Intelligent Transportation Systems (ITS) and Communications Systems

State Project No. 088-179

Technical Specifications

100% Design Submittal

Revised November 6, 2012

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STATE PROJECT NO. 88-179
CT***fastrak***
Towns of Hartford, West Hartford, Newington, and New Britain

The following Specifications constitute the 100% Design Submittal (revised on November 6, 2012) for the CT***fastrak*** Intelligent Transportation Systems (ITS) and Communications Systems.

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ACRONYMS AND ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials	MCGR	Mobile Communications Gateway & Router
AFC	Automatic Fare Collection	MDC	Mobile Data Computer
AIL	Action Items List	MDT	Mobile Data Terminal
ANSI	American National Standards Institute	MED	Mobile Enforcement Device
AOEC	Areas of Environmental Concerns	MIL	US Department of Defense Military Standard
APC	Automatic Passenger Counter	MTBF	Mean Time Between Failures
ASTM	American Society for Testing and Materials	NEC	National Electrical Code
AVAS	Automatic Voice Annunciation System	NEMA	National Electrical Manufacturers Association
BOC	Busway Operations Center	NFPA	National Fire Protection Association
CAD/AVL	Computer-Aided Dispatch/Automatic Vehicle Location	NTCIP	National Transportation Communications for ITS Protocol
CCSU	Central Connecticut State University	NTP	Notice to Proceed
CCTV	Closed-circuit television	NTSC	National Television Standards Committee
COTS	Commercial Off-the-shelf	NVR	Network Video Recorder
CPM	Critical Path Method	O&M	Operations and Maintenance
DMS	Dynamic Message Sign	OSHA	Occupational Safety and Health Administration
DMV	Department of Motor Vehicles	OVM	On-board Video Monitoring
ECB	Emergency Call Box	PA	Public Address
EIA	Electronic Industries Association	PCM	Primavera Contract Manager
ERD	Entity Relationship Diagram	PDT	Prototype Demonstration Test
FAT	Factory Acceptance Test	QC	Quality Control
FCC	Federal Communications Commission	QMS	Quality Management System
FHWA	Federal Highway Administration	RCDD	Registered Communications Distribution Designer
FTA	Federal Transit Administration	RFC	Request for Information
GPS	Global Positioning System	RFI	Request for Change
GUI	Graphical User Interface	RFI/EMI	Radio Frequency and Electromagnetic Interference
HASP	Health and Safety Plan	RFP	Request for Proposals
HVAC	Heating, Ventilation, and Air Conditioning	RSI	Repetitive Stress Injury
ICD	Interface Control Document	SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
ICEA	Insulated Cable Engineers Association	SDT	System Demonstration Test
IEC	International Electrotechnical Commission	TIA	Telecommunications Industries Association
IEEE	Institute of Electrical & Electronics Engineers	TIS	Traveler Information System
ISO	International Organization for Standardization	TVM	Ticket Vending Machines
IT	Information Technology	UL	Underwriters Laboratories
ITE	Institute of Transportation Engineers	UV	Ultraviolet
ITS	Intelligent Transportation Systems	VLU	Vehicle Logic Unit
LAN	Local Area Network	VMS	Variable Message Sign
MAPI	Messaging Application Programming Interface	WLAN	Wireless Local Area Network
		XML	Extensible Markup Language

SPECIFICATION 100 – GENERAL PROVISIONS

1. GENERAL

1.1. Introduction

This section describes the general requirements pertaining to the procurement, installation, integration, testing, and maintenance of the CT***fastrak*** Intelligent Transportation Systems (ITS) and Communications Systems. The systems shall include all hardware and software components and all communications equipment required to integrate the system and support transmission of data from on-board and field equipment to and from the Busway Operations Center (BOC). The work as described is also referred to in the documents as "the Work" or "the Project." The right-of-way on which the CT***fastrak*** buses shall operate shall be referred to as the "busway" or the "guideway." The Project Manager for the Connecticut Department of Transportation, or his/her designated representative(s), shall be referred to as the "Engineer" within these specifications. The Connecticut Department of Transportation also shall be referred to as the "Department".

Please refer to the Request for Proposals (RFP) document for additional project background information and a description of the scope of services.

This specification document (Specification 100 – General Provisions) for the CT***fastrak*** ITS and Communications Systems includes the general requirements for the Contractor, general Materials requirements, general Construction method requirements, and general requirements for spare parts, maintenance materials, and start-up support. These specifications apply to all equipment, hardware, software and labor to be provided by the Contractor. The specifications for each of the equipment items may include additional requirements pertaining to, but not limited to, product data, quality control, operations and maintenance documentation, maintenance and spares and warranty.

The CT***fastrak*** ITS and Communications Systems include:

- **Central Systems:** Central Systems hardware shall include workstations, servers, racks, communications hardware, video display equipment, a Network Video Recorder (NVR), and data storage hardware located at the BOC. Central Systems software shall include Computer-Aided Dispatch/Automatic Vehicle Location (CAD/AVL) Central Software, AVA (Automatic Voice Annunciation) Software, APC (Automatic Passenger Counters) Management Software, Traveler Information Software, CCTV (Closed Circuit Television) Camera Management Software, Emergency Call Box (ECB) Central Software, and a Network Management System. Central systems software shall be integrated as described in the specifications. The Central Systems' CAD/AVL software will be integrated by the Contractor with CTTRANSIT's existing scheduling software. All agencies operating transit vehicles operating on the CT***fastrak*** guideway will utilize instances of the same existing scheduling software (Trapeze FX – Version 11). The Contractor shall also install a workstation at the New Britain Station building to provide remote access to BOC systems.

- **Traveler Information Systems:** Includes Variable Message Signs (VMS) and Public Address (PA) systems installed on each station platform. These VMS and PA systems shall be coordinated and controlled from the BOC. VMS and PA systems shall also be capable of being controlled locally at the station during an emergency or if communications to the BOC is temporarily lost. A Traveler Information System (TIS) Controller at each station shall synchronize and coordinate messages delivered by the VMS and PA systems. The central Traveler Information Software (part of the Central Systems) will be interfaced by the Contractor with the CAD/AVL Central Software (also part of the Central Systems) to provide real-time bus arrival prediction information to the VMS and PA systems at the stations.

- **On-board Technology:** Includes Mobile Data Computers (MDCs), with built-in Mobile Data Terminals (MDTs), Vehicle Logic Units (VLUs) and GPS receivers, installed on all CT***fastrak*** transit vehicles. Also includes Automatic Passenger Counters (APC). The APC Management Software will be integrated by the Contractor with the CAD/AVL Central Software (both part of the Central Systems). Also includes on-board Automatic Voice Annunciation (AVA) controller and an interior Variable Message Sign (VMS). The AVA controller and the interior VMS shall be integrated with the MDC and the vehicle's existing PA system. Additionally, to facilitate communications to transit vehicles, a Mobile Communications Gateway and Router (MCGR) will also be installed on all CT***fastrak*** transit vehicles. Other on-board technologies, such as On-board Video Monitoring (OVM), silent alarms, and fuel and maintenance management systems will not be provided as part of this project. Equipment installed as part of this project will be integrated by the Contractor with existing on-board technologies. Equipment installed as part of this project shall not preclude installation and integration with future on-board technologies. In addition, the Contractor will coordinate with CTTRANSIT with regards to its larger system-wide efforts. The CAD/AVL system procured for CT***fastrak*** shall not preclude integration with CTTRANSIT's future system-wide CAD/AVL system. Refer to this specification and the specific equipment specifications for more information. On-board technology also includes On-board Processing Devices and Antennas for a limited number of non-revenue (supervisor, administrative, and maintenance) vehicles.

- **Safety and Security Systems:** Includes CCTV cameras to monitor: the platforms, the Ticket Vending Machines, and provide some coverage of station plazas and pedestrian pathways. CCTV cameras will also be placed at strategic operational locations along the CT***fastrak*** guideway in between stations to improve situational awareness for the dispatchers at the BOC. The video from these cameras will be transmitted to the BOC for viewing and recording. The video management and recording software will be included as part of the Central Systems. Emergency Call Boxes (ECBs) will also be installed at each station.

- **Communications System:** A fiber optic cable-based communications infrastructure will support the initial ITS deployment at stations and along the CT***fastrak*** guideway and provide capacity to support future ITS deployments. Fleet and vehicle voice communications will be handled by an upgraded radio communications system that will be deployed as part of a separate statewide effort by the Connecticut State Police. Fleet and vehicle data communications will be handled primarily by a cell data communications system, with unlimited cell data plans to be provided by the Department.

A bulk data communications system will also be deployed to support the exchange of information when transit vehicles are in proximity to future high-speed wireless network infrastructure installed at certain CTTRANSIT facilities.

