel edge or breaker, whichever is greater.
02. The seams for each cabinet shall be continuously welded at the outside and shall be ground smooth, and the cabinet thoroughly cleaned.
03. Cabinet shall be hot dipped galvanized after fabrication. In lieu of hot dip galvanizing, the manufacturer may construct the cabinet of Type 302 - 304 stainless steel. The hot-dip process shall, at a minimum, consist of the following:
 - a. Soil and grease removal including all material not removed by hot alkaline cleaner. Such material shall be removed by blasting or other mechanical means.
 - b. Pickling to provide a chemically clean metallic surface.
 - c. Prefluxing for all steel to remove oxides and prevent oxidation.

- d. Galvanizing by immersion in a heated bath of molten zinc.
 - e. Finishing by removal of excess zinc and cooling.
 - f. Inspection for determination of quality as stipulated by American Hot-Dip Galvanizers Associations.
- 04. All free standing cabinets shall be securely and adequately supported by approved angle iron and channel type frame work.
 - 05. Doors and trim shall be each of one piece, constructed of #12 gauge minimum galvanized steel and be designed so that doors will close against a rabbet. Trims shall be fastened with machine screws or bolts fastening to permanently affixed nuts on the cabinet. Self tapping screws or self adjusting clamps are not acceptable.
 - 06. Cabinet door shall be equipped with a concealed full length, stainless steel continuous piano type hinge. Yale Company, Division of Eaton Security Products & Systems, Catalog Number S1400, or Corbin Cabinet Lock Company Catalog Number 1000 vault handles with disc tumbler locks and three point latch shall be provided on doors twenty-four inches or over in height. Yale Company, Division Eaton Security Product & Systems Catalog Number T1403, or Corbin Cabinet Lock Company Catalog Number 1001 handles with disc tumbler locks and one point latch shall be provided on doors under twenty-four inches in height.
 - 07. A full size typewritten directory with steel frame and glass face shall be furnished and installed on the inside of the door of each cabinet. The directory frame shall be secured to the door without the use of screws or holes.
 - 08. Two keys shall be furnished with each cabinet and lock. All cabinet locks shall be provided to accept a CAT 60 Master Key (Corbin Lock or H. Hoffman Co.). Lock shall be arranged to permit key removal in locked and unlocked positions.
- C. Circuit Breakers:
- 01. Circuit breakers shall be of the bolt-in type, industrial heavy-duty, quick-make, quick-break, single or multi-pole of the type specified herein and shown on the Drawings.
 - 02. Circuit breakers shall be thermal magnetic type with common handle for a multiple pole circuit breakers. Circuit breakers shall

be a minimum 100 ampere frame and through 100 ampere trip sizes shall take up the same pole spacing. Circuit breakers shall be UL listed as type SWD for lighting circuits.

03. Molded case circuit breakers shall provide circuit overprotection with inverse time and instantaneous tripping characteristics. Ground fault protection shall be provided where shown on the Drawings.
04. Circuit breakers shall be operated by a toggle- type handle and shall have a quick-make, quick- break over-center switching mechanism that is mechanically trip free. Automatic tripping of the breaker shall be clearly indicated by the handle position.
05. Contacts shall be nonwelding silver alloy, and arc extinction shall be accomplished by means of DEION arc chutes.
06. Circuit breakers shall have the minimum symmetrical interrupting rating capacity as shown on the Drawings.
07. Each panelboard breaker shall be connected to the main bus with copper bus bar. Insulated cable is not acceptable.
08. Circuit breakers shall be Westinghouse, Series C, General Electric, or approved equal.

D. Fusible Switches:

01. Fusible switch units, 30 ampere through 400 amperes shall be quick-make, quick-break design, rated not less than 200kAIC with rejection type fuse clips. Switch units 600 amperes and larger shall be of the bolted pressure type rated 200kAIC with Class L fuses.

E. Interiors:

01. Interiors shall be completely factory assembled with bolt on devices. The interior shall be so designed that circuit breakers can be added or replaced without disturbing adjacent units and without removing main bus connectors, and shall be so designed that circuits may be changed without additional machining, drilling, or tapping. Spaces for future breakers shall have bussing provided, of the required capacity, for the maximum device that can be fitted into them.
02. All bus shall be hard drawn electrolytic copper, having 98 percent conductivity and sized on a basis of 1000 amperes, maximum, per square inch of cross sectional area.

03. Neutrals, where called for, shall be grouped and arranged on a common bus and each terminal shall be stamped to indicate the number of the breaker with which it is associated. Neutral busing shall have a suitable compression type lug for each feeder requiring a connection.
 04. Each panelboard shall be furnished with a full length ground bus drilled and tapped to accommodate a ground cable for each circuit breaker. Cable terminals shall be provided.
- F. Remote Control Switches:
01. When required by the Drawings, ASCO 920 bus connected contactors shall be provided for split bus arrangements.
- G. Branch Circuits:
01. Branches shall be 120 volt, single phase.
 02. Each fuse position shall be provided with a numerical designation strip.
 03. All branch circuit fuses shall be UL, Edison base plug fuse, Type T, of required capacity, rated at 125 volts AC in accordance with panelboard schedule. Fuses shall be capable of interrupting the maximum short circuit current available at their load terminals.
 04. Plug fuse shells shall be back connected to bus bars with studs. Bus bars, as minimum, shall be rated at full fuse loads, plus twenty-five percent for demand factor.

2.02 MANUFACTURERS

- A. Acceptable Panelboard manufacturers shall be Illinois Switchboard, Erickson Electric, or approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. The Contractor shall install the equipment in strict accordance with the approved shop drawing and the equipment manufacturer's instructions.
- B. Each surface mounted panelboard shall be supported and mounted away from the wall with "C" shaped channel. The channel shall be fiberglass, when stray current control isolation is required, and hot dipped galvanized steel for normal applications. The minimum separation between the equipment and the wall shall be one inch.

- C. The equipment shall be installed with work space clearances required by the Code.
- D. The equipment shall be installed to permit maintenance and replacement of parts, and shall be clear of all openings with swinging or moving doors, partitions or access panels.
- E. Each panelboard shall be mounted with the top a maximum of 6 feet, 6 inches above the finished floor unless shown otherwise shown on the Drawings.

END OF SECTION 16470

**DIVISION 16
ELECTRICAL**

**SECTION 16770
CENTRAL CONTROL SYSTEM**

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including the other sections of this Specification apply to this Section.

1.02 DESCRIPTION OF WORK

- A. The Contractor shall be responsible for providing a dedicated server to control the ATSS system in space provided by the CTA at the CTA Communications and Power Control Center located at 120 North Racine Avenue in the City of Chicago.
- B. The Contractor shall be responsible for providing the server software applications and Control Center Console software applications required to control and monitor the ATSS system. Software required to provide real-time countdown and/or schedule adherence information and advisory messages for each station to CTA and RTA web sites shall also be provided.
- C. The Contractor shall lease from the RBOC (Ameritech), in CTA's name, at least one dedicated data circuit (or more as required) between each CTA rail rapid transit station included in this project and the CTA Communications and Power Control Center. These data circuits shall be cable-extended to the ATSS Station Sign Controller (see Section 16771) from the Ameritech Telephone Terminal NET-POP at each station. These data circuits are required for controlling the ATSS system. The installation and lease charges for the warranty period are to be included in contract price.

1.03 FUNCTIONAL REQUIREMENTS

- A. The ATSS Central Control System performs six main functions:
 - 01. Time Synchronization: The ATSS Central Control System shall ensure that the system time used by each Station Sign Controller to compute countdown values is equivalent to the time used by the CTA Automatic Train Dispatching & Monitoring System (ATDMS) to compute schedule adherence.

02. Schedule Synchronization: The ATSS Central Control System shall ensure that the schedules of train arrival times used by each Station Sign Controller to compute countdown values is equivalent to the schedule used by the CTA ATDMS to compute schedule adherence.
03. Schedule Adherence Data Distribution: The ATSS Central Control System shall distribute the most recent schedule adherence value provided by the CTA ATDMS for the next two trains arriving in each direction at each station to the appropriate Station Sign Controller.
04. Text Message Distribution: The ATSS Central Control System shall distribute alphanumeric advisory messages on train services, such as delays, accidents, closures, etc., generated by staff at the CTA Central Communications and Power Control Center to any single Variable Message Sign (VMS) or group of VMSs via the appropriate Station Sign Controller(s).
05. Health Monitoring: The ATSS Central Control System shall monitor the operating status of each Station Sign Controller, VMS, and Vehicle Proximity Sensor in the system and report any abnormalities to Control Center staff.
06. Internet Interface: The ATSS Central Control System shall provide real-time transit service data on request to applications (not in Contract) providing traveler information over the CTA and RTA web sites.

1.04 SUBMITTALS

- A. For the hardware provided, the Contractor shall submit Equipment Manufacturer's Product Information, Installation Drawings, Shop Drawings (as applicable), Factory Acceptance Test Procedures, Factory Acceptance Test Results, Local Acceptance Test Procedures, Local Acceptance Test Results, Operations and Maintenance Manuals, according to the requirements of Section 16010.
- B. For the software provided, the Contractor shall submit a Software Design Plan and an Interface Control Document to the Authority for review and approval before software coding begins according to the requirements of Section 16010.

- C. The Contractor shall provide a system Test Plan and Procedures that demonstrates progressively that the technical requirements of each function of the ATSS have been met at each design phase.
 - 01. The documents defining the tests shall be submitted for approval with the corresponding design documentation.
 - 02. Following the completion of each set of tests, the Contractor shall submit a test report. The test report shall list all the test results, including version details, metrics, unexplained occurrences, incidents of non-conformance to the test specification, reasons noted, and corrective actions, if any.
 - 03. Documents shall be submitted to the Authority's Authorized Representative for review and approval during the phases indicated. A phase shall not be completed unless the required documentation has been reviewed with approval by the Authority's Authorized Representative.
 - 04. Any changes to the software, up to Final Acceptance, shall require a corresponding change to the documentation. All design and test documentation shall be kept up to date.
- D. Provide a fully staged Plan and Schedule to accomplish a smooth and orderly integration of the ATSS for approval by the Authority. This Plan and Schedule shall be provided at least 60 days prior to the start of Installation Testing activities.

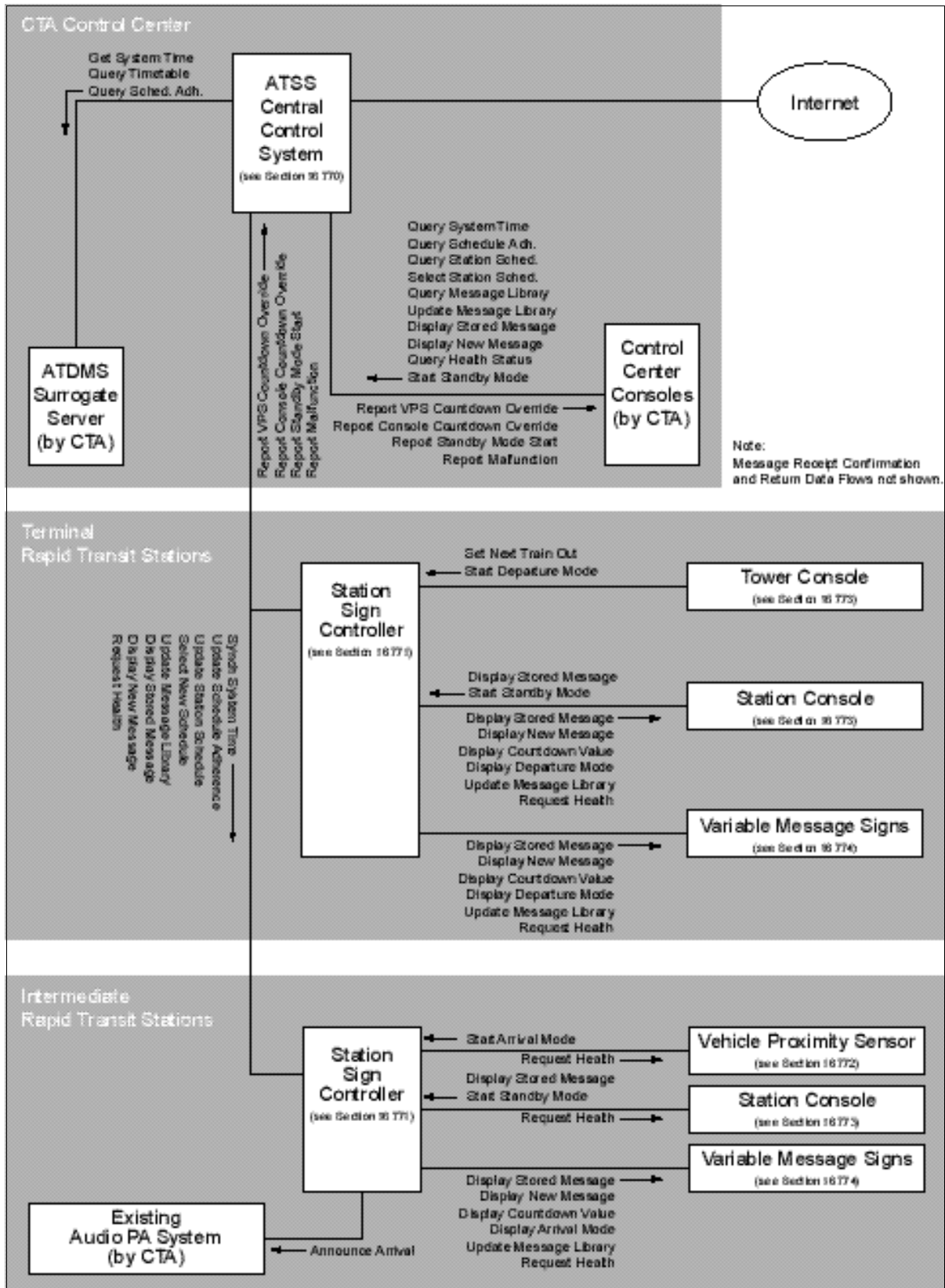
PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

- A. **Compatibility:** It is critical that the ATSS Central Control System design and operation follows the basic guidelines established by the Authority to ensure interoperability between systems. The Contractor shall be responsible for coordinating with the RTA and CTA on specific implementation details within the general guidelines defined in this Specification.
 - 01. The hardware, software, and communications designed for the ATSS system shall be compatible with existing hardware, operating systems, communication systems, and database management systems at the CTA to ensure interoperability.
 - 02. A thorough inventory of existing systems in use and planned by the RTA and CTA shall be conducted at the beginning of system development by the Contractor.

- B. High-Level Architecture Flow Diagram: The high-level architecture flow diagram on the following page is provided to illustrate the operation of the ATSS system. The Contractor shall develop data flow diagrams and interface diagrams supporting the standards and IDL's as identified per Section 16010, Subsection 1.09.

Figure 16770-1: High-Level Architecture Flow Diagram



2.02 HARDWARE

- A. ATSS Central Control System Server: The ATSS Central Control System shall be located in the CTA Central Communications and Power Control Center (CTA Control Center) at 120 North Racine Street in the City of Chicago.
 - 01. It is critical that the ATSS Central Control System design and operation follows the basic guidelines established by CTA to ensure interoperability between the ATSS and the Automatic Train Dispatching and Monitoring System (ATDMS). The CTA Control Center uses a 10/100 Base T/TX network of servers and operator workstations running on the Sun Solaris UNIX operating system. The Contractor shall be responsible for coordinating with the RTA and CTA on specific implementation details within the general guidelines defined in this Specification.
 - 02. Depending on the total data volume, the ATSS may utilize more than one computer server to ensure optimal system performance.
- B. Interface with CTA ATDMS: The ATSS Central Control System shall interface with a surrogate server (provided by the CTA) containing real-time updated Oracle version 8 databases of active schedule adherence information via an external 10/100 Base T/TX Ethernet port. The CTA will develop its ATDMS interface such that the total latency between ATDMS schedule adherence data collection and posting on the surrogate server will be less than 5 seconds. Schedule adherence data for each run will be updated no less than every 30 seconds by the ATDMS on the surrogate server.
- C. Interface with CTA Master Timetable System: The ATSS Central Control System shall interface with a surrogate server (provided by the CTA) containing real-time updated Oracle version 8 databases of timetable information via an external 10/100 Base T/TX Ethernet port.
- D. Redundancy: To maintain full system operation in the event of a drive failure, and to speed recovery without data loss, the ATSS Central Control System server shall operate dual hard disk drives in a RAID Level 1 disk-mirroring configuration to maintain duplicate copies of all files. No backup shall be necessary at Control Center Consoles to preserve data files necessary for the operation of the system, including message files created by any individual workstation.

2.03 SOFTWARE

- A. Central Control System Server Applications: The ATSS Central Control System software shall be implemented as one or more

independent X-Window applications running in the Sun Solaris UNIX operating system on a dedicated server. Specific software functional requirements for each of the main functions are listed as follows:

01. Time Synchronization

- a. The ATSS Central Control System shall use the same system time as the CTA ATDMS, which is based on the standard time distributed by the National Institute of Standards and Technology (NIST). Time correction and adjustment shall occur once every 15 minutes.
- b. The ATSS Central Control System shall synchronize the clocks contained in each Station Sign Controller with the system time no less frequently than once every 15 minutes and after any power supply interruption.

02. Schedule Synchronization

- a. The ATSS Central Control System shall distribute scheduled train arrival time information for each train scheduled to serve a station to the appropriate Station Sign Controller.
- b. The Station Sign Controller shall store no less than 8 daily schedules, corresponding to weekdays, Saturdays, Sundays, and special days, such as special events or construction.
- c. The ATSS Central Control System shall update schedules stored in each Station Sign Controller whenever the timetable used to compute schedule adherence by the ATDMS is changed. This normally occurs only several times per year.
- d. The ATSS Central Control System shall, per operator directive, be able to override the weekday-based default schedule used by the Station Sign Controller to accommodate holidays, construction, and other special events. Normally, the Station Sign Controller will use the stored Saturday schedule if the internal clock shows that it is Saturday, for example.
- e. The normal operation of the ATSS Central Control System and the Station Sign Controller shall not be interrupted or otherwise compromised by the schedule update process.

03. Schedule Adherence Data Distribution

- a. Each time the schedule adherence value for a train run is updated by the ATDMS or not less frequently than every 30 seconds, the ATSS Central Control System shall distribute the updated value to those stations for which the train represents the next scheduled train serving the station.
- b. The software and hardware shall be configured to minimize the latency between the ATDMS posting the updated schedule adherence value on the surrogate server and receipt by the appropriate Station Sign Controller to no more than 5 seconds.

04. Text Message Distribution

- a. The ATSS Central Control System shall distribute text advisory messages on train services, such as delays, accidents, closures, etc., generated by staff at the CTA Central Communications and Power Control Center to any single Variable Message Sign (VMS) or group of VMSs via the appropriate Station Sign Controller(s).
- b. The ATSS shall support pre-defined advisory message preambles, such as a flashing "Rider Alert" message, before the advisory message is displayed.
- c. Software shall be designed to provide/include a default value for each parameter supported. The Contractor shall obtain default parameter values from the Authority prior to installation and shall pre-load these default parameters during installation of ATSS system hardware and software.
- d. The ATSS shall be able to transmit an advisory message no less than 80 characters in length (not including preamble) to any combination of VMS Display Controllers via Station Sign Controllers in no greater than four (4) seconds, including connection and transmission time.
- e. The ATSS shall transmit commands causing any combination of VMS to enter a blank Standby Mode when initiated from a Control Center Console. Likewise, when such commands are initiated from Station Consoles, Control Center Consoles shall be notified.

05. Health Monitoring

- a. The ATSS Central Control System shall monitor the operating status of each Station Sign Controller, VMS, Vehicle Proximity Sensor, and Station Console in the system and report any abnormalities to Control Center staff.
- b. The ATSS Central Control System shall request and receive confirmation of normal operation from each Station Sign Controller in the system not less frequently than every 30 seconds.
- c. Any abnormalities detected by any Station Sign Controller, VMS, Vehicle Proximity Sensor, or Station Console shall be reported immediately and asynchronously to the ATSS Central Control System. Such abnormalities shall be reported as an alarm on one or more software-selectable Control Center Consoles.

06. Internet Interface

- a. The ATSS Central Control System shall provide time, schedule, and schedule adherence data as required to countdown applications running on remote computers at the RTA and/or CTA (not in Contract). These applications may be used to provide real-time traveler information to transit users via the Internet.
- b. The ATSS shall also provide the text of advisory messages to the countdown applications whenever Control Center Consoles are used to override the countdown display on station platform-area VMS.

B. Control Center Console Applications: The ATSS Central Control System operator interface shall be implemented as one or more independent X-Window applications running in the Sun Solaris UNIX operating system to allow ATSS control from existing Control Center Consoles (by CTA). The ATSS shall have a graphical user interface (GUI) to facilitate overall system configuration, message changing, updating, Station Sign Controller and Variable Message Sign status monitoring, etc. All functions shall be selected by pull down menus and point-and-click selection using a mouse and keyboard. Specific software functional requirements for each of the main functions are listed as follows:

01. Time Synchronization

- a. The current synchronized system time shall be displayable at the Control Center Consoles.

02. Schedule Selection

- a. The operator shall be able to view the schedules stored for use at any station.
- b. The operator shall be able to change the schedule used at any station from the Control Center Consoles for the current day or any future day within no less than one year. This function is generally used to accommodate holidays, construction, and other special events.
- c. The operator shall be able to select from one of the 8 daily schedules, corresponding to weekdays, Saturdays, Sundays, and special days, from the Control Center Consoles.

03. Schedule Adherence Monitoring

- a. The operator shall be able to monitor the schedule adherence values for each train operating on the Blue Line and the Purple Line, including the next two trains serving the Cumberland and Davis stations, from the Control Center Consoles.
- b. The operator shall be able to monitor countdown values displayed at each station. The algorithm used to compute countdown values shall be similar to that used by the Station Sign Controllers (see Section 16771), except that Vehicle Proximity Sensor data collected at the stations need only be reported to the Central Control System when it is used to override a schedule-

adherence-based countdown value. To minimize communications requirements, countdown values may be computed at the Control Center Consoles in real-time using schedule adherence, schedule, current time, and vehicle proximity sensor data provided by the ATSS server applications.

- c. The GUI for this function shall graphically accommodate display of data for other stations as they are added in future deployment phases (future stations are not part of this Contract).

04. Text Message Distribution

- a. The message control software shall support all of the functions described in Section 16774, Subsection 2.03, paragraphs D and E, in addition to the functions described in the following paragraphs.
- b. The operator shall be able to generate text advisory messages on train services, such as delays, accidents, closures, etc. for any sign, any station, any group of stations, any line, and the system as a whole. The operator shall be able to select message destinations so that messages will appear on any user-defined group of VMS units. The operator shall have the ability to create “zones”, or logical sign groupings.
- c. The software shall include a message editor similar to a word processor, where messages are created, edited, and saved. The software shall allow the operator to preview the VMS messages in motion on the Control Center Console screen, just as they will appear on the VMS displays. Operators shall be able to select any available commands using the mouse.
- d. The software shall allow text messages to be sent with user-selectable automatic expiration times, including display indefinitely (no expiration). Such messages shall be sent with user-selectable priority such that they can override default countdown value displays or be displayed interspersed with countdown values.
- e. The software shall have the capability to allow the operator to transmit messages using a variety of message scheduling parameters. Messages may be scheduled using combinations of date, day of week, and

time of day. Messages may be set up to display at specified intervals or scheduled to display at some time in the future.

- f. The software shall support text formatting options such as left, center, and right line justification, kerning, font selection, stroke width, and flashing characters. Each character in a display shall be individually formattable.
- g. The software shall also support flashing, alternating, and multi-page displays. For flashing displays, the flash rate shall be selectable in half-second increments. For alternating displays, the amount of time each page is displayed shall be selectable in half-second increments. For multi-page displays, pages shall be displayed either sequentially or in a vertical scrolling manner with each line held momentarily for continuity.
- h. Messages may be manually created or stored as part of a master library of messages. The user interface shall allow for viewing and management of the stored message library from a central location, including remote updating of the message libraries stored at each station.
- i. All messages shall be subject to a pre-defined list of acceptable vocabulary that is modifiable only by an authorized CTA supervisor.
- j. The software shall include utilities for spell checking, blocking of selected words and phrases, printing messages, and rapidly searching and locating specific messages in the message library.
- k. The ATSS shall support one or more operator-selectable advisory message preambles, such as a flashing "Rider Alert" message, before the advisory message is displayed. The characteristics of this preamble, including font, flashing frequency, text content, shall be programmable in advance by authorized users via the GUI.
- l. The display of variables maintained at the Station Sign Controller, such as countdown time and time of day, shall be able to be included in any message without the need to transmit updated variable values in real-time from the Central Control System.

- m. The software shall be able to cause any combination of VMS to enter a blank Standby Mode when initiated from a Control Center Console. Likewise, when such commands are initiated from Station Consoles, this status shall be reported immediately and asynchronously to the ATSS Central Control System. Such abnormalities shall be reported as an alarm on one or more software-selectable Control Center Consoles.

05. Health Monitoring

- a. The operator shall be able to monitor the receipt of health confirmation messages for any station or group of stations from the Control Center Consoles.
- b. The GUI shall report any abnormalities detected by any Station Sign Controller, VMS, Vehicle Proximity Sensor, or Station Console as an alarm on one or more software-selectable Control Center Consoles.

06. Internet Interface

- a. The operator shall be able to turn off reporting of schedule adherence, countdown, and advisory message information to the Internet at any time.

07. Context-Sensitive Help

- a. The Control Center Console software shall contain an integral, context sensitive help system. The help system shall contain a description of system commands and parameters, examples of command usage, error message definition, cross reference to related commands, parameters, and topics, and a topical search function.

C. Database Requirements

- 01. Static Schedule Database: The CTA uses a Hastus scheduling system developed by Giro of Canada to produce its master timetable. The timetable is stored in an Oracle database. A copy of this database will be made available on the CTA surrogate server.

- a. The Contractor will be required to develop an interface with this database to allow station-specific queries of the timetable to be distributed to the Station Sign Controllers without human intervention.

- b. The schedule stored in the Station Sign Controller shall be automatically updated each time the schedule used by the ATDMS to compute schedule adherence values is updated.
 - c. As a read-only user of the CTA ATDMS timetable database, the ATSS shall have no capability to write changes to the database.
02. Dynamic Schedule Adherence Database: The CTA ATDMS will store schedule adherence information, including route number, run number, schedule adherence, control point location, and time stamp of data collection in an Oracle version 8 database table on the CTA surrogate server. The table will consist of records for each active run on the CTA rail system.
- a. Schedule adherence values shall be recorded in multiples of one second, plus (late) or minus (early) scheduled arrival time at the control point at which the data is collected. A null schedule adherence value shall be used to signify a canceled run.
 - b. A run not represented in the system (e.g. not in the database of active runs) shall be assumed to indicate that the train has not yet departed the terminal.
 - c. The control point location at which data is collected shall be recorded in accordance with the Location Referencing Message Specification (LRMS) to establish a standard location referencing message framework for reporting train location and to facilitate transferring location data between service boards in the future.
 - d. As a read-only user of the CTA ATDMS database, the ATSS shall have no capability to write changes to the database.
03. ATSS Message Library: The message library shall contain pre-stored VMS messages in a format such that the most commonly used messages can be communicated by means of a shorthand reference, such as a standard Message ID number. The ATSS Central Control System shall be able to update the message libraries throughout the system remotely. Security of the message library will be maintained using password-protected UNIX file access management functions.
- a. The design of the message library shall support the storage of pre-stored audio messages associated with

the future integration of audio announcement functions with the ATSS text messaging system.

- b. The Central Control System server shall be capable of storing several thousand predefined text and audio messages. Operator-defined messages shall also be stored on the server. As all messages are stored on the server, operator-defined messages entered on one Control Center Console will be available for viewing, editing, and transmission on all other Control Center Consoles.
04. ATSS Data Dictionary: The ATSS data dictionary shall be designed as a logical structure for storing detailed information about data elements used by the system. It does the bookkeeping task for maintaining the data definition and defining how data can be retrieved, modified, and generated. The data dictionary shall be consulted whenever data retrieval or update operations are performed.
- a. As part of data dictionary, the metadata shall be defined to provide “data about data.” The metadata shall include at a minimum who (transportation agency in real world and software process in computer system) is responsible for generating and maintaining this data, the data life cycle (i.e., how often the data are being updated), data accuracy, and the coordinate system used if it contains information regarding spatial location.
 - b. A formal data definition language (DDL) shall be used to define data elements in an unambiguous way. This data definition language shall specify how the data are stored and define a set of access methods and instructions to facilitate the implementation details of data manipulation.
 - c. Every data flow included in the system architecture shall be defined in a data dictionary. Each data dictionary entry shall contain a textual description of the data flow and shall identify any lower level data elements that make up the data flow. The lower level data elements shall also be defined in the data dictionary.