The fiber optic communications system along the CT***fastrak*** guideway will provide a secure, high speed and reliable platform for transmission of voice, data and video to support monitoring and management of the bus operations and security functions at stations. This communications system shall include a dedicated fiber optic backbone installed along the length of the CT***fastrak*** guideway connecting to stations, intersections and stand-alone cameras. The fiber optic backbone will also extend from the northern terminus of the guideway to the BOC located at the CTTRANSIT facility in Hartford.

The fiber-optic communications system includes communications hubs (consisting primarily of Ethernet switches and fiber network devices) at each of the stations, with two hubs located at the East Main station (due to the physical separation of its platforms). A communications hub is a connection point on the communications network from where system data can be redistributed. The fiber optic backbone will interconnect each of the communications hubs. Communications cabling will be utilized to connect the communications hubs to the ITS field equipment at each station. Other communications hubs are located at the BOC and CCTV locations along the guideway. The communications network architecture will utilize Ethernet (IP) technology for backbone and distribution to provide a flexible, expandable, resilient and reliable network for both initial and future ITS requirements. Station and platform ITS components, security/surveillance cameras, and other equipment will connect to the network using standard Ethernet/IP interfaces.

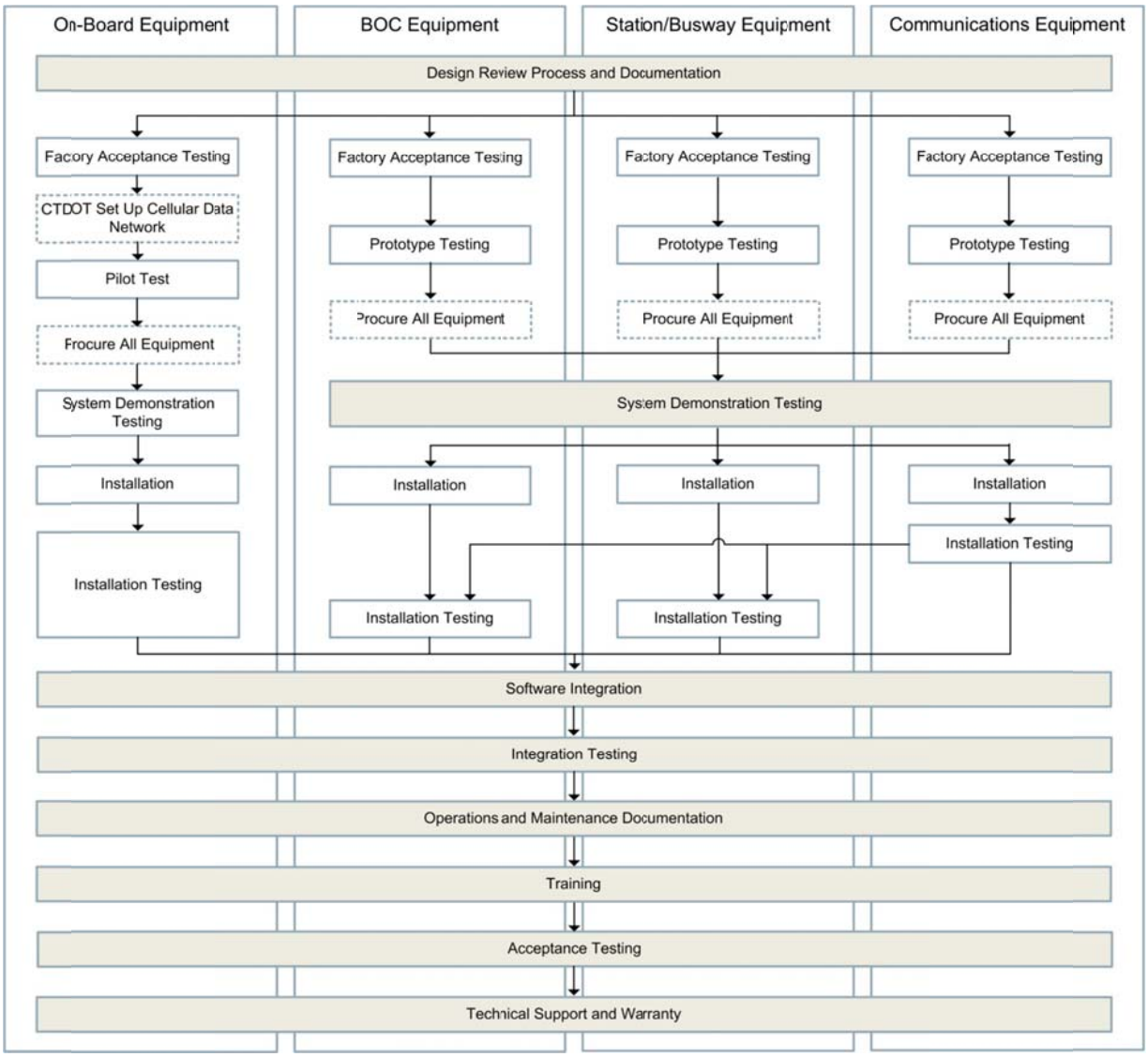
The bulk data communications system and the cell data communications system will facilitate data communications between the central system and vehicles. The bulk data communications system will support the exchange of information when transit vehicles are in proximity to high-speed wireless network infrastructure installed at designated CTTRANSIT facilities. The cell data communications system will support the exchange of information in real-time and when buses are outside the range of high-speed wireless network equipment at CTTRANSIT facilities.

The components of the ITS and Communications Systems for CT***fastrak*** to be furnished under this contract are described in greater detail in the various equipment specifications.

1.2. General Contractor Requirements

Figure 1 summarizes the process the Contractor shall use for the delivery and testing of ITS and Communications Systems hardware, software, and overall systems. The diagram distinguishes between On-Board, BOC, Station/Busway, and Communications equipment by showing them in separate columns. Steps are shown in chronological order from top to bottom, with concurrent activities more or less in line horizontally. In the case where a step is to be carried out for multiple types of equipment, the step is shown with a grey box spanning across the relevant columns. This process is described in more detail below.

Figure 1: Implementation Program



1.2.1. Design Review Process

1.2.1.1. General

Following Notice to Proceed (NTP), the Contractor shall complete a Design Review process leading to Department approved written documentation describing the system to be delivered including all equipment and software to be furnished and how the system will address the requirements.

During the Design Review Process, the Contractor shall participate in regular meetings with the Department to clarify system interfaces, data structures, communication links, and other items. As part of the Design Review Process, Contractor submittals will be reviewed by the Engineer to assess compliance with the design intent underlying the requirements, deployment staging, details on existing systems / data / infrastructure, and system configuration.

1.2.1.2. Design Documentation

The Contractor shall provide detailed documentation that describes the system design and configuration. Draft and Final Design Documentation shall be submitted as part of Preliminary Design and Final Design (see Sections 1.2.1.3 and 1.2.1.4 in this specification). For detailed submittal and control of materials requirements, refer to Section 1.4 in this specification and Specification 109 – Document Control Specialist. The Contractor shall meet the following additional requirements for the submission of Design Documentation:

- Equipment installation drawings shall be prepared in MicroStation and Adobe Acrobat or other format as directed by Engineer and provided electronically as well as hard copies.

- Electrical and electronics drawings shall be updated to incorporate engineering changes made to any component or module up to the end of the warranty period of the system supplied.

- All pages of the documentation shall carry a title, version number and issue date, and shall contain a complete subject index. The Contractor shall be responsible for fully coordinating and cross referencing all interfaces and areas associated with interconnecting equipment and systems.

- Documentation shall be re-issued if any change or modification is made to the equipment proposed to be supplied. The Contractor may re-issue individual sheets or portions of the documentation that are affected by the change or modification. Each re-issue or revision shall carry the same title as the original, with a change in version number and issue date.

Design Documentation submittals shall include the following:

- An overall system schematic and architecture diagram.

- A Project Management Plan in accordance with the description supplied as part of the Contractor's proposal, detailing the Contractor's approach to completing this Project within the specified period of time.

- A computerized Critical Path Method (CPM) schedule and Work Breakdown Structure, taking into account major assumptions and risks, in accordance with the pertinent provisions of "Section 2.3- Liquidated Damages" and "Section 2.4 New Third Party Contract Clauses Required by FTA Circular 4220.1f" of Form 816. See Specification 101 – Project Coordinator for more detailed requirements, including a separate deadline for the Work Breakdown Structure.

- A Submittal Forecast created in Primavera Contract Manager (PCM) containing the approximate schedule of each submittal. See Specification 109 – Document Control Specialist for more detailed requirements.

- A Quality Control (QC) Plan in accordance with the description supplied as part of the Contractor's proposal. See Specification 108 – Contractor Quality Control Program for more detailed requirements.