2.04 COMMUNICATIONS

- A. NTCIP Compliance: All communications and interfaces associated with the ATSS shall be designed to pass NTCIP-compliance testing by the United States Department of Transportation.

- B. The communication between the ATSS Central Control System and Station Sign Controllers shall be accomplished using NTCIP-compliant technologies at a minimum data rate of 28,800 bits per second. The Contractor shall utilize either CORBA, DATEX-ASN or XML over TCP/IP for data exchange. Initially, PPP communications over leased telephone lines will be used for the locations in this Contract, with the option of connecting through ATM and SONET over CTA-owned fiber optic lines at a later date.
- C. All data packets, including headers, addresses, commands, cyclic redundancy check (CRC), and data shall be fully documented.

PART 3 - EXECUTION

3.01 GENERAL

- A. Install all system equipment in accordance with all Contract requirements, with approved Contractor Drawings and in a workmanlike manner.

3.02 CONTROL CENTER INSTALLATION

- A. Furnish and install all equipment, including servers, cables, and power supplies in the CTA Power and Communications Control Center in locations made available by the CTA. The contractor shall coordinate with CTA to determine all equipment locations before proceeding with development of Installation Drawings and installation.
- B. The CTA will provide access to existing Ameritech twisted pair cables at the Control Center. It shall be the responsibility of the Contractor to extend Ameritech service as necessary to the designated Station Sign Controller location at each station as shown on the Drawings.

3.03 INSTALLATION INSPECTION

- A. The Authority may inspect equipment wiring following completion of all installation at the Control Center to verify that all electrical power and communications and mechanical connections are made and properly secured, all hardware is installed in its proper location, and all wiring is properly terminated.

END OF SECTION 16770

**DIVISION 16
ELECTRICAL**

**SECTION 16771
STATION SIGN CONTROLLER**

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including the other sections of this Specification apply to this Section.

1.02 DESCRIPTION OF WORK

- A. The Contractor shall be responsible for providing a Station Sign Controller at each of the four stations above to compute countdown values, control Variable Message Signs (VMS), and monitor the health of field devices.
- B. The Contractor shall be responsible for providing the Station Sign Controller software applications required to control and monitor the ATSS subsystems at each station.
- C. The Contractor shall be responsible for providing all wiring and cabling necessary at each station for a complete and fully operational ATSS, including a Station Sign Controller, one or more VMS, interfaces with existing CTA PA system(s), Vehicle Proximity Sensors (intermediate stations only), interfaces with existing CTA Tower Consoles (terminal stations only) and Station Consoles ("field devices") as specified in the Drawings. All conduit, backboxes, and junction boxes shall be provided by the Contractor. Each field device requires both communications and power connections. The Contractor shall provide and install raceways, cables, and hardware necessary to:
 - 01. Supply 115 VAC power from the station's power distribution panels to the Station Sign Controller and each field device.
 - 02. Supply data circuit, conduit, and cable from the Station Sign Controller to each field device.

1.03 FUNCTIONAL REQUIREMENTS

- A. The Station Sign Controller provides the interface between the ATSS Central Control System and local transit station signs for sign control and performance monitoring. One Station Sign Controller shall be

provided at each station served by ATSS. For more information on the role of the Station Sign Controller in the overall ATSS system, see the System Architecture Diagram included in Section 01010 and the conceptual Data Flow Diagram included in Section 16770.

- B. The functions of the Station Sign Controller differ for terminal and intermediate stations. At terminal stations, the Station Sign Controller performs five main functions:
01. Countdown Value Computation: The Station Sign Controller shall compute countdown values based on schedule departure times and current time information received from the ATSS Central Control System. At the Authority's option, this function may be disabled in the demonstration.
 02. Next Train Display: Based on information provided by the Towerman via an interface (by Contractor) with the existing CTA Tower Console (by CTA), the Station Sign Controller shall direct VMS to identify the track on which the next train is departing. The Station Sign Controller shall also include a fully documented, NTCIP-compliant interface with a future audible track identification system furnished under separate contract.
 03. Train Departure Message Display / Announcement: When a train is expected to depart imminently from the station, the Station Sign Controller shall trigger pre-recorded "Train departing shortly" audio and text messages. The formats of these messages for each VMS are defined in Section 16774. At the Authority's option, this message shall be triggered either by computed countdown values or the Towerman via an interface (by Contractor) with the existing CTA Tower Console (by CTA). The Towerman currently illuminates a start light from the Tower Console shortly before departure that signals the Train Operator to close the doors and begin his or her run.
 04. Text Message Distribution: The Station Sign Controller shall distribute messages directed to platform, intermediate, and entrance VMS to the appropriate signs. To minimize communications for frequently recurring messages, the Station Sign Controller shall maintain a library of pre-recorded text and audio messages.
 05. Health Monitoring: The Station Sign Controller shall monitor the operating status of itself, the Station Console, and each VMS at the station and report confirmation of normal operations periodically or any abnormalities to the ATSS Central Control System.

- C. At intermediate stations, the Station Sign Controller performs five main functions:
01. Countdown Value Computation: The Station Sign Controller shall compute countdown values based on information received at various intervals from the ATSS Central Control System.
 02. Vehicle Proximity Monitoring: The Station Sign Controller shall receive signals from Vehicle Proximity Sensors associated with each boarding platform to trigger train arrival messages if they have not already been triggered by countdown values and to reset the countdown timer on the departure of the train. When VPS input is used to override normal countdown mode, the Station Sign Controller shall send a message to the ATSS Central Control System indicating this discrepancy between actual train movements and predicted train movements.
 03. Train Arrival Message Display / Announcement: When a train is expected to arrive imminently at the station, the Station Sign Controller shall trigger pre-recorded "Train arriving shortly" audio and text messages. The formats of these messages for each VMS are defined in Section 16770.
 04. Text Message Distribution: The Station Sign Controller shall distribute messages directed to platform, intermediate, and entrance VMS to the appropriate signs. To minimize communications for frequently recurring messages, the Station Sign Controller shall maintain a library of pre-recorded text and audio messages.
 05. Health Monitoring: The Station Sign Controller shall monitor the operating status of itself, each VMS, and each Vehicle Proximity Sensor at the station and periodically report confirmation of normal operations or any abnormalities to the ATSS Central Control System.

PART 2 - PRODUCTS

2.01 HARDWARE

- A. One Station Sign Controller shall be located at each station as shown in the Drawings. In general, these devices are located in the electrical room where other public address equipment is located.
- B. The Station Sign Controller shall consist of a rack-mounted Model 2070 Series Advanced Traffic Controller unit, as manufactured by Eagle Traffic Control Systems, or approved equal. Model 2070 controller dimensions are typically 177mm x 260mm x 483mm. The

controller shall be equipped with a real-time multitasking operating system such as OS-9 to handle real-time requests. The controller shall be equipped with any interface cards, expansion cards, or other manufacturer's options as required to provide the ATSS functions described in this Specification.

- C. Interface with Station Public Address System: The Station Sign Controller shall provide digitized train arrival or departure audio announcements over the existing public address (PA) system at the platform area and fare collection area of each station. The ATSS shall interface with the existing digital PA system by means of the "Train Arrival Trigger Circuit" on the station PA Controller Unit. In this manner, a single digitized audio message will be stored by the PA system for announcement when triggered by the ATSS. The ATSS shall be designed to support future integration of simultaneous audio and text messaging capability.
- D. Future Audio Capabilities
 - 01. It is intended that the ATSS will eventually support simultaneous announcement of pre-stored and newly-generated audio messages with pre-stored and newly-generated text messages. These messages shall be transmitted to station PA equipment via the Station Sign Controller. The Contractor shall design the ATSS system to support such data traffic. The increased communications bandwidth required for this function is expected to be provided as part of a future upgrade of center-to-station communications to CTA-owned optical fiber. Sufficient communications bandwidth for this function is thus not required to be installed as part of the demonstration, however, software and hardware designs shall be scalable for future additive enhancement without duplication or replacement of products provided as part of the Contract.
 - 02. It is intended that the ATSS will eventually include a directed audio announcement system for guiding visually impaired persons to the next train departing from terminal stations. The Contractor shall design the Station Sign Controller to provide the required information to this system and fully document the interface.

2.02 SOFTWARE

- A. General Requirements
 - 01. The Station Sign Controller software shall be implemented as firmware, i.e. stored in non-volatile, flash-upgradeable memory,

in the single Station Sign Controller module located at each station.

B. Terminal Station Sign Controllers: Specific software functional requirements for each of the main functions of Station Sign Controllers located at terminal stations (O'Hare and Midway) are listed as follows:

01. Countdown Value Computation

- a. Note: At the Authority's option, this function may be disabled at terminal stations in the demonstration.
- b. The Station Sign Controller shall compute countdown values to the departure of the next train based on schedule departure times and the current time.
- c. The ATSS shall derive the time until the next train departs a given station by identifying the next train scheduled to depart by run number, looking up its scheduled departure time, and looking up the current system time.
- d. The ATSS Station Sign Controller shall compute the raw countdown value by applying the following general formula no less frequently than once every ten seconds:

$$\text{Scheduled Departure Time} - \text{Current Time} = \text{Run Countdown Time}$$
- e. The Station Sign Controller shall format the raw countdown value for display on VMS by rounding to the nearest minute. For example, a countdown value of 340 seconds (5:40) would be displayed as 6 minutes.
- f. The Station Sign Controller shall be equipped with enough memory and have its own CPU and system clock to perform the countdown operation.
- g. The Station Sign Controller shall have enough memory to store at least eight types of daily schedules at that station, including schedules for five weekdays, Saturday, Sunday and at least one special day to accommodate regular and irregular transit operation.
- h. The "Countdown" VMS displays shall be formatted in accordance with Section 16774.

02. Train Departure Mode Display & Announcement

- a. When the raw countdown value is less than 90 seconds (1:30), the Station Sign Controller shall begin "Departure Mode" and display a pre-programmed alert message such as "Train departing shortly" on VMS located on the platform. On VMS located at entrances, in the fare collection area, and other intermediate locations, a flashing "2" shall be displayed in place of the countdown value.
- b. If a departure message is received from the interface (by Contractor) with the existing CTA Tower Console (by CTA) while the countdown value is being displayed (i.e. before Departure Mode begins), the Station Sign Controller shall immediately begin Departure Mode.
- c. The beginning of Departure Mode shall also trigger a chime and a digitized audio announcement, such as "All aboard ... train departing shortly", over the existing station PA system in the platform area.
- d. The "Departure Mode" VMS display shall be formatted in accordance with Section 16774.

03. Next Train Display

- a. The Station Sign Controller shall receive input from an interface (by Contractor) with the existing CTA Tower Console (by CTA) to indicate the track and/or platform on which the next train will depart.
- b. The VMS on the platform shall indicate the next train departing the station with a "Next train" message combined with an arrow. All other tracks shall be marked with VMS messages indicating "Do not board".
- c. The "Next train" VMS displays shall be formatted in accordance with Section 16774.

04. Text Message Distribution

- a. The Station Sign Controller shall receive advisory messages from the Central Control System and the Station Console and distribute them to the appropriate VMSs.

- b. When initiated from any Control Center Console or the Station Console, the Station Sign Controller shall cause any single VMS or group of VMS to enter a blank "Standby Mode". When this command is made from the Station Console, the Station Sign controller shall report this occurrence immediately and asynchronously to the ATSS Central Control System.
- c. Any Control Center Console or the Station Console shall also have the capability to return the display to the normal ("Next train") mode of operation. When this command is made from the Station Console, the Station Sign Controller shall report this occurrence immediately and asynchronously to the ATSS Central Control System.
- d. The content displayed on the ATSS VMS shall be managed at all times by a priority function. The system shall use priorities to manage users in the system, allowing higher priority users to preempt lower priority users. User priorities shall be user-definable in the Station Sign Controller, but shall initially be assigned as follows:
 - First Priority: Tower Attendant
 - Second Priority: Control Center Personnel
 - Third Priority: Station Attendant
 - Fourth Priority: Train Departing Shortly
 - Fifth Priority: Countdown and/or Next Train
- e. The Station Sign Controller shall use a message library synchronized with the ATSS Central Control System and individual VMS to transmit messages using a shorthand reference, such as a Message ID number.

05. Health Monitoring

- a. The Station Sign Controller shall monitor the operating status of itself, each VMS in the station subsystem, and the Station Console and report any abnormalities to the ATSS Central Control System on an asynchronous basis.
- b. The Station Sign Controller shall respond to requests for confirmation of normal operation from the ATSS Central Control System at the frequency specified in Section 16770.

C. Intermediate Station Sign Controllers: Specific software functional requirements for each of the main functions of Station Sign Controllers at intermediate stations (Cumberland and Davis) are listed as follows:

01. Countdown Value Computation

- a. The Station Sign Controller shall compute countdown values to the arrival of the next train in each direction based on schedule arrival times, the current time, and the most recent schedule adherence information for the next train scheduled to serve the station as received from the ATSS Central Control System.
- b. The ATSS shall derive the time until the next train arrives at a given station by identifying the next train scheduled to arrive by run number, looking up its scheduled arrival time, looking up its most recent reported schedule adherence value, and looking up the current system time.
- c. If schedule adherence is not being reported for the next train (i.e. it has not yet departed the terminal), a value of zero shall be assumed for schedule adherence until the train begins its run.
- d. If the schedule adherence value is null (indicating that the run has been cancelled), the algorithm shall skip to the next scheduled train.
- e. The ATSS Station Sign Controller shall compute the raw countdown value by applying the following general formula no less frequently than once every ten seconds:
$$\text{Scheduled Arrival Time} - \text{Current Time} + \text{Schedule Adherence} = \text{Run Countdown Time}$$
- f. The Station Sign Controller shall format the raw countdown value for display on VMS by rounding to the nearest minute. For example, a countdown value of 340 seconds (5:40) would be displayed as 6 minutes.
- g. If schedule adherence values change such that formatted countdown values increase by two minutes or less, the most recently displayed countdown value shall be held until computed countdown values are less than the displayed value.
- h. If schedule adherence values change such that formatted countdown values increase by more than two minutes, a

pre-programmed alert message such as “Minor service delay”, shall be displayed.

- i. The Station Sign Controller shall be equipped with enough memory and have its own CPU and system clock to perform the countdown operation.
- j. The Station Sign Controller shall have enough memory to store at least eight types of daily schedules at that station, including schedules for five weekdays, Saturday, Sunday and at least one special day to accommodate regular and irregular transit operation.
- k. The “Countdown” VMS displays shall be formatted in accordance with Section 16774 and the Drawings.