- Detailed description of all subsystems and equipment and hardware, including functional description, interface descriptions, power and communications loading details, Documentation on Materials (see Section 1.2.1.2.1 in this specification), all sub-documentation, configuration details and installation details.

- Communications Network Design Documentation, including a detailed fiber network architecture, fiber path drawings, fiber topology, splicing details, communications and data capacity calculations, path redundancy and resiliency provisions, and network configuration details.

- Installation Design Documentation, including detailed descriptive design and installation drawings, for hardware at stations, on the busway, at the BOC, and for each vehicle type, providing detailed information on: placement of all relevant equipment at stations, on the busway, and at the BOC; placement of all communications equipment that interface with this equipment; mounting details for all equipment; connections to all network, data, power/electrical or other infrastructure provided by a third party; wiring connections, size, identification, fusing, and clamping (wiring diagrams); power pick-up location and circuit breaker locations; grounding; and cable routing.
  Wiring/installation diagrams for in-vehicle systems shall be provided by the Contractor for each make/model of vehicle. Mounting documentation shall include drawings and calculations stamped by a structural engineer licensed in the State of Connecticut demonstrating the ability of mounting equipment to meet mounting and installation requirements.

- IP Address Coordination Plan. The Contractor shall provide a network configuration diagram and detailed information on proposed IP addressing schema, VLAN configurations, network security configurations, and all other relevant network configuration information for review by the Engineer. The Department shall review the proposed IP address schema and provide IP addresses to the Contractor to be incorporated in the Final Design submission.

- Detailed description of all software, including functional description, system interface descriptions, Graphical User Interface (GUI) descriptions with mock-ups, database design documentation, standard reports, report configuration utilities (software documentation).

- List of spare parts and maintenance materials. Upon selection, the Contractor shall be responsible for reviewing the spare parts and maintenance materials and providing a revised list as part of the Design Documentation. This should include the revised spare quantities, as well as more specific information regarding the parts that may be required to allow the Contractor to meet technical support and warranty requirements, and justification for any changes to quantities than what was initially proposed.

- A Standards Compliance Plan document describing what ITS standards (in particular, NTCIP standards) the system shall comply with and to what extent it shall comply with those standards. The document shall not just certify compliance, but shall describe exactly how the Contractor will demonstrate full standards compliance to the Engineer. The Plan shall include a description of the certification and compliance documentation that will be submitted for all hardware and software.

- Software development methods to be used for any new or modified application software.

- Description of how the system deals with a loss of communication, including what happens to the data and what is visible through the GUI for the software.

- Description of how the system deals with data backup and system recovery.

- System Security Plan, identifying the system elements that require protection, and describing mechanisms, procedures and processes to counter security threats to those elements. See Section 1.2.1.2.2 in this specification for more information.

- Interface Control Documents with detailed description of all interfaces to external systems. See Section 1.2.1.2.3 in this specification for more information.

- Detailed description of the information style and content that will be disseminated to the public, including but not limited to, VMS and PA system message sets.

- Test Plan outlining the criteria for test initiation, test equipment, detailed test procedures and expected results, and procedures for dealing with test failures and retests, and the test schedule. For more information on the Test Plan, refer to Specification 200 – Testing. The Test Plan must reflect the final design of the system.

- A requirements traceability matrix shall be submitted that can be used to verify that the design addresses all system requirements in accordance with standard Systems Engineering practices.

- A written site-specific Health and Safety Plan (HASP) that addresses the relative risk of exposure to documented hazards present within the Project limits. For more information on the HASP, refer to Specification107 – Environmental Health and Safety. If work in any Areas of Environmental Concerns (AOECs) is scheduled to begin less than four (4) weeks after the Design Documentation is due, the HASP shall be submitted four (4) weeks before that work is to commence.

1.2.1.2.1. Documentation on Materials

For custom-manufactured equipment, the Contractor shall submit a set of comprehensive shop drawings and specifications. The comprehensive shop drawings shall include the general arrangement, layout, wiring details, mounting requirements, location for conduit entry and any physical or electrical requirements.

For standard commercial off-the-shelf items, the Contractor shall submit detailed manufacturer product specifications, mounting requirements, location of conduit entry and any other physical or electrical requirements.

The Contractor shall provide certification and compliance documentation for all standards that apply to the manufacturing of the equipment, whether custom-manufactured or off-the-shelf.

The Contractor shall include certification and compliance documentation for equipment availability and reliability figures, whether custom-manufactured or off-the-shelf.

The Contractor shall also provide all details of connectors and interconnect cables to the Department.

The Contractor shall also provide documents demonstrating how manufacturers/vendors meet manufacturer requirements described in Section 2.2 in this specification, generally and for each equipment item.

1.2.1.2.2. System Security Plan

The System Security Plan shall describe the intended functionality for each of the system security elements, shall identify security threats, and shall describe procedures, functions and systems for detecting and mitigating those threats.

The System Security Plan shall identify system users, and describe rules that govern how those users will have access to system data, resources and processes.

The System Security Plan shall identify methods of detecting security breaches independent of whether there is a detectable change in the performance of the system.

All data on logged security breach detections shall be confidential, and accessible only to users with appropriate access permission.

Security provisions for owned and non-owned communications networks shall be described.

The Contractor shall implement system security services to achieve the approved System Security Plan.

As a minimum, the system security shall protect the following types of system elements:

- Servers installed at BOC and in remote locations
- The Department's IT network
- Software source and compiled code
- Data communications and interfaces
- Other communications and interfaces as might be required for the work
- System data supplied to the Contractor

The Contractor shall coordinate with the Department to develop system security elements and procedures so as to function correctly with existing Department firewalls.

As a minimum, the system shall provide the following alarms, and shall notify the Department in the event an alarm is triggered:

- Detection of invalid or erroneous data
- Detection of a security breach
- Detection of a device or system fault

All security alarms shall be recorded and stored in a database, along with any history of corrective actions entered.

1.2.1.2.3. Interface Control Documents

The Contractor shall provide Interface Control Documents (ICDs) such that the Department and designated third parties have the right to perpetual access free from any fee, royalty or other charge. This access shall be for internal use by the Department as well as for integration with future external parties designated by the Department. These ICDs will include a data dictionary and an Entity Relationship Diagram (ERD) for all data tables. The following summarizes a list of interfaces that will require an ICD, to enable integration by others. In this list, external interfaces are defined as interfaces between components of the ITS and Communications Systems for CT***fastrak*** and other systems not included in this Work. Internal interfaces are defined as interfaces between multiple components of the ITS and Communications Systems for CT***fastrak***.

External Interfaces

- AVA Controller – PA System
- Mobile Data Computer – Headsign
- Mobile Data Computer – Farebox
- Mobile Data Computer – P-25 Compatible Radio Subscriber Unit
- Mobile Data Computer – Digital Video Recorder
- CAD/AVL Central Software – Department's Scheduling Software (Trapeze FX – Version 11)
- CAD/AVL Central Software – External CAD/AVL System (XML Data Feed)
- CAD/AVL Central Software – Department's Geographical Information System (GIS)-based mapping software
- CAD/AVL Central Software – Vehicle Lists

Internal Interfaces

- Mobile Data Computer – Automatic Passenger Counter (40-foot bus), Automatic Passenger Counter (60-foot bus)
- Mobile Data Computer – CAD/AVL Central Software
- Mobile Data Computer – AVL Controller
- CAD/AVL Central Software – Non-Revenue Vehicle Equipment
- CAD/AVL Central Software – APC Management Software
- CAD/AVL Central Software – Traveler Information Software
- CAD/AVL Central Software – AVA and Trigger Location Management Software
- Traveler Information Software – TIS Controller
- TIS Controller – PA System
- TIS Controller – Variable Message Sign (Single-sided, Pole Mounted), Variable Message Sign (Single-sided, Cantilever Mounted), and Variable Message Sign (Double-sided)
- On-Board VMS – AVA Controller

1.2.1.3. Preliminary Design

Within forty (40) business days following NTP, the Contractor shall provide a Draft Design Documentation submittal to the Department. This Draft Design Documentation submittal shall include all the items described in Section 1.2.1.2 in this specification.

A series of site surveys are required to help the Contractor collect necessary information to complete the task. The Contractor shall visit all relevant locations related to installation of system equipment including but not limited to:

- BOC
- Future station locations
- Future busway locations
- Sites designated for installation of equipment on-board vehicles

The Contractor shall meet with the Department IT group to agree to system security measures including remote access, firewall, data encryption/privacy, and communication requirements.

The Contractor shall coordinate with other busway and station Contractors to get the latest plans for the construction of busway and stations. See the RFP for more information on coordination.