02. Train Arrival Mode Display & Announcement

- a. When the raw countdown value is less than 90 seconds (1:30), the Station Sign Controller shall begin “Arrival Mode” and display a pre-programmed alert message such as “Train arriving shortly” on VMS located on the platform. On VMS located at entrances, in the fare collection area, and other intermediate locations, a flashing “2” shall be displayed in place of the countdown value.
- b. If an arriving vehicle is detected by the Vehicle Proximity Sensor while the countdown value is being displayed (i.e. before Arrival Mode begins), the Station Sign Controller shall immediately begin Arrival Mode.
- c. The beginning of Arrival Mode shall also trigger a chime and a digitized audio announcement, such as “Caution ... train arriving shortly”, over the station PA system in the platform area.
- d. The “Arrival Mode” VMS display shall be formatted in accordance with Section 16774 and the Drawings.

03. Text Message Distribution

- a. The Station Sign Controller shall receive advisory messages from the Central Control System and from the Station Console and distribute them to the appropriate signs.

- b. When initiated from any Control Center Console or the Station Console, the Station Sign Controller shall cause any single VMS or group of VMS to enter a blank "Standby Mode". When this command is made from the Station Console, the Station Sign controller shall report this occurrence immediately and asynchronously to the ATSS Central Control System.
- c. Any Control Center Console or the Station Console shall also have the capability to return the display to the normal (countdown) mode of operation. When this command is made from the Station Console, the Station Sign controller shall report this occurrence immediately and asynchronously to the ATSS Central Control System.
- d. The content displayed on the ATSS VMS shall be managed at all times by a priority function. The system shall use priorities to manage users in the system, allowing higher priority users to preempt lower priority users. User priorities shall be user-definable in the Station Sign Controller, but shall initially be assigned as follows:
 - First Priority: Control Center Personnel
 - Second Priority: Station Attendant
 - Third Priority: Train Arriving Shortly
 - Fourth Priority: Countdown
- e. The Station Sign Controller shall use a message library synchronized with the ATSS Central Control System and individual VMS to transmit messages using a shorthand reference, such as a Message ID number.

04. Health Monitoring

- a. The Station Sign Controller shall monitor the operating status of itself, the Station Console and each VMS and Vehicle Proximity Sensor in the station subsystem and report any abnormalities to the ATSS Central Control System on an asynchronous basis.
- b. The Station Sign Controller shall respond to requests for confirmation of normal operation from the ATSS Central Control System at the frequency specified in Section 16770.

2.03 COMMUNICATIONS

- A. NTCIP Compliance: All communications and interfaces associated with the ATSS shall be designed to pass NTCIP-compliance testing by the United States Department of Transportation.
- B. Station Consoles to Station Sign Controllers: The signal shall be transmitted using PPP and FSK modems over twisted-pair copper wire at a minimum data rate of 9,600 bits per second. At a minimum, display information shall be accomplished using communications technologies in accordance with NTCIP 1203 (NTCIP Object Definitions for Dynamic Message Signs). All data packets and signals, including headers, addresses, commands, cyclic redundancy check (CRC), and data, shall be fully documented.
- C. Vehicle Proximity Sensors to Station Sign Controllers: The signal shall be carried using twisted-pair copper wire. Special attention to attenuation is needed if wire runs exceed 800 feet. All signals and interfaces shall be fully documented.
- D. Station Sign Controllers to Variable Message Signs: The communication between the Station Sign Controllers and Variable Message Signs shall be accomplished using communications technologies in accordance with NTCIP 1203 (NTCIP Object Definitions for Dynamic Message Signs) at a minimum data rate of 9,600 bits per second. Multiple signs may be supported on the same channel using PMPP and FSK modems over twisted-pair copper wire. Signs installed on their own channel shall use PPP and FSK modems over twisted-pair copper wire. All data packets, including headers, addresses, commands, cyclic redundancy check (CRC), and data and interfaces shall be fully documented.

PART 3 - EXECUTION

3.01 STATION INSTALLATION

- A. Furnish and install Station Sign Controllers, Vehicle Proximity Sensors, Station Consoles, Variable Message Signs, interfaces with existing CTA Tower Consoles and PA systems, and all wiring and wiring devices required to complete each station installation throughout the station. Cable distribution to the various station and platform components shall meet the requirements of related sections of this Specification.
- B. Furnish all rack-mountable equipment with sufficient hardware to install the equipment in new open racks.

- C. Verification of Conditions: Examine the areas to receive the work and the conditions under which the work would be performed. The Contractor shall remedy any conditions detrimental to the proper and timely completion of the work.
- D. Upon completion of the work, repair surfaces that have been permanently stained, marred or otherwise damaged. Replace work which is damaged or cannot be adequately cleaned as directed.
- E. Upon completion of work, remove unused materials, debris, containers and equipment from the project site. Clean the work as recommended by the manufacturer.

END OF SECTION 16771

**DIVISION 16
ELECTRICAL**

**SECTION 16772
VEHICLE PROXIMITY SENSORS**

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including the other sections of this Specification apply to this Section.

1.02 DESCRIPTION OF WORK

- A. The Contractor shall furnish and install: All electrical work, materials and accessories indicated schematically by drawings, schedules and specified herein which include, but is not limited to, the following:

- 01. Electrical power systems
- 02. Radar vehicle detector units
- 03. Communication and power cables
- 04. Separately derived systems
- 05. Enclosures
- 06. Equipment

1.03 FUNCTIONAL REQUIREMENTS

- A. The Vehicle Proximity Sensor shall provide a redundant train arrival warning system to the ATDMS-based system used for normal countdown operations.
- B. The Vehicle Proximity Sensors shall detect train arrival at intermediate rail rapid transit stations not less than 10 seconds before the train reaches the approach end of the platform at normal running speed.
- C. The Vehicle Proximity Sensor shall send a contact closure-type signal to the Station Sign Controller indicating imminent train arrival. This signal will be used by the Station Sign Controller to start Arrival Mode if it has not begun already based on ATDMS-derived schedule adherence information.

PART 2 - PRODUCTS

2.01 MATERIALS

A. General

01. All Equipment and component parts furnished shall be new, be of the latest design and manufacture, and be in an operable condition at the time of delivery and installation. All parts shall be of high quality workmanship, and no part or attachment shall be substituted or applied contrary to the manufacturer's recommendations and standard practices.
02. The design shall be such as to prevent reversed assembly or improper installation of connectors, fasteners, etc. Each item of equipment shall be designed to protect personnel from exposure to high voltage during equipment operation, adjustments, and maintenance.
03. The designed Mean Time Between Failures (MTBF) of the Vehicle Proximity Sensor unit, operating continuously in its application, shall be 10 years or longer.

B. Environmental

01. Except as stated otherwise herein, the equipment shall meet all its specified requirements during and after subjecting to any combination of the following:
 - a. Ambient temperature range of -37 to +74 degrees C.
 - b. Relative humidity from 5 to 95 percent, non-condensing.
 - c. Power surge of 6 KV - 10,000 amps.
02. The design shall be inherently temperature compensated to prevent abnormal operation. The circuit design shall include such compensation as is necessary to overcome adverse effects due to temperature in the specified environmental range.
03. Except as may be otherwise stated herein for a particular item, no item, component, or subassembly shall emit a noise level exceeding the peak level of 55 dBa when measured at a distance of one meter away from its surface.
04. The detector shall include surge protection in accordance with IEEE Standard C62.41 - 1980 Category C.

05. The detector shall be resistant to vibration in accordance with IEC 68-2-30 (test Fc), NEMA TS-1 (Section 2.1.12), or approved equivalent. The microwave detector shall be resistant to shock in accordance with IEC 68-2-27 (test Ea), NEMA TS-1 (Section 2.1.13), or approved equivalent.

C. Capabilities:

01. The detector shall be of the microwave type.
02. The detector shall be a true presence detector which can provide presence and occupancy information on up to eight discreet detection zones. This information shall be available to ATSS controllers via contact closure pairs and via serial communications lines.
03. Each detector shall transmit on a frequency band of 10.525 GHz +/-25 Mhz or another approved spectral band. The detector shall comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC rules or the appropriate Spectrum Management Authority. The detector shall not interfere with any known equipment, including two-way radio communication and Automatic Train Control (ATC) signal systems. Transmitter power shall not exceed 10 milliwatts (mW).
04. The detector unit shall be operable from either 12 - 24 VAC/DC dissipating 6W, or 95 - 135 VAC @ 60 Hz. Power supply shall be obtained from the power distribution assembly within the ATSS controller cabinet.
05. The communications interface shall consist of a single MS connector which provides power to the unit, output contact closure wire pairs for each of the required detection zones rated at 200V AC/DC 100 mA, and serial communication lines for programming, testing or modem interface at 9600 Baud rate. Data format of the serial port shall be standard binary NRZ 8 bits data, 1 stop bit, no parity.
06. A UV-resistant cable of multiple twisted pairs of stranded AWG #20 or #22 wires with a common shield rated at 300V with a temperature rating of 105° C (Belden #9516 or approved equal) will provide connection between the RVD and the cabinet equipment.
07. The MS connector pins must be crimped to the cable conductors and assembled and tested prior to installation and pulling of cable on site.

08. The junction box or cabinet to house the RS 232 connector must be located within sight of the desired detection zones in order to initially set up the sensor or to alter the set-up at a later date.
09. The detector's field of view shall cover an area defined by an oval shaped beam and its maximum detection range shall be as follows:
 - a. Elevation Beam Width 45 degrees.
 - b. Azimuth Beam Width 15 degrees.
 - c. Range 10 to 200 feet.
10. The maximum number of detection zones that may be defined shall be no less than six (6). The range limits of each zone shall be user defined in 7 ft. resolution.
11. The detector shall identify vehicle (train) presence within each detection zone with a 100% accuracy, independent of the train's direction of travel through the detection zone.
12. The detection zones shall be set up using the provided software and a Notebook PC.

D. Training

01. Work under this item shall consist of providing qualified instructors and all materials for training the Authority's and other designated personnel in the operation and maintenance of the detector. All training sessions shall be conducted locally.
02. Training shall consist of formal classroom lectures as well as "hands-on" training, working with the actual equipment. One day shall be provided for a training session.
03. A "day" of training shall consist of 7 hours. The attendance of each session shall be of no more than 6 people

2.02 MANUFACTURERS

- A. Acceptable Vehicle Proximity Sensor manufacturers shall be EIS, or approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. The Contractor shall install the equipment in strict accordance with the approved shop drawing and the equipment manufacturer's instructions.
- B. The microwave radar detector shall be enclosed in a rugged weatherproof box and sealed to protect the unit from wind up to 90 mph, dust and airborne particles, and exposure to moisture (NEMA type 3R enclosure). The overall dimensions of the box, including fittings, shall not exceed 8-inches x 10-inches x 6-inches. The total weight of the microwave radar detector assembly shall not exceed 5 pounds.
- C. The detector shall be mounted in Side-fired configuration. It shall be mounted on the train platform structure at the specified locations, using the supplied mounting brackets. The brackets shall be attached with approved stainless steel mounting hardware of sufficient strength to support 100 pounds.
- D. The Contractor shall install the detector unit at a sufficient height above the track surface so that the train is the only object that will trigger the detector and that all detection zones are contained within the specified elevation angle as suggested by the manufacturer.
- E. The equipment shall be installed with work space clearances required by the Code.
- F. The equipment shall be installed to permit maintenance and replacement of parts, and shall be clear of all openings with swinging or moving doors, partitions or access panels.
- G. The mounting assembly shall have all painted steel, stainless steel, or aluminum construction, and shall support a load of 20 pounds. The mounting assembly shall incorporate a ball-joint, or other approved mechanism, that can be tilted in both axes, then locked into place, to provide the optimum area of coverage.
- H. Installation shall have no effect on train service or station operations. Where required, CTA will provide flagmen to protect Contractor's workers at Contractor's expense. Contractor shall pay for CTA safety training of any personnel required to work in proximity to moving trains or at track level.

END OF SECTION 16772

**DIVISION 16
ELECTRICAL**

**SECTION 16773
STATION CONSOLES**

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including the other sections of this Specification apply to this Section.

1.02 DESCRIPTION OF WORK

- A. Furnish and install: All electrical work, materials and accessories indicated schematically by drawings, schedules and specified herein which include, but is not limited to, the following:
 - 01. Electrical power systems
 - 02. Station Console at all rail rapid transit stations (Cumberland, Davis, O'Hare, and Midway)
 - 03. Communication and power cables
 - 04. Separately derived systems
 - 05. Enclosures
 - 06. Equipment

1.03 FUNCTIONAL REQUIREMENTS

- A. The Station Console shall be installed in the Terminal Supervisor booth on the platform at each terminal station and in the Customer Assistant booth near the fare payment area at each intermediate station.
- B. The Station Console has two primary functions:
 - 01. It shall permit the Terminal Supervisor or the Customer Assistant to display not less than four (4) pre-stored messages at any time. These messages shall override the normal countdown display on selected Variable Message Signs (VMS). Not all messages will necessarily be displayed on all VMS, but the distribution of messages will be programmed in advance from the Central Control System. The Station Sign Controller

shall contain the logic for determining which VMS displays are overridden by actions initiated from the Station Console.

02. It shall permit the Terminal Supervisor or the Customer Assistant to place the local ATSS system at the station in Standby Mode at any time.
- C. Both Station Console initiated actions described in subsection 1.04.B above shall be reported to the ATSS Central Control System by the Station Sign Controller.

PART 2 - PRODUCTS

2.01 MATERIALS

A. General

01. All Equipment and component parts furnished shall be new, be of the latest design and manufacture, and be in an operable condition at the time of delivery and installation. All parts shall be of high quality workmanship, and no part or attachment shall be substituted or applied contrary to the manufacturer's recommendations and standard practices.
02. The design shall be such as to prevent reversed assembly or improper installation of connectors, fasteners, etc. Each item of equipment shall be designed to protect personnel from exposure to high voltage during equipment operation, adjustments, and maintenance.

B. Environmental

01. Except as stated otherwise herein, the equipment shall meet all its specified requirements during and after subjecting to any combination of the following:
 - a. Ambient temperature range of -10 to +60 degrees C.
 - b. Relative humidity from 5 to 95 percent, non-condensing.
 - c. Power surge of 6 KV - 10,000 amps.
02. The design shall be inherently temperature compensated to prevent abnormal operation. The circuit design shall include such compensation as is necessary to overcome adverse effects due to temperature in the specified environmental range.

03. Except as may be otherwise stated herein for a particular item, no item, component, or subassembly shall emit a noise level exceeding the peak level of 55 dBA when measured at a distance of one meter away from its surface.