The Contractor shall identify the preferred equipment installation location for: all vehicle types and their configurations; at all stations; at all points on the busway and in the BOC; and for all communications equipment. Documentation including drawings (dimensioned sketches are acceptable) and photographs illustrating the proposed equipment locations shall be submitted.

The Contractor shall coordinate a meeting with the Department to present the Draft Design Documentation and respond to Department questions or comments. Such comments shall augment any written comments provided separately.

1.2.1.4. Final Design

Upon receipt and incorporation of Department comments on the Preliminary Design, the Contractor shall provide a Final Design Documentation submittal to the Department. This Final Design Documentation submittal shall include all the items described in Section 1.2.1.2 in this specification.

Following review of the Draft Design Documentation submittal, the Contractor shall coordinate with the Department to arrange additional site visits and coordination meetings as necessary to finalize the design.

The Final Design Documentation shall incorporate all Department comments and identify suitable modifications for any and all problems identified throughout the design process. Modifications and additions desired by the Department that cannot be implemented shall be raised by the Contractor and agreed upon by the Department prior to the submittal of the Final Design Documentation.

Following approval of Final Design Documentation by the Connecticut Department of Transportation, the Contractor will be directed by the Department in writing to begin the Factory Acceptance Tests.

1.2.2. Factory Acceptance Tests (FAT)

After the Design Review Process has been completed and all Design Documentation has been received, reviewed, and approved by the Department, the Contractor shall be responsible for FAT of system hardware and software to ensure that the supplied and developed components meet all functional and environmental requirements and specifications. For commercial off-the-shelf products, the FAT may be replaced by certified quality testing documents from an approved testing facility before the equipment leaves the manufacturers' production facilities. Each requirement listed in the specification shall be tested where possible; if it cannot be tested compliance shall be proven by corresponding written documentation or certificates. The central system software FAT may be completed with field devices or components running in simulation mode or with representative field samples. The FAT shall be conducted in accordance with the Contractor's accepted Test Plan. Following Department review and approval of the Contractor's submitted FAT documentation, the Contractor will be directed by the Department in writing to commence the Prototype Demonstration Test and the On-board Equipment Pilot Test. See Specification 201 – Factory Acceptance Tests for more information

1.2.3. Prototype Demonstration Test (PDT)

Prior to procuring complete quantities of all required equipment or installing any equipment, the Contractor shall conduct a Prototype Demonstration Test (see Specification 202 – Prototype Demonstration Test) for BOC, station and busway, and communications equipment using a representative minimum quantity of each specified equipment item in order to form a complete system, connected and configured in accordance with the Drawings and submitted Design Documentation, to demonstrate that all selected equipment is fully functional, compatible and interoperable. The PDT shall be conducted at the Contractor's facility. The PDT shall be conducted to the satisfaction of the Engineer. The Contractor shall notify the Department of the scheduled date and time of the PDT a minimum of two (2) weeks prior to the performance of the test. The Department reserves the right to require Department representatives to be on-site to review the operation of the test and accept or reject the test results. The PDT shall be conducted in accordance with the Contractor's accepted Test Plan. Following Department review and approval of the Contractor's submitted PDT documentation, the Contractor will be directed by the Department in writing to procure all specified and accepted equipment quantities for the complete system (excluding on-board equipment).

1.2.4. On-board Equipment Pilot Test

Prior to procuring complete quantities of all required on-board equipment or installing any on-board equipment, the Contractor shall conduct an On-board Equipment Pilot Test (see Specification 203 – On-board Equipment Pilot Test). As part of the On-board Equipment Pilot Test, the Contractor shall install on-board equipment on at least one vehicle of each vehicle type that shall be operating on the busway, using the minimum number of each specified piece of equipment in order to form a complete on-board system in each case. In addition, the Contractor shall install on-board equipment on at least one (1) vehicle of each non-revenue vehicle type (supervisor and maintenance vehicles), using the minimum number of each specified piece of equipment in order to form a complete on-board system in each case. To test mobile data communications functionality between these vehicles and the central system as set up at their factory, the Contractor shall coordinate with the Department to establish the necessary number of cellular data accounts and acquire the associated cellular modem cards.

The installation of the equipment shall require no major disassembly or modification of the vehicles, and installation of the equipment shall not damage the vehicles in any way. As installed, the on-board equipment shall be easily replaceable and shall not pose a hazard to vehicle operators or passengers. Installed on-board equipment shall also be easy to replace with basic hand tools. The On-board Equipment Pilot Test shall be conducted on-board vehicles at a location to be determined by the Department. The Contractor shall notify the Department of the date and time of the scheduled On-board Equipment Pilot Test a minimum of two (2) weeks prior to the performance of the test. The Department reserves the right to provide representatives on-site to review the operation of the test and accept or reject the test results. The On-board Equipment Pilot Test shall be conducted in accordance with the Contractor's accepted Test Plan. Following Department review and approval of the Contractor's submitted On-board Equipment Pilot Test documentation, the Contractor will be directed by the Department in writing to procure all specified and accepted on-board equipment quantities for busway vehicles and non-revenue vehicles.

1.2.5. Procure all Equipment

After the Prototype Demonstration Testing has been completed and approved by the Department for the BOC, stations, busway, and communications hardware and software, the Contractor shall procure all equipment for the BOC, stations, busway, and communications system. Similarly, after the On-board Equipment Pilot Testing has been completed and approved by the Department, all on-board equipment and related software shall be procured by the Contractor. All equipment shall be procured before carrying out the System Demonstration Test.

1.2.6. System Demonstration Test (SDT)

The System Demonstration Test shall only be carried out after the Department has approved the Prototype Demonstration Test and the On-board Equipment Pilot Test. The Contractor shall use the SDT to demonstrate that all system equipment is fully operational, free of material defects and failures, and has been completely and correctly configured prior to its installation in the field. Once all hardware, software, and communications equipment has been procured, connected, and properly configured, the Contractor, at its own facility, shall conduct a System Demonstration Test, (see Specification 204 – System Demonstration Test). The SDT shall utilize the complete set of system equipment. The Contractor shall remain responsible for the safety and security of all system equipment. The Contractor shall notify the Department of the

date and time of the scheduled SDT a minimum of two weeks prior to the performance of the test. The Department reserves the right to provide representatives on-site to review the operation of the test and accept or reject the test results. The SDT shall be conducted in accordance with the Contractor's accepted Test Plan. Following Department review and approval of the Contractor's submitted SDT documentation, the Contractor will be directed by the Department in writing to prepare all equipment for installation.

1.2.7. Installation

After the successful completion and Department approval of the SDT, the Contractor shall provide a Construction Field Office for the duration of all installation and testing work, and if required, for a maximum of ninety (90) days thereafter, for the exclusive use of CTDOT forces and others who may be engaged to augment CTDOT forces with relation to the contract (See Specification 101 – Construction Field Office, Large). The Contractor shall provide Construction Communication Equipment for the duration of all installation and testing work, and if required, for a maximum of sixty (60) days thereafter, for use of inspection personnel, including a toll-free, reservation-less telephone conference call account for the use of the Engineer. (See Specification 106 – Construction Communication Equipment). The Contractor shall then prepare all equipment shipping, ship all equipment to their respective installation sites, and install them at the BOC, stations, along the busway, and on all vehicles. Equipment installed shall be the same equipment used in the SDT. Before installation of on-board equipment, the Contractor shall coordinate with the Department to establish the necessary number of cellular data accounts and acquire the associated cellular modem cards. No substitution of equipment to be installed in the field will be permitted without written approval by the Engineer. The Contractor shall be responsible for ensuring that all equipment shall be installed in accordance with these General Specifications requirements, the equipment specifications requirements, manufacturer recommendations, and all applicable federal, state, and local regulations, policies, statutes, laws, and specifications. The Contractor shall be required to obtain all necessary state and local permitting. The Contractor shall be required to perform all necessary coordination with local utilities. The Contractor shall be required to provide maintenance and protection of traffic and employ trafficpersons as necessary to safely complete installation work (See Specification 102 – Maintenance and Protection of Traffic, Specification 103 – Trafficperson (Municipal Police Officer), and Specification 104 - Trafficperson (Uniformed Flagger).

1.2.8. Installation Tests

The Contractor shall conduct Installation Tests for each device in the field once it has been installed and configured. The Installation Tests shall be completed on the devices in isolation to confirm that each installed device complies with installation, functional and performance requirements. At a minimum, the installation test for each unit shall include (as applicable): power-up/power-down tests, log-on/log-off tests, verification of major functions, and verification of operational interfaces to other devices. Installation Tests for on-board equipment can be carried out independently from Installation Tests for busway field equipment. Refer to Specification 205 – Installation Tests for detailed test requirements. The Department reserves the right to provide representatives on-site to review any and all Installation Tests and accept or reject the test results. The Installation Tests shall be conducted in accordance with the Contractor's accepted Test Plan. Following Department review and approval of the Contractor's

submitted Installation Test documentation for each device, the Contractor will be directed by the Department in writing to prepare for Software Integration and the Integration Test.

1.2.9. Software Integration

The Contractor shall configure and integrate all software provided as part of this Work as described in the Design Documentation, ICDs, and in all software specifications. The Contractor shall successfully integrate all software and demonstrate full functionality and operation of the integrated software to the satisfaction of the Engineer. Integration shall include all automated software interfaces; requiring no manual interventions to accomplish required software functionality. The Contractor shall also configure all menu options, user screens, maps, performance measures, and reports in accordance with input from the Engineer and operations staff to allow for full system operation, as intended. Following acceptance of software integration by the Engineer, the Contractor will be directed by the Department in writing to prepare for the Integration Test. Refer to Specification 206 – Software Integration for detailed integration requirements.

1.2.10. Integration Test

Integration testing shall commence for each subsystem only after all equipment has been installed, Installation Tests have been completed, Software Integration has been completed, and the results have been accepted by the Department. The purpose of the Integration Test is to confirm that the devices are fully integrated with the other devices to which they interface or interact with and comply with all functional and performance requirements. Refer to Specification 207 – Integration Test for detailed test requirements. The Integration Test shall be conducted in accordance with the Contractor's accepted Test Plan.

In addition to providing all required Integration Test documentation, the Contractor shall update the Design Documentation to reflect "As-Built" conditions. The updated Design Documentation shall also be sufficiently detailed to facilitate operation, maintenance, modification and expansion of the equipment or any of its individual components to the satisfaction of the Department or its representative. As-Built Documentation shall include: (1) an inventory of all components supplied including supplier, model number, serial number and installation location; (2) an inventory of all spare parts supplied including supplier, model number, serial number and storage location; (3) all reference and user manuals for system components, including those components supplied by third parties; (4) all warranties documentation, including that for components supplied by third parties; (5) a diagram indicating the as-built interconnections between components; (6) the version number of all software, including that supplied by third parties; and (7) updated Drawings reflected installed conditions in the field.

Following Department review and approval of the Contractor's submitted Integrated Test and "As-Built" documentation, the Contractor will be notified by the Department in writing of approval of the Integration Test.

1.2.11. Operations and Maintenance Documentation

Prior to commencing training, the Contractor shall submit to the Department all Operation and Maintenance (O&M) Documentation necessary for the Department to operate and maintain the

ITS and Communications Systems for the busway. O&M Documentation shall document in detail the maintenance and service aspects of the equipment on an item by item basis with clearly detailed illustrations, and shall include schematic diagrams where necessary. The O&M Documentation will be comprised of hardware manuals, software manuals (for both users and system administrators), and manuals for on-board equipment for vehicle operators and maintenance technicians.

The Contractor shall deliver fifteen (15) complete hard-copy sets of O&M manuals, as well as an electronic copy of each manual through the PCM, unless specified otherwise by the Engineer. Refer to Specification 109 – Document Control Specialist for more requirements regarding submissions. The Contractor shall allow the Department to print unlimited quantities of manuals for internal use. The Contractor may use manufacturer's data and handbooks for individual items of the equipment that are a sub-component of the overall system. The hard-copy manuals shall be assembled in volumes of similar 3-ring binders of 75mm maximum thickness and shall be indexed item by item. Several equipment items may be covered in a single binder.

1.2.11.1. Hardware Manuals

The Contractor shall provide hardware manuals for each type of component provided unless specified otherwise. The manuals shall provide sufficient detailed installation and maintenance instructions to allow the Department or its representative to properly and safely install, connect and commission the hardware supplied and to operate and maintain the system.

The Contractor shall also provide all details of connectors and interconnect cables to the Department or its representative.

The Hardware Manuals shall be a detailed presentation and shall include illustrations where applicable. For each unit, it shall include at a minimum:

- General description
- Functional descriptions
- Functional block diagram
- Images and/or illustrations
- Operating instructions
- Maintenance and repair procedures
- Test procedures
- Schematic drawings and circuit diagrams
- Parts list

Each type of maintenance manual shall contain at a minimum:

- Description of operation including start-up, shut-down and emergency procedures, with illustrations
- Installation procedures, with illustrations
- Complete parts identification diagram and list
- Troubleshooting procedures, with illustrations

- Inspection procedures, with illustrations
- Preventive maintenance procedures and program, with illustrations
- Repair procedures, with illustrations
- Diagnostic procedures, with illustrations
- Wiring diagrams
- Electrical schematics with board and cable identification
- Adjustment procedures, with illustrations
- Seasonal maintenance requirements, with illustrations
- Equipment arrangement and drawings
- Names and schedules of all lubricants and cleaners used
- Other consumable materials for the equipment stating where used, quantity, service intervals and annual consumption

The Contractor shall provide a parts list for each piece of equipment as supplied. The parts list shall identify the manufacturer(s) and model/part number.

Where an equipment component is of such a nature that local repairs cannot be made and it must be returned to the factory as a unit for overhaul, specific information concerning its repair and breakdown into component parts shall be provided.

1.2.11.2. Software Manuals

User Manual

A User Manual shall be provided for each software application. The User Manual shall include illustrations such as screen captures and easy to follow instructions to assist the users through all of the tasks that they may need to complete. The User Manual shall include an index.

As a minimum, the User Manual shall include all information that is available through the context sensitive help.

Fault procedures shall be described, as well as procedures for dealing with problems.

System Administration Manual

A System Administration Manual shall be provided for each software application. The System Administration Manual shall document central systems software functions and operations, all of the configuration parameters, details on how to configure the parameters, scheduled maintenance required for the central systems, back-up and recovery process, troubleshooting techniques, technical support information, and database structure and data dictionary.

Fault procedures shall be described, as well as procedures for dealing with problems.

1.2.11.3. Vehicle Operator Manual

A Vehicle Operator Manual shall be provided for the ITS equipment in each vehicle. The Vehicle Operator Manual shall document the operation and maintenance of the in-vehicle equipment from the perspective of the vehicle operator, and shall include screen captures and easy to follow instructions to assist the users through all of the tasks that they may need to complete.

1.2.12. Training

A minimum of forty (40) business days prior to the commencement of training, the Contractor shall submit a Training Plan to the Department for review and approval. Upon receipt, review and approval by the Department of the Training Plan and all O&M Documentation, and Department approval of Integration Test and "As-Built" documentation, the Contractor shall be directed by the Department in writing to commence training. The Contractor shall provide training for Department-designated personnel for all Intelligent Transportation Systems and Communications Systems hardware, software, communications and overall systems. Instruction shall include training in system operation, system maintenance and troubleshooting, and system administration. The minimum training shall be that which is necessary to bring employees designated to the level of proficiency required for performing their respective duties. The Contractor shall provide all necessary training materials and allow the Department to make unlimited quantities of training materials for internal use. The Contractor shall also video record each type of training session and submit this video record to the Department. Refer to Specification 300 – Training for more information on the Training Plan and training. Following Department acceptance of all training, training materials, and training records, the Contractor will be notified by the Department in writing to commence the Acceptance Test.

1.2.13. Acceptance Test (30-day Operational Tests)

The Acceptance Test will occur for a contiguous thirty-day (30-day) period (unless otherwise approved by the Engineer) after all Training has been completed and accepted by the Department. The Department shall not authorize the commencement of the Acceptance Test until all training and required system documentation has been successfully submitted and accepted. During the 30-day period, the system shall be tested under full operations to ensure that the performance requirements are met and to measure the system reliability and availability. System failures may result in the suspension or restart of the 30-day period. Refer to Specification 208 – Acceptance Test for detailed test requirements. During the course of the Acceptance Test, the system must function continuously in accordance with the specifications for the duration of the test. If a system failure occurs during the test, the Contractor shall make all necessary repairs to the system and re-establish proper operation. Upon verification by the Engineer that the issue has been successfully resolved, the Engineer shall authorize the 30-day test to be re-started. During the Acceptance Test period, all failures shall be documented and reported to the Department.

For measuring the accuracy of Traveler Information System predictions during Acceptance Testing, the Contractor shall provide the Department with Accuracy Testing Procedures for the Traveler Information Software. For system acceptance, the Contractor shall provide archived raw prediction records (indicating the vehicle, route, direction, stop, time of prediction, and predicted times) and archived data on when vehicles actually arrived at the stops, sufficient to conduct the Accuracy Testing Procedures, and to allow the Department to define periodic excerpts of these

data in terms of the range of vehicle, routes, and stops included and the overall number of prediction records.