C. Capabilities:

01. The Station Consoles shall contain momentary contact switches as required to support the functional requirements.
 - a. Each switch shall be labeled with its pre-programmed function.
 - b. Switches that initiate pre-stored messages shall be identified with interchangeable labels to support changing of the messages associated with each switch.
02. The Station Consoles shall contain a backlit LCD display showing the current message being displayed on the platform VMS.
 - a. The LCD display shall be readable in all ambient lighting conditions in the Customer Assistant booths and the rail operations towers. The display shall have an operator-adjustable brightness and contrast control.
 - b. The LCD display shall be surrounded with a scaled-down representation of the ATSS platform sign that it represents.
03. The Station Consoles shall not be larger than 30 cm x 30 cm x 6 cm and shall be self-supporting for desk- or wall- mounting.
04. The Station Consoles shall communicate with the Station Sign Controller over twisted-pair copper wire using NTCIP-compliant communications protocols.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. The Contractor shall install the equipment in strict accordance with the approved shop drawings and the equipment manufacturer's instructions.

END OF SECTION 16773

**DIVISION 16
ELECTRICAL**

**SECTION 16774
VARIABLE MESSAGE SIGNS**

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including instructions to Proposers and sections of this Specification apply to this Section.

1.02 DESCRIPTION

- A. The work shall consist of the final design, manufacture, provision, installation, test, and acceptance of twenty-one (21) custom designed variable message signs (VMS) for demonstration purposes at two CTA rail rapid transit terminal stations (Midway Airport and O'Hare Airport) and two intermediate stations (Cumberland Avenue and Davis Street-Evanston).

1.03 REFERENCES

- A. The following is a listing of the publications referenced in this Section:
 - 01. National Transportation Communications for ITS Protocol (NTCIP) Refer to Section 16010.
 - 02. Pantone Match System (PMS) Specifications for Printing Inks
 - 03. American Society for Testing and Materials (ASTM)
 - a. ASTM A36 - Specification for Structural Steel.
 - b. ASTM B209 - Specification for Aluminum and Aluminum-alloy Sheet and Plate.
 - c. ASTM B-221 - Specification for Aluminum-Alloy Extruded Bars, Rods, Wire, Shapes, and Tubes.
 - d. ASTM D256 - Test Methods for Impact Resistance of Plastics and Electrical Insulating Materials.
 - e. ASTM D523 - Test Method for Specular Gloss.

- f. ASTM D790 - Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
 - g. ASTM D1003 - Test Method for Haze and Luminous Transmittance of Transparent Plastics.
 - h. ASTM D1004 - Test Method for Initial Tear Resistance of Plastic Film and Sheeting.
- 04. American Welding Society (AWS)
 - a. AWS D1.1 - Structural Welding Code, Steel.
 - b. AWS D1.2 - Structural Welding Code, Aluminum. Standard Code for Arc and Gas Welding in Building Construction.
 - 05. National Association of Architectural Metal Manufacturers (NAAMM) - Metal Finishes Manual
 - 06. National Association of Plastics Fabricators Specifications
 - 07. National Electrical Manufacturers Association (NEMA) - Standards Publication LD3-1980
- B. Comply with the following codes and standards:
- 01. The Americans with Disabilities Act of 1990
 - 02. National Fire Protection Association (NFPA) regulation
 - 03. Occupational Safety and Health Act of 1970 (OSHA) Standards
 - 04. Underwriters Laboratory (UL) Standard 48
 - 05. Electrical Testing Laboratories, Inc. (ETL)
 - 06. Electronic Institute of America (EIA)
 - a. EIA/TIA-323-232-E Interface Between Data Terminal Equipment and Data Circuit Terminating Equipment Employing Serial Binary Data Interchange
 - b. EIA-422-A Electric Characteristics of Balanced Voltage Digital Interface Circuits
 - 07. National Electrical Code (NEC)

08. Federal Communications Commission (FCC)

1.04 DESCRIPTION OF WORK

- A. The Contractor performing the work of this Section shall include all labor, materials, tools, equipment, and service required to design, engineer, fabricate, deliver, finish and install all items necessary for the proper execution and completion of said items of work, as shown on the Contract Drawings, as specified herein and/or as required by job conditions to provide a complete installation.
- B. The work shall consist of the following at the four demonstration sties.
 - 01. Removal and disconnection of existing CTA Variable Message Signs (VMS) and mounting stanchions/brackets at eleven (11) locations and replacement with new ATSS/VMS signs, mounting stanchions/brackets. At these locations utilize, as much as possible, the existing power and signal feeds to these signs.
 - 02. Removal and disconnection of existing CTA internally illuminated directional static signs and mounting stanchions/brackets at seven (7) locations and replacement with new ATSS/VMS signs, mounting stanchions/brackets. At these locations, a dedicated power feed must be provided and signs should not be on the lighting circuit. New signal conduit/cabling must be provided. The Contractor shall be responsible for carefully removing and delivering to CTA in good (same as existing) condition any electronic or static signs that are removed for ATSS. Many of these signs will be reused.
 - 03. Installation of new ATSS signs and stanchions/brackets at three (3) locations where no existing VMS or static directional signs exist. Install conduits with power and signal feeds to these locations.
- C. The Contractor's work shall include, but not be limited to:
 - 01. The Contractor shall verify the static and variable messages to be displayed on each sign with RTA and CTA. Design VMS matrices to accommodate full range and sizes of messages to be displayed. Coordinate with the RTA and CTA the removal of existing signs and replacement with new signs so that no gaps in the wayfinding signage system are created.
 - 02. The Contractor shall finalize the design and completely fabricate and install twenty-two (22) new sign boxes per specifications and drawings. Integrate VMS matrices and components into sign design to achieve monolithic appearance and meet

functional requirements. Apply the static messages to the second surface of face panels per the processes specified herein and per finalized legends and layouts developed by the Contractor and approved by the RTA and CTA.

03. The complete design and fabrication of these signs shall include all the necessary components, i.e., lamps, ballasts, fuses and wiring to accommodate the VMS components, i.e., matrices, power packs and controller cards for a completely functional system.
04. The messages, layout and width of sign types indicated on layouts are conceptual, and are intended only as a basis for cost estimation. Minor changes to messages and panel widths may occur after award of the Contract. Develop layouts of each permanent and temporary sign based upon the finalized sign legends and guidance provided by the referenced layouts and general layout standards on drawings. Report any messages which do not fit on the panel to the RTA and CTA.
05. The Contractor shall field verify each sign location to insure the sign fits within the space indicated on drawings. Check each mounting location for specific physical conditions, strength of architectural structural members, and sightlines in relation to the viewing approach and existing signs in the vicinity and report any conflicts to the Authority.
06. The Contractor shall configure electrical components, i.e., lamps, ballasts and wiring in new boxes to accommodate VMS components, i.e., matrices, power packs and controller card(s) and to meet applicable UL or ETL standards. The Contractor shall also design and install VMS and other electrical components for front face access to matrices and other internal electrical components. Upon removal or hinging of VMS matrix, all components and wiring interconnections should be visible for servicing and diagnostic testing.
07. The Contractor shall evaluate heat build-up within boxes and provide the proper ventilation required to maintain program operating temperature and humidity range.
08. The Contractor shall design and engineer all wiring or electrical connections, fuses, etc., in sign boxes to capacities required to support maximum combined electrical load of VMS and static portions of signs.

09. The Contractor shall connect electrical power and signal feeds to signs, and all internal wiring and connections. Furnish and install hubs, pull and hookup signal cabling through new conduit, between station controllers and ATSS locations.
 10. The Contractor shall provide final design and engineering of mounting methods, number and spacing of supports necessary for sign weight and loading requirements, balanced loading of sign framing and achieve level (no sagging) appearance throughout width of signs. Provide consistency of support spacing for ease of interchanging sign at same locations.
 11. The Contractor shall coordinate with the Authority and finalize interface issues to insure VMS functions as intended and specified herein. Coordinate connection with station sign controller and central control system for compatibility and NTCIP compliance.
 12. The Contractor shall provide a laptop computer loaded with local ATSS control software for each matrix type and for local downloading of messages or diagnostic testing.
- D. Signs to be fabricated and installed are identified on the legends that follow and are indicated on plans, supplemented with these technical provisions. Graphic standards and conceptual design are indicated on drawings. External shape and form of signs shall follow standards established. Contractor shall determine construction methods to achieve appearance and function indicated and specified.
- E. The Contractor shall be responsible for the final design, structural and electrical engineering and structural integrity of signs and mountings.
- F. Prior to commencing shop drawings, the Contractor shall fabricate a sample single faced VMS 5'-2" wide x 22" high representative of the production model with recommended facing material. This sample shall be programmed to display typical countdown and advisory messages in varying character heights and interline spacings.
- G. The Variable Message Signs and Internal Controllers shall operate successfully throughout a temperature range of -34 degrees Celsius (-30°F) to +60 degrees Celsius (+140°F) and throughout a relative humidity range of 0 to 100% non-condensing. The cooling and ventilation system shall be engineered to maintain the operating temperature.
- H. The presence of ambient radio signals, magnetic or electromagnetic interference, including those from ballasts, transformers, or motors within one foot of any component of the system, shall not impair the

performance of the system. The system shall not radiate any electrical or electromagnetic signals that could adversely affect any other electrical or electronic device in accordance with FCC Part 15 regulations.

- I. Performance of the ATSS and Internal Controller equipment shall not be impaired due to continuous vibration caused by train induced structural vibration or HVAC air movement.
- J. The LED VMS message shall be sharp and clearly visible and legible by pedestrians from horizontal viewing conditions between distances of 4' and 60' under ambient lighting conditions present at each sign location.
- K. The signs and VMS faces shall be optimally aimed at each location to maximize visibility and legibility of messages and to minimize LED cutoff effect for approach viewing conditions.
- L. The Contractor shall be responsible for furnishing the VMS electronic engineering services required to develop hardware, select electronic components and materials, develop wiring/interconnect diagrams, translate specifications into a finished operational system, develop the Test Program, Quality Control Program, Operations and Maintenance Manual, and to furnish all shop and final as-built drawings, and provide routine and emergency maintenance.
- M. The Contractor shall comply with all applicable rules and policies in effect by CTA working on CTA and airport property.
- N. Materials, design, detailing, fabrication, and erection shall conform to the following:
 - 01. City of Chicago Building Code, Latest edition
 - 02. AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings
 - 03. AWS D1.1 Structural Welding Code, Steel
 - 04. AWS D1.2 Structural Welding Code, Aluminum
 - 05. AA Specifications for Aluminum Structures
- O. Details shown on the Drawings shall be followed for visual appearance. The internal construction indicated may be changed after prior approval by the Authority's Authorized Representative.

P. Structural Design Criteria:

01. Provide signs capable of carrying total supported load (including hangers, supports, and attachments) and wind loads specified below. Wind load shall be considered to be acting on the total sign area - in all directions.
 - a. Overhead signs shall be designed to sustain an additional 300-pound concentrated load per support.
 - b. Overhead signs installed under canopies slabs or mounted on concrete beams shall be supported from structural framing and subframed as required. Provide and install any required subframing.
 - c. Suspended sign assemblies shall be designed to prevent buckling, opening up of joints, and overstressing in members and connections that would cause permanent deformation or structural failure.
02. Wind Load: Exterior Signs: 80 miles per hour

Q. Design Calculations: Submit complete design calculations covering all structural and electrical elements (including connections), sign framing (including any required structural steel sub-framing not shown elsewhere on the Contract Drawings), sign supports and their anchorage to the existing building, prior to the preparation of Shop Drawings and prior to any fabrication.

1.05 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Provide signage produced by a single manufacturer with not less than five years experience in the design and fabrication of sign assemblies involving quantities and complexities at least equal to those required for the Work of this Section.
- B. Installer's Qualifications: All signage systems specified in this Section shall be installed by an entity that has no less than five (5) years experience in the installation of systems involving quantities and complexities at least equal to those required for the Work of this Section and is acceptable to the signage manufacturer for the sign type or graphic process involved.
- C. Completed Work: Completed work shall be structurally sound, free from scratches, abrasions, distortions, chips, breaks, blisters, holes, splits or other disfigurements considered as imperfections for the specific material.

- D. The VMS manufacturer shall have been in the business of designing/manufacturing VMS systems equal to that specified in this Section for a minimum of three (3) years. This manufacturing should include amber LED outdoor type full-matrix LED VMS and control systems.
- E. The VMS equipment furnished under this Contract shall have been satisfactorily installed and operated in at least three different sites with similar environmental conditions and in applications of similar or equivalent complexity to that specified in this Contract, for a period of not less than two (2) years.
- F. The LED VMS and all associated field control equipment shall be furnished by the same manufacturer.
- G. All electrical materials and equipment used for which there are established Underwriters Laboratories (UL) and Electrical Testing Laboratories (ETL) standards shall bear the UL and ETL labels. These labels shall be affixed inside the sign cabinet.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Product Delivery and Storage: Deliver graphic materials in protective wrapping, and store protected from weather, moisture and soiling. Coordinate on-site storage with the Authority.
- B. All materials delivered shall be properly stored and handled to prevent deterioration or damage due to moisture, temperature change, contaminants, vandalism, or other causes.
- C. The LED VMS enclosures shall be supported for their full lengths during shipment. Structures shall be shimmed, braced, blocked, and tied down to prevent distortion or other damage from occurring during transportation. The use of any device, which does not support the member for its entire length, shall not be permitted.
- D. The Contractor shall repair any signs or equipment damaged in shipment or installation.

1.07 SUBMITTALS

- A. General: Submit in accordance with the documentation requirements of Section 16010, Subsection 1.09. Additionally for VMS submit:
 - 01. Product Data: Submit manufacturer's product data for each type of sign, including details of construction relative to materials, dimensions of individual components, profiles, and finishes.

02. Design Drawings: Submit design drawings showing fabrication and erection of temporary and permanent signs. Include plans, elevations, and large-scale sections of sign boxes and their supports, showing typical members and other components. Show anchors, grounds, layouts, and reinforcement. Indicate all materials required for a complete installation. All design drawings will be according to CTA standards, including Authority contract number and title that appears on Contract Drawings.
 - a. Provide message list for each sign required, including large-scale details of wording and lettering layout.
 - b. Submit Design Drawings showing the full details of all field splices in the sign structures and sign faces.
 - c. Submit Design Drawings showing internal construction of all signs.
 - d. Submit Design Drawings indicating all electrical fixtures and required electrical connections into existing circuits.
 - e. Light Emitting Diode manufacturer's technical specification sheets showing compliance with the requirements of Subsection 2.03, Paragraph F.
 - f. LED VMS matrix sizes, pixel arrangements and fonts.
 - g. Matrix driver and display boards.
 - h. Controller cards.
 - i. Method of applying messages and luminous intensity of sign faces.
 - j. External and internal framing extrusions.
 - k. Methods of mounting signs to facility.
 - l. Cut-off angles for VMS display — vertical and horizontal.
03. Wiring Diagrams: Submit wiring diagrams for VMS components and illuminated sign units.
04. Samples: Review of samples shall not preclude the rejection of the completed work. After a material has been reviewed, no change in brand, make, series or model will be permitted without the Authority's Authorized Representative's prior approval. Samples shall show anticipated range of color and/or

texture. The Authority's Authorized Representative may require additional submissions if the range of samples submitted are not satisfactory. Submit 12 inch x 12 inch samples for each type of material and finish to be used for the sign boxes and sign faces.

- B. Calculations: Submit structural and electrical design calculations.
- C. VMS Electrical Design Drawings
 - 01. System Block Riser Diagram illustrating the interrelationship among the various components, including a functional drawing defining the operational configuration of the LED VMS, the sign controller and all other required control and communications devices.
 - 02. Diagram of system power and communications interconnection wiring, broken down into "factory" and "field" wiring.
 - 03. One-line diagram of power service requirements for each location in the VMS System, broken down by electronics, illumination and, if present, environmental controls such as ventilation.
 - 04. Details of fixed LED-dimming circuit.
 - 05. Drawings for each LED VMS showing configuration and arrangement of matrix display units and pixel arrangement and configuration on each display unit, to obtain the specified number of characters per line, number of lines and character display. Typical message displays using the proposed configuration shall be included.
 - 06. Design of any ventilation, heating and cooling systems required for the sign enclosure or any other equipment enclosures. Indicate methods to secure and eliminate any light leaks.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to each of the following manufacturers certifying that their VMS and sign controllers comply with the requirements of NTCIP 1203, the LED display components of signs, display drivers, and associated VMS equipment, shall be designed and manufactured by one of the following or approved equal:

01. American Electronic Sign
Spokane Industrial Park
Building 10
3808 North Sullivan Road
Spokane, WA 99216-1670
02. Daktronics, Inc.
P. O. Box 4128
331 32nd Avenue
Brookings, SD 57006
03. Data Display
5004 Veterans Memorial Highway
Holbrook, NY 11741
04. Doyle Signs, Inc.
232 Interstate Road
Addison, IL 60101
05. Hitech Electronic Displays
13900 US Highway 19N
Clearwater, FL 33764
06. Signature Technologies
3728 Benmer Road
Miamisburg, OH 45342
07. Vultron, Inc.
2600 Bond Street
Rochester Hills, MI 48309
08. White Way Sign
1317 Clybourn Avenue
Chicago, IL 60610
09. Young Electric Sign Co.
5119 South Cameron
Las Vegas, NV 89118

- B. Other manufacturers may be considered if they meet the Quality Assurance Criteria defined in Section 16010, Subsection 1.06, and are subject to approval by the Authority's Authorized Representative. Substitutions must be requested in writing, along with documentation of Qualifications and Experience, 10 days before bid due date.

2.02 MATERIALS

- A. General: Provide materials, which have been selected for their surface flatness, smoothness and freedom from surface blemishes wherever exposed to view in the finished unit. Exposed surfaces, which exhibit pitting, seam marks, roller marks, "oil canning", stains, discolorations, and other imperfections will not be acceptable for installation.
- B. Aluminum Support Posts: Provide aluminum tube extrusions of external size and shapes as shown on the Contract Drawings. Posts shall have a 1/8" minimum wall thickness and of alloy and temper recommended by aluminum producer for the type of use and finish indicated, and with not less than the strength and durability properties specified in ASTM B221 and 6063-T5.
- C. Aluminum Sheet: Provide aluminum sheet of alloy and temper recommended by the aluminum producer or finisher for the type of use and finish indicated, and with not less than the strength and durability properties specified in ASTM B 209 for 500-H15.
- D. Aluminum Extrusions: Provide aluminum extrusions of alloy and temper recommended by the aluminum producer or finisher for the type of use and finish indicated, and with not less than the strengthened durability properties specified in ASTM B221 for 6063-T5.E.
- E. Aluminum Bars and Shapes: Provide aluminum bars and shapes of alloy and temper recommended by the aluminum producer or finisher for the type of use and finish indicated, and with not less than the strength and durability properties specified in ASTM B221 for 6063-T5.
- F. Polycarbonate, where specified, shall be as manufactured by General Electric Company (Lexan), XL Sheet clear polycarbonate with low glare finish first side. Polycarbonate shall be of a self-extinguishing type, which conforms to applicable building codes. Polycarbonate shall be of the thickness and finish as indicated on the Contract Drawings.
- G. If low glare finish is applied as a secondary process to polycarbonate face it shall be Vuegard 901 Anti-Glare Coating or equivalent by Panelgraphic Corporation – 54 gloss finish.

- H. Vinyl Film: Provide computer-cut vinyl, pressure-sensitive legends, 3M Company Scotchcal or approved equal. Execute computer-cutting in such a manner that all edges and corners of finished letterforms are true and clean. Letterforms with round positive or negative corners, nicked, cut or ragged edges, etc., will not be acceptable.
- I. Fasteners: Use the same material as items fabricated, unless otherwise specified. Provide types, gauges and lengths to suit unit installation conditions. Fasteners shall be installed so as to be concealed from view, unless otherwise indicated.
- J. Anchors and Inserts: Provide non-ferrous type metal anchors and inserts. Use epoxy type anchoring systems for interior and exterior installations. Manufacturer: Hilti, Inc., or other approved manufacturer of epoxy anchoring systems.
- K. Mastic Sealant: Polyisobutylene; nonhardening, nonskinning, nondrying, nonimmigrating sealant.
- L. Gaskets: Tubular or fingered design of neoprene or polyvinyl chloride, or block design of sponge neoprene.
- M. Lamps: Fluorescent lamps shall be manufactured by General Electric, Sylvania, North American Phillips, Westinghouse, or Durotest, and be selected for energy efficiency and maintenance efficiency. Lamp sizes shall be standard sizes, no custom or special size lamps and kept to the smallest number required to lamp each sign type. Provide T8 lamps to provide 9,000 lumens /25 foot candles average illumination.
- N. Ballast: Provide exterior grade Universal Magnetek electronic ballast, rapid start that comply with Certified Ballast Manufacturers Association standards and carry the CBMA label.

2.03 CONSTRUCTION

- A. General: All work shall be fabricated to the concept design and layouts shown on the Contract Drawings and the approved Contractor's Design Detail Drawings and shall be first class workmanship in accordance with the best trade practices. All cutting, fabrication, and assembly shall be done in the factory and shipped to the job site as one complete unit. All joints, corners, miters, splices, etc., shall be accurately machined, filled, fitted, filed, and rigidly framed together at joints and contact points and painted smooth to give a monolithic appearance and imperceptible joints. All mechanical fasteners shall match color and finish of the area sign where they occur. All surfaces shall be smooth with unblemished finish. There shall be no visible connections, unless otherwise shown.
01. All welding shall be in accordance with the Standard Code for Arc and Gas Welding in Building Construction of the American Welding Society. All welding shall be performed by AWS Certified welders.
 02. Perform engineering and internal construction of all signs; provide for all anchorages. Include required provisions for electrical fixtures and required connections into sign circuits. Determine and provide electrical circuits capable of supporting the load imposed by signing.
 03. All surfaces shall be covered with a non-deleterious protective cover to protect the finish for protection until final installation or erection.
 04. Take field measurements prior to preparation of Design Drawings and fabrication. Do not delay job progress; allow for trimming and fitting when taking field measurements, before fabrication, that might delay work. Coordinate with support fabricator.

- B. Welding, Brazing, and Soldering: Comply with American Welding Society (AWS) D1.1 and D1.2, National Association of Architectural Material Manufacturers (NAAMM) Metal Finishes Manual, for recommended procedures in welding, brazing, and soldering. Use filler metals that will blend with and match the color of sheet metal being used and the required exposed finish appearance of the metals. Continuously weld, braze, or solder corners and seams, and grind smooth and flush on exposed surfaces. Discoloration or stains between base metal and filler metal will not be acceptable for exposed portions of natural metal finish.
01. Clean, preheat, heat, flux and sweat solder through full contact area of surfaces to be joined, in accordance with the best standards of practice in modern sheet metal shops. Remove all flux residue and foreign matter after soldering. Rinse all soldered areas with water and wipe clean.
 02. Form closures and trim members to the profiles shown using the gauge sheet metal shown. Furnish all components required for support and installation of closures and trim. Fabricate closures and trim to tightly close with adjoining work. Finish all exposed edges of all trim and closure strips. All joints in exposed work shall not vary more than 1/32 inch in either width or alignment.
 03. Locate fasteners to be concealed wherever possible; otherwise to be as inconspicuous as possible. Size fasteners to securely support the work and space to prevent buckling or waviness of the finished surface. Exposed fasteners shall be countersunk, and filled to match adjacent finish.
 04. Drill and tap holes required for securing closures to other surfaces. All fasteners shall be countersunk flush to surface, unless shown otherwise.
 05. Provide continuous concealed support at joints to hold meeting faces in flush alignment. Miter or cope trim members at corners to form tight joints.

C. Typography:

01. Font Style Helvetica Medium is the standard for all static sign messages, unless shown otherwise on the Contract Drawings. It is called out in the Contract Drawings as "Helvetica Medium". This is the generic name, which refers to the type styles shown on the Contract Drawings. Symbols and Arrows: Symbols and arrows, including train and bus symbols, roller curtain representations, wheelchair accessibility symbols, directional

arrows, etc., shown shall be the standard design of CTA as indicated in the Contract Drawings.

02. Visual rendition of static messages shall match existing signs in brightness, finish and other appearance characteristics.
03. Messages: Prepare full-scale fabrication message patterns from sign panel layouts in accordance with Sign Schedules and as shown on the Contract Drawings. Sign panel layouts shall be enlarged for position only, and shall not be used for photographic reproduction. Provide full-size patterns for typical messages.

D. Variable Message Sign Functional Requirements

01. Internal VMS Controller will provide the ability to operate the VMS in the following modes:
 - a. Static Message – the message chosen shall be displayed constantly on the sign face until the sign controller is instructed to do otherwise.
 - b. Flashing Message – a selected line or lines of the chosen message(s) shall be displayed and blanked alternately at durations separately controllable in ½ -second increments.
 - c. Multi-Page Message – The chosen message shall display up to three different pages alternately at durations separately controllable in ½-second increments.
 - d. Display effects - instant, flash, vertical and horizontal scroll, travel, and roll.
02. The signs shall be capable of displaying multiple stroke width and height characters, with control via control system software and varying the kerning (letter spacing) between individual characters to improve legibility.
03. Time required to change a message (from the Station Sign Controller to the VMS display) shall not exceed 500 milliseconds.
04. In the event of communication errors or controller lock-ups, the sign shall retain the current advisory message. In the event of a power failure, the sign shall display the current advisory message upon restoration of power. The VMS portion of signs

shall have the capabilities of locally blanking messages without affecting static messages.

05. Characters – signs shall display a message composed of any combination of the following characters and shapes in 5x7, 6x9, 10x14, and 20 x 28 character fonts:
 - a. “A” through “Z” – all upper case letters and all lower case letters
 - b. “0” through “9” – all decimal digits
 - c. A blank or space.
 - d. Punctuation marks shown in following brackets: [. , ! ? – ‘ ‘ “ “ / ()]
 - e. Special characters shown in following brackets: [# & * + < >]
 - f. An airport symbol that represents the American Institute of Graphic Arts / Department of Transportation (AIGA / DOT) airport / air transportation symbol as closely as possible using VMS pixels
 - g. CTA train and bus symbols that represent the standard graphic symbols used by the CTA as closely as possible using VMS pixels
 - h. Full matrix signs shall be capable of graphic displays upon upgrade of software in the Central Control System and Station Sign Controllers. Capability for upgrade shall be within the Contract price (no additional cost to the Authority).
06. All messages shall be in upper and lower case initial caps unless specified otherwise.
07. Signs shall be full matrix, and all matrix modules among sign types shall be interchangeable and replaceable.
08. The signs shall be capable of displaying simultaneously lines of text using a standard font and condensed font and all caps and upper and lower case. The operator shall have the option of condensing font by line to fit message on matrix.
09. The signs shall allow the ability to display variable interline spacing, column widths, full width, and single columns. They

should also allow the ability to display messages other than countdown in information.

10. Each VMS shall have the brightness of the display adjusted for optimal contrast under all ambient lighting conditions. The luminance contrast ratio between the display and ambient illuminator should be greater than or equal to 0.1. For low ambient illumination the ratio should be greater than or equal to 9.0. This adjustment shall be electronically controlled at locations where ambient light levels vary by an optic sensor or equivalent.

E. Message Format: All VMS shall be programmed to accomplish the display of messages in accordance to the requirements per their location.

01. Advisory and Other Information

- a. At all locations capability of displaying preprogrammed and “live” visual messages. “Live” messages shall be displayed within four (4) seconds of transmission of the “live” message from any of the Central Control System Control Center Consoles. “Live” messages are defined as being unique, created at the time of need to respond to specific conditions.
- b. The ATSS shall display information provided by CTA Control Center staff under the following conditions:
 - Delays: When real-time arrival time cannot be estimated,
 - Disruptions: When service will not be available,
 - Platform Changes: When the boarding point for the next vehicle will vary from the schedule (such as “board on center platform” or “board bus on far side”),
 - Service Changes: When service will not be provided as scheduled, such as express operations where transit vehicles skip stops,
 - Alternate Service: When use of alternate transit routes or lines is suggested due to service disruptions, delays or other reasons,

- System-wide Disruptions: When inclement weather or electrical problems inhibit service on a widespread basis, and
 - Route Changes: When transit routes will be modified due to construction or incidents.
- c. Advisory messages shall contain information in the following general order: the problem, the result, the action required.
 - d. The ATSS shall function as a visual paging device for ADA compliance when auditory announcements are made.
 - e. The ATSS shall be capable of displaying the following types of information not strictly related to transit service provided by CTA Control Center staff:
 - Station emergency, such as fire,
 - Security issues,
 - Safety issues,
 - Current time of day,
 - Current ambient temperature, and
 - Community events information
 - f. The ATSS shall display information in a fixed (non-phased) manner whenever possible, especially in circulation areas.
 - g. When complete messages cannot be displayed in a fixed manner, messages shall be displayed sequentially, with each segment on display for a duration of 10 to 20 seconds.
 - h. Sentences that cannot be displayed in a fixed manner shall be scrolled vertically one line at a time, momentarily holding the second line for continuity.
 - i. When advisory messages exceed the display capacity and must be presented sequentially, information shall be presented in the following general order: the problem, the result, the action required.