The successful completion of the Acceptance Test is a pre-requisite for the Department to issue a notice of Final Acceptance. Upon successful completion of the Acceptance Test, the Department shall issue a formal written notice of Final Acceptance. After formal system Final Acceptance is issued, the Technical Support and Warranty Services (see Specification 400) period shall commence. The technical support and warranty period shall not commence prior to the Department issuing Final Acceptance, regardless of any beneficial use derived by the Department during the installation and testing period.

1.2.14. Technical Support and Warranty

Following issuance of Final Acceptance, the Contractor shall provide Technical Support and Warranty Services to the Department for all supplied equipment, hardware, and software for a period of two (2) years. At the Department's discretion, they may choose to extend the Contractor's Technical Support and Warranty Services for two additional one (1) year periods (for a total of four years following Final Acceptance). Refer to Specification 400 – Technical Support and Warranty Services for additional information on technical support and warranty requirements.

1.2.15. OPTION: Additional Technical Support and Warranty

Upon completion of Years 1 and 2 of the Technical Support and Warranty Period, the Department may, at its sole discretion, choose to extend this contract to include an additional one (1) year of Technical Support and Warranty Services (Year 3). Upon completion of Year 3, the Department may, at its sole discretion, choose to extend this contract to include another additional one (1) year of Technical Support and Warranty Services (Year 4). Refer to Specification 400 – Technical Support and Warranty Services for additional information on technical support and warranty requirements.

1.2.16. OPTION: Additional Modular Chassis Switch and Network Equipment

At its sole discretion, at any time during the contract duration, including the initial Technical Support period, the Department may choose to have the Contractor provide additional equipment and services to implement a redundant Modular Chassis Switch and associated network communications equipment at the Downtown New Britain Station supervisors building.

The modular chassis switch to be installed at the Downtown New Britain Station shall comply with Specification 533 – Modular Chassis Switch and shall be of the identical made and model as the switch to be installed in the Busway Operations Center, and shall include all rack equipment needed for installing the chassis switch in accordance with specified requirements and manufacturer recommendations. As shown in Drawings (Communications Network Block Diagram – Option: Full Redundant Chassis Switch), the chassis switches at Hartford and New Britain shall be connected to all field equipment (through network switches at each of the stations) over separate (redundant) resilient packet rings. The chassis switches at Hartford and New Britain, the network switches and equipment at each of the stations and field equipment locations, and Busway Operations Center system equipment shall be configured to allow the

transmission of data and video from the station and field equipment to and from the Busway Operations Center on both "A" and "B" resilient packet rings. The chassis switches, station network switches, and Busway Operations Center equipment shall be configured to maintain no loss of functionality in the event of a failure of any network switching component or link.

1.2.17. OPTION: Network Attached Storage System

At its sole discretion, at any time during the contract duration, including the initial Technical Support period, the Department may choose to have the Contractor provide an option and pricing details for the installation of a Network Attached Storage System (NAS) in replacement of the storage installed within the servers. The NAS option shall include all storage devices and software to comply with requirements as detailed in Specification 535 – Server, including the electrical requirements, environmental requirements, storage requirements, storage disk requirements, support for virtualization, clustering, and system uptime requirements. In addition, the NAS option shall also have dual redundant hot-plug power supplies, dual redundant controllers, dual 1/10GbE network interface cards (NICs) and all drives shall be hot-pluggable. The option shall also include a spare requirement of 10% of all installed hot-plug hard-disk drives, one (1) hot-plug power supply unit, one (1) 1/10GbE NIC. All spares shall be of the same make and model as originally installed in the NAS.

1.2.18. OPTION: Expansion of Transit ITS Capabilities

At its sole discretion, at any time during the contract duration, including the initial Technical Support period, the Department may choose to have the Contractor provide additional equipment quantities and installation and integration services to expand the CAD/AVL Central System to accommodate a larger geographic area and additional vehicle fleets. This work would include the provision of remote instances of BOC central software and supporting hardware at various locations throughout the State.

For costing purposes, the Contractor shall assume the following locations and fleet sizes:

Location	Transit Vehicles	Non-Revenue Vehicles
Hartford	300	35
Hamden	160	25
Stamford	100	15
Waterbury	100	17
DATTCO (in New Britain)	20	2
New Britain	20	6
TOTAL	**700**	**100**

As part of this option, the Contractor shall provide the following on-board equipment for transit vehicles: the Mobile Data Computer (including a Vehicle Logic Unit and Mobile Data Terminal), AVA controllers, interior VMSs, Automatic Passenger Counters, a Mobile Communications Gateway and Router, and a Multi-band On-board Antenna. The Contractor shall also provide the following on-board equipment for non-revenue vehicles (e.g., supervisor, administrative, and maintenance vehicles): On-board Processing Device with an integrated GPS receiver and cellular data modem card, and an Antenna that supports GPS and cellular frequencies. Refer to equipment specifications and testing specifications for further equipment details. Project schedule and Department responsibility for the equipment and services provided

as part of this option would be separately negotiated and would not subject to the time constraints identified herein, except as specifically identified by mutual agreement.

1.3. **Progress Meetings**

The Contractor shall participate in regular progress meetings to be conducted at a location determined by the Department every two (2) weeks, unless otherwise directed by the Engineer. At the Engineer's discretion, the Contractor may be allowed to participate in these project meetings via teleconference. Attendance at all progress meetings by the Contractor shall be provided at no additional cost to the Department.

The Contractor shall prepare and present progress reports, including an agenda for the Progress Meeting and the updated CPM schedule that shall be submitted to the Department at least two (2) days prior to each Progress Meeting. Progress reports shall be submitted in a format approved by the Engineer.

The Contractor shall be represented in these Progress Meetings by at a minimum their Project Manager, as well as any additional Contractor staff necessary to properly address the current issues and project status.

The Contractor shall submit minutes and an updated Action Item List (AIL), if needed, within one (1) week of each Progress Meeting.

1.4. **Submittals and Control of Materials**

The following table summarizes the major submittals to be provided by the Contractor to the Engineer for review and approval, where they are referenced in this or other specifications, and the timeline for the submittal. These items are in addition to other requirements described in the Specifications. Additional submittals may be required as part of the Contract Terms and Conditions. Where conflicts exist, the Contract Terms and Conditions shall govern. All correspondence for the project shall be produced and controlled using PCM software. Refer to Specification 109 – Document Control Specialist for additional submission requirements for all documentation.

Table 1: Summary of Submittals and Submittal Timeline

Submittal	Reference	Submittal Timeline
Preliminary Design Documentation	1.2.1.2 and 1.2.1.3	40 business days following NTP
Final Design Documentation	1.2.1.2 and 1.2.1.4	Prior to approval to commence Factory Acceptance Tests
As-Built Design Documentation	1.2.10	Prior to approval to commence training
Factory Acceptance Test Documentation	1.2.2	Prior to approval to commence the Prototype Demonstration Test and the On-board Equipment Pilot Test
Prototype Demonstration Test Documentation	1.2.3	Prior to approval to procure all specified and accepted equipment quantities for the complete system (excluding on-board equipment)
On-board Equipment Pilot Test Documentation	1.2.4	Prior to approval to procure all specified and accepted on-board equipment quantities for vehicles
System Demonstration Test Documentation	1.2.6	Prior to approval to install all equipment
Installation Test Documentation	1.2.8	Prior to approval to commence Integration Test
Integration Test Documentation	1.2.10	Prior to approval to commence Training
Training Plan	1.2.12 / Specification 300	40 business days prior to commencement of Training. (Training shall be completed after Integration Test and before commencement of Acceptance Test will be authorized)
Training Materials	Specification 300	40 business days prior to commencement of Training (except for video recordings of training sessions, which shall be submitted prior to commencement of Acceptance Test)
O&M Documentation	1.2.11	Prior to approval to commence Training
Documentation on Failures during the Acceptance Test	1.2.13	As needed prior to System Acceptance
Accuracy Testing Procedures for the Traveler Information Software	1.2.13	Prior to System Acceptance
Progress Meeting Materials	1.3	Throughout duration of project: Progress reports at least 2 days prior to meetings and minutes within 1 week of meetings
Progress Meeting Minutes and AIL	1.3	Within one (1) week after progress meetings
Initial Work Breakdown Structure	Specification 101	Within five (5) business days of NTP
Document Control Specialist Name and Resume, Name of Personnel to Access Document Control System	Specification 109	Within five (5) business days of NTP
Monthly updates of CPM schedule	Specification 101	Monthly, by the 5th business day
Biweekly Schedule	Specification 101	The 1st business day of each week
As-Built Schedule	Specification 101	Within 20 business days of completion of the Work
QC Records	Specification 108	As needed throughout the Project to demonstrate compliance with the QC Program
QC Inspection Reports	Specification 108	Monthly, by the 5th business day
Detailed repair records and monthly performance reports during the warranty period(s)	Specification 400	Sent on monthly basis (unless otherwise agreed upon by the Engineer) during the Technical Support and Warranty period