- j. Advisory messages and ADA-compliant visual paging messages shall be given priority over real-time displays and shall be preceded by a flashing “Rider Alert” preamble. This message shall be the default preamble, but alternative preambles shall be stored and shall be definable and selectable at any Control Center Console.
- k. In the event of a malfunction or communications lapse, a default message shall be displayed.
- l. The VMS shall be capable of entering a blank Standby Mode when commanded from any Control Center Console or Station Console.

02. Countdown Information

- a. At all sign locations, VMS shall have the capability of displaying message in accordance to those requirements described in Section 16771, Subsection 1.04 for terminal and intermediate stations.
- b. At station entrances as shown on plans display two 4” high lines displaying the estimated arrival of the next train in each direction of travel.
- c. At side platform stations as shown on plans two lines of 4” high text “Minutes to next train” and the 8” high countdown number.
- d. At center platforms only the 8” high countdown number to be displayed on each end of the display associated with the direction of travel. The numbers on each end of the matrix must operate independently from each other based upon schedule adherence for each direction of travel.
- e. Countdown displays shall be capable of displaying up to 999 minutes. In the rare cases when three digits must be displayed, a condensed font may be used to minimize constraints on sign layout.

F. Light Emitting Diode (LED) Display Modules

- 01. LED Display Pixel Technology: Display pixels shall incorporate daylight readable light emitting diode (LED) technology with variable luminous intensity levels to ensure that proper legibility is maintained under all ambient light conditions.

02. Each sign type VMS matrix shall have superbright discrete monochrome T-1-3/4 (5.08 mm) second generation AlInGaP amber LEDs manufactured by Toshiba or approved equal by Hewlett Packard or Sharp. The LED used shall be Toshiba part number TLYH156P or approved equal. The center to center spacing of the pixels should be 0.3" (7.62mm).
03. The discrete amber LEDs shall have the following optical characteristics:
 - a. 592 nanometer wavelength
 - b. Intensity: 1200 millicandela @ 20 milliamps
 - c. Viewing angle 30 degrees (half power angle)
04. The peak forward current used to drive the LEDs shall be a minimum of 20 milliamps, but shall not exceed 25 milliamps. The LEDs shall be the most efficient for power consumption available at the time of fabrication of the sign face.

The LEDs shall have an ultraviolet light inhibitor in the epoxy dome package and be of a production type already tested for use in high vibration commercial traffic environments and climate of the north-central United States.

The manufacturer's discrete LED data sheet shall be provided with the VMS submittal.

05. The LEDs used in the display shall be obtained from batches sorted for luminous output, where the highest luminosity LED in the batch shall not be more than fifty percent more luminous than the lowest luminosity LED in the batch. To ensure uniformity of display and operational life, all LEDs used to make up a display module shall be obtained from the same manufacturing batch.
06. The LED mean time before failure (MTBF) shall be a minimum of 100,000 hours of permanent use at an operating temperature of 140 degrees Fahrenheit, when driven at the specific forward current used for normal daylight LED VMS display operation. As part of the LED manufacturer's technical specification sheet submittal, the specific forward current shall be noted.

07. The LEDs used in the display shall have a high temperature operating life (HTOL) performance, at an ambient temperature of 131 degrees Fahrenheit, while driven at a direct current of 30 milliamps, as follows:
 - a. A maximum of 15% reduction in light output after 1000 hours.
 - b. A maximum of 25% reduction in light output after 100,000 hours.
08. The Contractor shall submit LED manufacturer's certification that the lamps being used by the LED VMS manufacturer, for the work of this Contract, meet or exceed the design and performance requirements of Subsection 2.03, paragraphs F 1 thru 3 herein. The certification shall include the batch and bin numbers of the LEDs to be used.
09. The LED display modules shall have a minimum refresh rate of 100 frames per second.
10. The LED VMS shall have a dimming system, which allows automatic or manual dimming modes based upon twenty levels from the sensed ambient light. The LED VMS shall have a photocell-controlled dimming circuit, which shall automatically adjust the luminance of the sign display pixels adjusted for viewing through a tinted sign face in accordance with ambient light conditions. As part of the Contractor's shop drawing submittal, a complete schematic of the LED display power, driver and dimming circuits shall be provided for approval by the Authority's Authorized Representative.
11. The VMS sections of signs shall consist of discrete LEDs arranged in a full matrix display. Character based matrix arrangements shall not be acceptable. Each LED shall be individually installed and separately connected to the circuit board. The centers of all pixels shall be spaced so as to maintain the same horizontal and vertical clearances between adjacent pixels. All pixels shall be replaceable. The LED grouping and mounting angle shall be optimized for maximum readability.
12. The electronics for the LED VMS shall be fully configured to drive the total number of LEDs making up a matrix. The failure of one discrete LED shall not affect the operation of others. The power driver circuitry shall be designed to minimize power consumption. The VMS Controller shall have the ability to

detect the failure of an LED display module, down to the pixel level, and report the failure via the sign protocol to the Central Control System via the Station Sign Controller.

13. The LED driver electronics and display module assembly shall be easily disconnected from other boards making up the matrix. Failure of any display module shall not affect the operation of the remaining module.
14. The LED VMS shall be protected from degradation due to sunlight. The method used shall not obstruct the view of the display or reduce the viewing angle below that provided by an unprotected LED VMS. The method and design of the LED VMS sunlight protection shall be approved by the Authority's Authorized Representative.
15. LED Pixel Board Construction: The LED display boards of varying size and number of pixels shall be wave-soldered into a double-sided printed circuit board.

During the wave solder process, the discrete LEDs shall be precision-jigged to ensure that they remain perpendicular to the PC board and can therefore be accurately and effectively aimed toward the intended users.

No driver electronics or other components shall be located on the LED display printed circuit boards.

16. Display Module Construction: A display module shall consist of an aluminum panel to which a varying number of pixel strips are attached. Holes, which are the same diameter as the pixels, shall be punched in the front of the panel and shall allow all the LED light to pass through without hindering pixel intensity or viewing angle.

All module surfaces, which are visible from outside the VMS, excluding the LED pixels, shall be painted flat black in order to provide maximum display contrast and readability.

One electronic driver shall be securely attached to the back of each module and shall control that module.

17. Electronic LED Driver Circuitry: Driver circuitry shall be configured for full matrix operation and flexibility in the display of varying character heights, stroke widths, letter spacing, line spacing and, in the future, graphic displays.

18. Serviceable Parts: Excluding the VMS pixels, all serviceable parts, including driver boards and power supplies, shall be accessible from the front of the VMS.

Display modules, drivers and other internal VMS assemblies shall be removable from the VMS with either simple hand tools or no tools required. The removal of one or more display modules shall not alter the structural integrity of the sign display assembly, nor of the sign cabinet.

Additionally, the removal of any display modules shall not affect the operation of the remaining display modules.

G. VMS Controller Functional Requirements

01. Full Matrix Display Presentation – The VMS Controller shall control the driver modules in such a way as to create the desired display on the sign. At a minimum, the signs shall be able to display the characters as described in Subsection 2.03 D. Space allocated to each character shall be proportional to the character's true width. The VMS Controller shall support at least six (6) downloadable fonts, which can be transferred into non-volatile memory from any communication port. The VMS Controller shall also control flash and alternating between pages of a two- and three-page display.
02. Display Selection – In the absence of instructions to the contrary from the remote control port, the VMS Controller shall implement a display selected from those stored in its memory based upon data received from the Station Sign Controller system. The VMS Controller shall be able to maintain a library of not less than 60 different display messages and related parameters in non-volatile electronic memory.
03. The display of the scheduled message may be overridden by instructions sent from the Central Control System or a laptop connected to the VMS Controller. A remote computer shall be able to cause the VMS Controller to implement a particular display selected from the messages stored in its memory, or a new display entered through the remote computer. A remote computer shall also be able to edit or completely replace a message stored in the VMS Controller's memory, or revise the message schedule. In addition, it shall be able to cause the VMS Controller to report its schedule or the text of any message stored in its memory.

04. Software shall incorporate fail-safe procedures to check messages received and shall not change a message stored in memory, the display currently on the sign, the schedule stored in memory, or the current time unless the message is received correctly.
05. Normally, a display shall remain on the sign until either a command to change the current display or the schedule in the VMS Controller's memory indicates that it is time for a different display. However, it shall be possible to confer a "priority" status to each stored message. If the priority status is higher than the status of the message that it is to replace, the new message shall remain on the sign indefinitely until a new command rescinds the priority. When the VMS Controller receives a command to change the sign display while a priority display is on the sign, the VMS Controller shall transmit a response indicating that the new command was ignored because of the priority status of the current display.
06. The VMS Controller shall meet the following minimum requirements:
 - a. Real time clock and temperature control
 - b. Sign testing standards: FCC, part 15 Class A; ETL/UL-48 and UP-1452
 - c. Communication - full duplex RS-232/RS-422 serial port for laptop computer and modem per Section 16771, Subsection 2.03 for Station Sign Controller
 - d. Memory: 256KB
 - e. High reliability, solid state flash ROM for non-volatile memory
 - f. Watchdog timer performs automatic system reset
 - g. Address: I-240 setting
 - h. Processor: Intel 386 EX-25 MHz microprocessor
 - i. Built-in message scheduling
 - j. Software Interface: Refer to Sections 16770 and 16771

H. Illuminated Sections of Signs:

01. Sign housing shall be aluminum extrusions with integral top hinges and prop rods. Painted finish of hinged or removable sign surface shall be acrylic polyurethane.
02. Graphics shall be applied to second surface using opaque and transparent films as required and shown on sign layouts. Provide internal light baffles to isolate light leaks between fluorescent lamps and LED matrix.
03. All wiring within the sign shall be installed in accordance with the National Electric Code and shall be neatly arranged and supported.
04. Each ballast shall be individually fused in a manner approved by CTA.
05. All wire terminals, taps and other electrical connectors shall be of an approved swagged, clinched or positive clamping type. Plain soldered lugs with no means of mechanically holding the wire without solder will not be permitted.
06. All lamps, ballasts, and fuses shall be arranged so that they will be readily accessible to maintenance. Lamps and ballasts shall comply with the requirements of the materials section of this Specification. Maximum wattage shall be as indicated on the Contract Drawings and herein. Provide suitable lamps for interior and exterior use as required for even illumination of messages. Evidence of "hot spots" or "cold spots" in the sign face will not be acceptable.
07. All illuminated signs shall be connected to the station dedicated power circuitry and shall be rated 120 VAC. Provide all conduit and conductors to the service entrances in the signs for the purpose of providing power to the lamps.
08. Illuminated signs shall be provided with vent holes protected with insect screening. Vent holes shall be adequately light proofed.
09. Signs shall have an inconspicuous external power cut-off switch exact location and type to be approved by CTA.
10. All electrical equipment, wiring and connections shall comply with requirements of Section 16010.

11. Primary power source is 120 VAC. Verify at each station, provide step down transformer if power feeds used for signs are not 120 VAC.
12. Use separate power hookup to primary power source for VMS and static portions of sign. Malfunction or failure of either VMS or static portions shall not affect the operation of the other.
13. UL labels shall be applied to the inside of cabinets. No Contractor-applied labels will be permitted on exterior of cabinets.

2.04 VMS CONTROLLER AND STATION SIGN CONTROLLER INTERFACE

- A. The VMS Controller shall be capable of interfacing with the Station Sign Controller and Central Control System software to accomplish all functions described in Section 16770 and Section 16771.
- B. Communication – the VMS Controller shall be able to communicate with the Central Control System via the Station Sign Controller. In polled operation, there will be regularly scheduled communication between each VMS Controller and the Central Control System via the Station Sign Controller. Each VMS Controller shall be assigned a unique ID number so that it will only receive messages meant for the specific sign. In the polled wired operation, controllers never initiate communication, but merely transmit their responses to commands or queries from the Central Control System. The Central Control Center shall query each VMS Controller via the Station Sign Controller frequently about its current status in order to monitor health and detect problems.

Local communication involves attaching a laptop computer directly to the sign controller's external serial port. Upon any status changes initiated either locally or through the Central Control System, the VMS Controller shall automatically update the Central Control System. The VMS Controller shall support both communication modes sequentially; if a local controller is attached, commands from the Central Control System will have to wait for local control to end.

- C. Diagnostic Test – upon command from the Central Control System or a local computer, the VMS Controller shall test the electrical operation current of all drivers. The VMS Controller shall analyze the pixel current and determine whether the pixel is operating with “normal,” “under,” or “over” current and shall communicate the result to the Central Control System. Diagnostic tests shall use, at a maximum, the 75 percent usage wattage.

- D. Power Interruptions – the contents of the VMS Controller’s memory shall be preserved by battery power during power interruptions and the VMS Controller shall resume operation automatically when power is restored. Upon recovering from a power interruption, the VMS Controller shall leave the current display on the sign until it receives a command to change it, or until a message change is called for by its schedule. For countdown messages, the VMS Controller shall display no countdown value after power restoration until it has received updated information from the Station Sign Controller. Also, the VMS Controller shall report to the Central Control System that it has just recovered from a power interruption.
- E. Software Duplication Rights – The Authority shall have the right to duplicate the VMS Controller software as needed for use in controlling signs under its jurisdiction.

2.05 VMS ELECTRICAL REQUIREMENTS

- A. All equipment supplied shall operate from 120 volts \pm 20 volts, 60 Hz \pm 1 Hz, unless otherwise noted on the Contract Drawings. Any and all transformation equipment required shall be supplied by the Contractor. The equipment shall have surge suppressors and have automatic recovery from a power failure and shall be "brownout" and "transient" protected.
- B. All wiring and conduits shall be in accordance with the requirements of the NFPA-70, or any local codes having jurisdiction at the installation site, and as shown on the Contract Drawings or specified herein. No wiring shall be exposed.
- C. Electrical field connections shall be provided by barrier type terminal connection blocks as defined in NEMA Standard Specification No. TS-1. All terminal block connections shall be identified and readily accessible for maintenance. All wire and cable terminations shall be made with insulated spade terminals as defined in NEMA Standard Specifications No. TS-1. Soldering of field terminal connections shall not be permitted.
- D. The circuit number of all cables and wires shall be identified by cable tags attached to each of the cables or wires in all junction boxes, sign panels and cabinets. The cable tags shall be secured to the cable or wire with nylon cable ties. All wires shall be neatly laced into cables with nylon lacing, or approved equal. All cables shall be secured with nylon cable clamps. Spare wires shall be properly terminated and identified as such. All wires shall be neatly routed to their connections.

- E. All conduit connections to the sign enclosures shall be watertight and allow for adjustment of the sign enclosures for optimum viewing. Methods and materials used shall be approved by the Authority's Authorized Representative, prior to installation of the signs. Power and communications cables connected to the LED VMS shall be run in separate conduits. The running of power and communications cables in the same conduit shall not be acceptable.
- F. Where a cable or wire passes through a hole or runs along a surface at any point through or on a completed assembly, such holes and/or surfaces shall be deburred and void of any sharp edges that may damage the cable or wire passing through or along the surface. All deburred holes shall be equipped with a rubber or plastic grommet. If penetrating a fire rated wall, maintain (or return to) the required fire rating.
- G. Cable:
 - 01. The cable type, gauge and number of conductors shall be indicated on Shop Drawings and comply with data cable specifications in Section and as required to meet functional and code requirements. Individual conductors shall be color-coded as per IMSA Specifications 19-1 and 19-3.
 - 02. Cable used shall be in accordance with Section 16010 and 16100 of these Specifications. All cables used shall be listed as approved for that use in accordance with NFPA-70, or any local codes having jurisdiction. VMS control cables shall be protected by grounded metal oxide varistors -- one varistor for each wire in the cable.
 - 03. Unless otherwise specified, cable splices will be permitted only in pullboxes, junction boxes and utility manholes. Cable splices in conduits shall not be permitted.
 - 04. If joints or splices are necessary, they shall be made only if special approval is granted by the CTA. They shall be compression type with Raychem heat shrink type with type S waterproof sealant. The conductors shall be thoroughly cleaned immediately prior to splicing/ joining, with a minimum of insulation.
- H. Sign enclosure connections:
 - 01. The gauge of all insulated wires between various parts and components shall be of adequate size, in accordance with NFPA-70, or any local codes having jurisdiction. All sign

enclosure wiring shall be in accordance with NEMA Standard Specification No. TS-1 or approved equal.

02. All terminal blocks and strips located within the sign enclosures shall be accessible to the extent that it shall not be necessary to remove any equipment from the housing to make an inspection or connection.
03. All wires shall be cut to their proper length before assembly. No wire shall be doubled back to make up for unnecessary slack. However, sufficient slack shall be provided such that any wire end can be cut back, re-stripped and connected at least twice. Panduit type wire management shall be used within all cabinets.
04. All electrical connections in the sign enclosures shall have sufficient clearance between each terminal and the housing so as to prevent a leakage path or physical contact under stress. The lay of the interconnect cables between components shall be such that when the housing door is closed, it will not press against the cables or force the cables against various components inside the housing. Plug-in locking connectors shall be provided on each driver board for all connections.
05. The ground side of service shall be carried throughout all sign enclosures without a break. All equipment grounds shall run directly and independently to the ground bus. The grounding strip shall be connected directly to the housing wall. Grounding shall be in accordance with Division 16 of these Specifications.

I. Circuitry Protection:

01. Appropriate devices shall be installed in the sign enclosure to protect the LED VMS electronics from over-voltage situations and power surges over the lines.

J. Component Identification

01. Each printed circuit and higher level assembly shall be clearly marked with the manufacturer's part number and the revision level of the assembly. Changes to components shall be indicated by an unambiguous change to the marked revision level. A master revision level list shall be maintained, by the Contractor, until the VMS is installed and accepted by CTA.
02. All electronic parts (such as capacitors, resistors and integrated circuits) shall be marked, either with the characteristics of the part or with an industry standard part number. Custom parts, such as Read Only Memories, shall be labeled to identify the

information, the revision level, date and checksum of the information stored.

03. All printed circuit card cages, all slots within the cages and all printed circuit card interconnection cables shall be clearly labeled. Printed circuit cards and cable connectors shall be keyed to prevent insertion into incorrect locations.
- K. All printed circuit boards shall be FR4 or G10 fiberglass epoxy material (phenolic is not acceptable), with two ounce copper circuits, double-sided with plated-through holes. All connectors and connector fingers shall be gold plated. Each board shall have a moistureproof conformal coating.
- L. VMS Power Supplies
01. The LED display modules shall be operated at low internal DC voltage not exceeding 24 Volts.
 02. The LED display modules shall be powered by regulated DC power supplies.
 03. The power supplies shall be rated for at least 25% spare capacity over that required to light every pixel on the line.
 04. The power supplies shall be short circuit protected by DC power OFF, and shall reset automatically after five seconds or AC power OFF. The power supplies shall also be protected by an overload allowance ranging from 105% up to 135% and by a suitable inrush current allowance to be recommended by the manufacturer.
 05. The power supplies shall have an efficiency rating of at least 75%.
 06. Calculations that prove that adequate power supply capacity has been designed into the VMS shall be provided with the VMS submittal. These calculations shall account for both power supply efficiency and performance derating at high temperatures.
 07. The power supply data sheet shall be supplied with the VMS submittal.
 08. Power supplies shall be UL listed.

M. Electronics

01. All system electronics shall be of 100% Solid State technology with the exception of ventilation fans.
02. All high voltage (exceeding 24 Volts DC) electronic and electrical components used in the LED display or the field controller shall be UL listed.

N. VMS Electrical Service

01. Surge Suppression and Protection - The necessary equipment to protect all VMS components from electric and electromagnetic surges shall be supplied as part of the VMS assembly. This shall also include all components, circuits, and accessories needed to adequately protect internal Controller from damage due to voltage surges. All protection devices shall be readily accessible for ease of replacement.
02. Data Line Protection - An data line surge suppressor shall be provided inside the VMS cabinet for the connection with the Station Sign Controller and the RS-232 serial port.
03. Power Consumption - The internal controller and LED VMS shall not exceed the maximum during testing and normal operation the maximum available power supply.

Contractor shall submit the total estimated maximum power requirements for each sign type based upon matrix design, including fans, ventilation, air conditioning, and other electrical equipment with shop drawing submittal. Power consumption should be broken down by components and stated as watts.

2.06 SHOP FINISHING

- A. Signs - General: All materials comprising a sign shall be finished with a coating system compatible with that material; appropriate preparatory work/priming shall be done in accordance with the finisher's specifications unless specified otherwise. All exposed surfaces, edges and connections shall receive the same finish system.
 01. All housings shall be painted with Matthews Acrylic Polyurethane manufactured by Matthews Paint Company, 400 S. Mercantile Ct., Wheeling, IL 60090.

- B. Metal Finishes: Comply with NAAMM “Metal Finishes Manual” for finish description and application recommendations, except as otherwise shown and specified.
 - 01. Sheet Aluminum: Clean, treat and prime sheet aluminum in the shop. Apply shop finish to all surfaces of the fabricated units, whether exposed or concealed when installed.
 - a. Prior to painting aluminum, the surface shall be cleaned of all dirt, oil, grease and other foreign material.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Before manufacture or procurement of equipment, submit detailed specifications, catalog cuts and design drawings outlining the construction and operation details of all equipment for prior approval by the Authority’s Authorized Representative as specified in herein. No equipment shall be procured for the VMS until the Authority’s Authorized Representative has given written approval.
- B. Incorporate into shop drawings, matrices, Controllers and other equipment all modifications affecting system operation control procedures, and hardware obtained through the testing and demonstration program and other submittal reviews.
- C. If the Contract Drawings indicate that the VMS are to be installed within static sign panels, the Contractor shall verify the static messages and layouts and coordinate the VMS design and manufacture with the fixed sign panel design and manufacture to ensure that proper provisions are made so that the LED VMS will fit properly and securely within the static sign panel.
- D. Comply with the manufacturer’s product data and published instructions for material installation requirements. Where manufacturer’s representative offers recommendations (oral or written) on material use, verify recommendations in writing substantiated by dated, printed, published product data or material use statement which is complete, definite and clear, and signed by company president.
- E. Before sign components are delivered to the site, examine the locations in which the signs are to be erected, and report in writing to the Authority’s Authorized Representative any conditions that will prevent proper execution of the Work or endanger its permanency. The erection of the signs shall not proceed until such conditions are corrected or adjusted to the satisfaction of the Authority’s Authorized Representative.

- F. After erection, all surfaces marred during erection, and exposed bolts, bolt heads, etc., shall be retouched with the same paint system used to coat the factory original surface.
- G. Install the Work plumb, level and straight with no distortions. Shim as required using concealed shims. Install to a tolerance of 1/8" in 8'-0" for plumb and level, with maximum 1/32" offset in flush adjoining aluminum panels, and maximum 1/16" offsets in flush and in revealed adjoining surfaces. Leveling is to be done only with instruments; measuring equal distances from existing building surfaces will not be acceptable as a basis of level and/or plumb.
- H. Execute drilling, cutting and fitting carefully and fit at job before finishing. Provide anchors and expansion shields for complete anchorage. Install all supporting members, fastenings, framing, bracing brackets, straps, bolts, and angles required to set and connect signage Work rigidly and properly to supporting construction.
- I. Do not field cut or drill galvanized metal without prior approval of the Authority's Authorized Representative. Set Work in location, in alignment and in elevation, plumb, true and free of rack, measured from established lines and levels.
- J. Set anchor bolts and anchorages with templates to correct elevations, plumb and true. Complete all connections in proper alignment and tighten bolts securely.
- K. All sign faces shall be flat, true and free from waviness; all exposed surfaces shall not deviate from flat by more than 1/16" in any 36-inch distance.

3.02 INSTALLATION

- A. Install equipment and components in accordance with the Contract Drawings and approved design drawings. Set work accurately in location and alignment.
- B. Provide anchorage devices and fasteners where necessary for installation and connection to other construction.
- C. Prior to energization, test all field installed wiring for continuity and hook-up. Tag identify all terminations.
- D. The Contractor shall furnish and install all temporary signs, equipment, components, enclosures, terminals, boxes, wiring, cabling, conduit, connectors, fittings and hardware; and make all necessary connections required for a complete operational installation between the station controllers and the LED VMS.

- E. Pull signal cable wire through conduit and connect to the Station Sign Controller at each station.
- F. Scheduling: Schedule installation of signs at the convenience of the CTA, in order that the work may be coordinated with other work going on within the building. Work shall be erected by skilled workmen especially trained in this type of work.
- G. Install all signs, structures, anchorages, electrical fixtures, and miscellaneous trim pieces. All power connections shall be performed in accordance with Section 16010 and 16100.
 - 01. Work shall be erected by skilled workmen specifically trained in this type of work.
 - 02. Determine location of any utilities that will be within the excavation site and immediately notify the Authority's Authorized Representative of any conflicting conditions.
 - 03. Set anchor bolts and anchorages with templates to correct elevations, plumb and true.
 - 04. There shall be no visible utility and support connections, unless otherwise shown on approved submittals documents.
 - 05. Form tight joints with connections accurately fitted together. Provide reveals and openings for sealants and joint fillers, as shown.
 - 06. Repair damaged finishes. Restore finishes and paint so that there is no evidence of corrective work. Return items, which cannot be refinished in the field to the shop, make the new required alterations, and refinish the entire unit or provide new units at fabricator's option.
 - 07. Provide concealed gaskets, flashing, sealants, fillers, and insulation, and install as the work progresses to make the installations sealed.
 - 08. Provide concealed fasteners, except where otherwise noted on the Contract Drawings. Exposed fasteners shall be flush and shall match adjacent surfaces in color and finish.
 - 09. When dissimilar metal are in contact, the contacting surfaces shall be coated and finished compatible to their adjacent surfaces.

10. Exterior welding shall be continuous, ground smooth and finished flush with adjacent surfaces. Exterior welded seams shall be invisible. Interior welding shall be structurally sound and eliminate racking. Do not field weld galvanized metal.
11. Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint. Paint exposed areas with the same paint system used for shop painting. Apply by brush or spray to provide a minimum dry film thickness of 2.0 mils. Repainted surfaces shall match the finished appearance of adjacent surfaces.

3.03 INSPECTION AND TESTING

- A. Examine conditions at each sign location, Station Sign Controller location, and the Central Control System location. Notify the Authority's Authorized Representative of conditions that adversely affect completion of the work as specified. Incorporate findings into design drawings, equipment layouts and other submittals required. Do not proceed with work until approval is received for submittals and/or satisfactory conditions are corrected.
- B. Verify that all prerequisite electrical work, conduit and components have been installed before proceeding.
- C. The VMS matrices and sign cabinets shall be inspected at the place of manufacture.
- D. After delivery a field inspection of the VMS will be made by the Authority.
- E. Test and adjust electrical signs for illumination level, hot spots and light leaks.
- F. The VMS shall be tested as one of the pieces of equipment of the ATSS system per the requirements of Section 16010, Subsection 3.05 Testing Requirements. The VMS shall be tested to meet the individual sign functional requirements, then as part of the overall ATSS system connected to the station controller and central control. Tests include:
 01. Factory Acceptance Testing
 02. Installation Testing including NTCIP Compliance
 03. Local Acceptance Testing
 04. Performance Testing

05. Test Support

3.04 CLEANING, PROTECTION, AND CLEANUP

- A. Provide final cleaning of Work, at a time directed by the CTA's Authorized Representative. Final cleaning shall consist of cleaning each surface or unit of work to result in a "first-class clean" condition. Comply with manufacturer's instructions for cleaning instructions and recommendations. The following are examples, but not by way of limitation, of cleaning levels required:
01. Remove labels that are not required as permanent labels - mount inside cabinet.
 02. Clean exposed exterior and interior hard-surfaced finishes, to a dirt free condition, free of dust, stains, films and similar noticeable distracting substances. Except as otherwise indicated, avoid disturbance of natural weathering of exterior surfaces. Restore reflective surface to original reflective conditions.
 03. Wipe surfaces of mechanical/electrical equipment clean; remove excess lubrication and other substances.
 04. Clean light fixtures and lamps so as to function with full efficiency.
 05. Clean the construction site of litter and foreign substances. Sweep paved areas to a broom-clean condition; remove stains, petrochemical spills and other foreign deposits.
 06. Protect installed Work during construction period to prevent damage to finish surfaces. Install temporary opaque covers for all sign faces.
 07. Upon completion of the work, remove from the construction site all tools, equipment, surplus and discarded materials including discarded existing finishes, debris, dirt and rubbish, accumulated as result of the installation of the signs. Leave the construction site in a neat and presentable condition.

END OF SECTION 16774

END OF SPECIFICATION