2. GENERAL MATERIALS REQUIREMENTS

2.1. Applicable Codes and References

The Contractor shall adhere to all relevant statutes, regulations, and codes in force in the State of Connecticut. The Contractor shall ensure that systems comply with all functionally necessary and appropriate standards as listed below and in the individual equipment specifications. Installation procedures and the materials provided shall comply with all legal requirements, applicable laws, and applicable codes, standards, regulations, recommendations, and authorities including but not limited to those of the following entities:

- Standard Specifications of the Department of Transportation of the State of Connecticut
- Intelligent Transportation System (ITS) Architecture for Connecticut and related standards
- International Organization for Standardization (ISO)
- International Electrotechnical Commission (IEC)
- Federal Highway Administration (FHWA)
- Federal Communications Commission (FCC)
- American National Standards Institute (ANSI)
- American Association of State Highway and Transportation Officials (AASHTO)
- SAE International
- Electronic Industries Association (EIA)
- Institute of Electrical & Electronics Engineers (IEEE)
- Institute of Transportation Engineers (ITE)
- National Television Standards Committee (NTSC)
- Telecommunications Industries Association (TIA)
- Underwriters Laboratories (UL)
- National Electrical Code (NEC)
- Insulated Cable Engineers Association (ICEA)
- National Electrical Manufacturers Association (NEMA)
- American Society for Testing and Materials (ASTM)
- National Fire Protection Association (NFPA)
- Occupational Safety and Health Administration (OSHA)
- US Department of Defense Military Standard (MIL)

The Contractor shall comply with relevant National Transportation Communications for ITS Protocol (NTCIP) specifications including, but not limited to:

- 1203 NTCIP Object Definitions for Dynamic Message Signs (DMS)
- 1205 NTCIP Objects for CCTV Camera Control
- 1208 NTCIP Object Definitions for Video Switches
- 1212 NTCIP Objects for Network Camera Operation
- NTCIP 1405 – Transit Communications Interface Profiles – Standard on Spatial Representation (SP) Objects
- NTCIP 1407 – Transit Communications Interface Profiles – Standard on Control Center (CC) Objects

In the event of any conflict between the aforesaid laws, regulations, standards, codes, ordinances and documents, and the government's specifications, the Contractor shall immediately bring the conflict to the attention of the Engineer.

All Equipment must be able to support current and future Department IT requirements and policies at no additional cost. Links are listed below:

- http://www.ct.gov/best/cwp/view.asp?a=3978&q=462024&bestNav=|
- http://www.ct.gov/best/cwp/view.asp?a=1245&q=253994&doitNav=|&bestNav=|

When applicable, equipment shall comply with "Energy Star" requirements and carry "Energy Star" labeling. Such equipment shall comply with current "Energy Star" requirements on the date of placement and must be in compliance with (Sec. 4a-67c: Equipment and appliances for state use, energy standards). Contractor shall ensure that all "Energy Star" features of the equipment are installed and operational for the life of the Placement.

2.2. **Manufacturer Requirements**

Each manufacturer shall have an in house Quality Management System (QMS) in place certified by an approved registrar to the latest ISO 90001 standards.

The manufacturer shall provide a toll-free help desk number that will be manned during normal business hours.

In addition to these overall manufacturer requirements, see individual equipment specifications for additional detail.

2.3. **General Physical Requirements**

2.3.1. General

Equipment shall meet or exceed the minimum conditions listed in the individual equipment specifications. Any equipment that does not meet those conditions shall be subject to the approval by the Engineer.

All equipment and components shall be new at time of testing and installation.

All equipment shall be designed for use in the transit industry, with specific attention to ergonomics, reliability, efficiency, and safety for passengers, operators, maintenance personnel and other system users.

Equipment shall be identified by a part number and/or serial number, permanently and legibly affixed directly to the surface of the unit.

Equipment furnished under these specifications shall be the latest model in current production, as offered to commercial trade at time of design documentation finalization, and shall conform to quality workmanship standards and use materials consistent with transit industry requirements.

System components shall be built in accordance with best commercial practice. As a minimum, the design and construction shall provide for:

- Safe, reliable and stable operation.
- Minimum maintenance, configuration and calibration required.
- Minimum number and variety of assemblies and spare parts.
- Maximum attention to human engineering.
- Simplified design and rapid fault isolation to reduce the requirement for highly skilled maintenance personnel.

The Contractor shall make required improvements and provide all required structures and services for equipment or elements to be installed at all sites and in vehicles.

All external screws, nuts, and locking washers shall be stainless steel or an approved alternate non-corrosive material; no self-tapping screws shall be used unless specifically approved.

All parts shall be made of corrosion resistant material, such as UV resistant plastic, stainless steel, anodized aluminum, or brass.

The Contactor shall utilize modular, expandable design throughout.

Standard, commercially available components shall be used wherever possible.

Standard maintenance activities shall not require the use of specialized tools or equipment.

All functionally identical modules, assemblies and components shall be fully interchangeable between all equipment acquired under this contract.

All modules and assemblies shall be connected using standardized durable, positive-locking, indexed quick disconnect connectors. Weatherproof connectors shall be supplied for all connections exposed to the exterior environment.

All equipment shall be modularly upgradeable so that it does not need to be replaced in its entirety to increase memory capacity, to upgrade processing performance, or to reconfigure I/O options.

For the purposes of this Work, “modular” shall be interpreted to include, but not be limited to, equipment composed of standardized units or sections that allow for easy construction, flexible arrangement, and ease of removal/replacement. Items shall not be considered “modular” if equipment modules cannot be removed without permanent damage to the equipment, or if modules are permanently fastened to the chassis or motherboard.

Equipment shall be designed to prevent unauthorized access, and to facilitate only authorized access.

Provisions shall be made to protect all equipment and components from common vandalism and physical abuse.

Any retrofit or post-delivery change to one item of one type of equipment will be reviewed with the Department project manager, and upon approval changes shall be made identically to all units.

2.3.2. On-board Equipment

On-board equipment includes all equipment installed on-board transit and non-revenue vehicles.

Unless otherwise approved, internal (to the on-board equipment) batteries shall not be used to maintain parameter information in on-board equipment when it is in its powered down state. Internal batteries may be used for certain very limited functions such as maintaining the operation of a real-time clock when the equipment is powered down, provided that power is consumed from the batteries only when the equipment is powered down, and that such batteries have a minimum life of four (4) years when the equipment is stored in inventory, and eight (8) years of life when the equipment is in operation. It shall be possible for Department vehicle maintenance staff to replace any such batteries.

Equipment shall allow for easy installation in vehicles without major disassembly of the vehicle.

In-vehicle system components shall be identical in mounting characteristics and inter-unit cabling across the entire fleet, so that a specific piece of equipment will be installable with minimal modification in any of the vehicles for which it might be used. This requirement does not apply to mounting brackets that may be unique to each vehicle type and configuration. Unique mounting brackets shall be interchangeable between vehicles of the same vehicle type.

Equipment shall not pose a hazard to drivers or passengers when operated in accordance with manufacturers' recommendations.

Individual equipment components to be installed shall be capable of being carried by a single person, and as such shall not exceed fifteen kilograms in mass.

Equipment shall be able to be replaced in a vehicle in five minutes or less with basic hand tools when a spare unit is available.

Equipment shall be designed and rated to handle vehicle vibration, as compliant with SAE J1455-06 or MIL-STD-810F.

All roof or exterior mounts shall incorporate a drip loop.

2.3.3. Indoor Equipment

Indoor equipment includes all equipment installed inside of buildings, including at the BOC and CTTRANSIT building facilities.

Indoor equipment components shall be identical in mounting characteristics and inter-unit cabling across all of the units, so that a specific piece of equipment will be installable with minimal modification at any of the stations or at any point along the busway for which it might be used.

System control shall be achieved by operators with as few separate steps for commonly performed functions as possible, or by operator created macros.

Human factors engineering shall be conducted such that repetitive stress injury (RSI) risk is low.

2.3.4. Outdoor Equipment

Outdoor equipment includes all equipment that is not installed inside of a building. This includes all equipment installed at stations and along the busway, whether or not in protective housing or under shelters.

Equipment shall be of rugged construction and designed to be resistant to vandalism and theft.

Equipment shall be designed to conform to the colors and graphics of the CT***fastrak*** stations.

Components shall be identical in mounting characteristics and inter-unit cabling across all of the units, so that a specific piece of equipment will be installable with minimal modification at any of the stations or at any point along the busway for which it might be used.

Equipment shall not pose a hazard to pedestrians when operated in accordance with manufacturers' recommendations.

All parts and equipment shall be designed to withstand vibration consistent with location on an active busway and adjacent to an active rail line.

2.4. **General Environmental Requirements**

Equipment shall meet or exceed the minimum conditions listed in the individual equipment specifications. Any equipment that does not meet those conditions shall be subject to the approval by the Engineer.

The climatic factors described below and in individual equipment specifications shall be used as design guidelines and shall be considered as operational requirements. Actual local temperatures and environmental conditions within the devices may be more severe than the general ambient conditions and the Contractor shall be responsible for evaluating these during their design effort. Additionally, the Contractor shall be responsible for advising if there are any environmental factors to which their equipment may be sensitive that are not listed in the following sections and individual equipment specifications. The Contractor shall ensure that no equipment damage occurs during manufacture, storage and shipment as a result of climatic conditions that differ from those listed in the following sections.

Protection shall be provided against radio frequency and electromagnetic interference (RFI/EMI) emission sources, as well as internal conductive or inductive emissions. The Contractor shall describe what provisions, under FCC Part 15 and IEC standards shall be included for RFI/EMI protection.

All outdoor equipment shall be designed for and suitably protected against exposure to snow, ice, fog, rain, hail, de-icing salt and other environmental conditions prevalent in the northeastern United States.

Enclosures shall include any provisions necessary to maintain the internal equipment at the manufacturer's specified temperature and humidity.

2.5. General Electrical Requirements

2.5.1. General

All device enclosures shall contain an easily accessible master circuit breaker that will remove power from the equipment when tripped. Circuit breakers shall clearly indicate when they have been tripped.

All enclosures, chassis, assemblies, panels, switch boxes, terminal boxes, exposed metal equipment and metal shall be grounded.

All equipment connected to copper power or communications cables that may be exposed to electrical transients such as power surges or lightning shall be protected with transient suppressors (surge suppressors) that are designed specifically for the type of circuit to which it is applied. Transient suppressors shall be installed in accordance with manufacturer guidelines and shall be connected to low resistance ground using the largest gauge copper grounding wire that the grounding terminal of the transient suppressor can accept, and the grounding wire shall be installed following the shortest path to the ground connection while minimizing bending of the grounding wire.

Conductors carrying fifty volts or more shall not be bundled with any lower voltage conductors.

Wire dress shall allow sufficient slack for three additional "re-terminations" without excess tension.

Wire splices are not permitted.

Wire and cable ties shall not be so tight as to cause indentation and damage to the insulation.

Adhesive-mounted bases shall not be used to support wire ties or cable supports.

All conductors within each enclosure shall be installed free from metal edges, bolt heads, and other sharp or interfering points.

All conductors providing connections between components shall be provided with strain-relief, and be clear of moving objects that could damage either the conductor or the object.

Where wires pass through openings, appropriate bushings shall be provided to protect the integrity of the wiring insulation.

All terminations and cables shall be clearly indexed, labeled and schematically identifiable.

All wire labels shall be non-metallic and shall resist standard lubricants and cleaning solvents.

When components shall be connected to each other through individual wires, the wiring shall be incorporated into a wiring "harness," where each branch of each circuit can be separated from others for troubleshooting.

Operation of equipment shall not be affected by electromagnetic effects in the vicinity of electric trolley buses, light rail vehicles and associated electrical systems.

Operation of equipment shall not be affected by the electromagnetic fields generated by utility transmission lines, by an overhead catenary at distances as close as twenty-five feet, or by local power distribution lines at distances as close as fifty feet.

The Contractor shall be responsible for securing all electrical certifications as may be required to address local code requirements, and shall be responsible for any costs associated with the certification process and/or inspections.

2.5.2. On-board Equipment

On-board equipment includes all equipment installed on-board transit and non-revenue vehicles.

On-board components shall run on standard vehicle power and operate at a nominal +12.5V DC, and be fully functional within operating supply voltage ranges of + 9V DC to +30V DC. Voltages shall be measured at the power connector to the device.

Contractor shall provide power conditioners/filters for all in-vehicle equipment. Test procedures shall demonstrate the effectiveness of power conditioning in blocking line voltage noise and spurious signals.

In the event that any existing vehicle wiring, switches or contact points are utilized, the Contractor shall be responsible for testing and certifying that the wiring, switches or contact points are in an acceptable state and suitable for reuse (TEST-1: Wiring, Switch, Contact Point Test). In the event that such wiring, switches or contact points are not suitable for reuse, the Contractor shall immediately upon discovery notify the Department that replacement is required.

All electronic equipment should be self-protecting in the event of shorts in the cabling, and also in over-voltage (e.g. over 32V DC on a 24V DC nominal voltage rating with a maximum of 50V DC) and reverse polarity conditions. If an electronic component is required to interface with other components, it shall not require external pull-up and/or pull-down resistors and associated external power supplies. Where this is not possible, the use of a pull-up or pull-down resistor and associated external power supplies shall be limited as much as possible and easily accessible and labeled.

Operation of equipment shall not affect or be affected by vehicle components, such as engine ignition, or other on-board equipment including vehicle power supplies, radios, automatic vehicle identification systems, and on-board data collection and processing equipment.

All wiring that requires shielding shall meet the following minimum requirements. A shield shall be generated by connecting to a ground, which is sourced from a power distribution bus bar or chassis. A shield shall be connected at one location only, typically at one end of the cable. However, certain standards or special requirements, such as SAE J1939 or RF applications, have separate shielding techniques that also shall be used as applicable.

The Contractor shall identify the power and operating specifications of all equipment to be installed on vehicles.

The Contractor shall follow recommendations from vehicle manufacturers and subsystem suppliers regarding methods to prevent damage from voltage spikes generated from welding, jump starts, shorts, etc.

2.5.3. Indoor Equipment

Indoor equipment includes all equipment installed inside of buildings, including at the BOC and CTTRANSIT building facilities.

All Equipment installed in Department or third-party facilities with the exception of any on-board equipment shall operate from a nominal line voltage of 120 VAC, within voltage tolerances of +10% to –20%, and a frequency range of 57 Hz to 63 Hz without equipment damage.

2.5.4. Outdoor Equipment

Outdoor equipment includes all equipment that is not installed inside of a building. This includes all equipment installed at stations and along the busway, whether or not in protective housing or under shelters.

All equipment installed at stops or terminals shall operate from a nominal line voltage of 120/240 VAC, within voltage tolerances of +10% to –20%, and a frequency range of 57 Hz to 63 Hz without equipment damage.

2.6. **General Software Requirements**

All software shall be fully licensed and applicable to proposed system. Software licenses shall be obtained in the name of the State.

All software shall be written in a common and well-known, modern, high-level, highly structured language.

Current commercial off-the-shelf (COTS) software required to perform system functions shall be used whenever possible. Open source and platform independent software and systems are preferable. In addition, other software applications, including all necessary third-party applications, shall be procured as necessary to configure system for optimal performance.

Software shall be developed in a modular design and organized in a modular fashion to the extent possible.

All software shall be the current version in production at the time of installation. Software versions shall be approved by the Engineer.

All software shall contain version control numbers.

Features shall be provided to identify the software version on each device, and verify that it is the correct or most recent version for that device.

For all software and firmware, revision and version updates and upgrades shall be provided by the Contractor to the Department on an ongoing basis at no additional cost throughout the duration of the Technical Support and Warranty period and for as long as the software remains under a current maintenance/service agreement.

For all software, the software manufacturer shall commit to continue to offer a maintenance/service agreement for the software for a minimum ten (10) year period. The maintenance/service agreement shall include providing patches, bus fixes, security upgrades, and ongoing technical support.

All use of assembly/machine language shall be submitted for review and approval during the design review.

Adjustable, specific, and customization parameters shall not be hard-coded into the source-code. They shall be user-modifiable.

Application software (both user and system) shall be portable, i.e., the source code shall be transferable to other computers using the same hardware and operating system without any modifications.

The application software shall be reasonably scalable to newer, higher performance hardware or operating systems.

New or modified application software shall be developed using structured software development methods (to be approved by the Engineer), and shall be submitted for the design review.

All software shall be optimized for ease-of-use and ease-of-maintenance. Software shall be developed to allow for configuration and customization by Department IT staff. Software shall be configurable without additional third-party support or resources. Software shall not require special additional tools or software for configuration, customization, or maintenance.

The system shall contain all supporting software required to implement, operate, modify, and maintain all graphics displays and interactive screens.

Passwords shall not be displayed unencrypted.

All application software shall be self-diagnostic.

All application source code shall include application and individual module descriptions.

All user and system interfaces shall have online help features.

The system date and time shall adjust automatically for daylight saving, daylight ending and holidays.

The system date and time shall provide the same date for service times associated with a complete 'Transit Day', where number of hours in one day is based on start and end of service regardless of service extending past midnight.

The system security shall provide features to maintain data integrity, including error checking.

All software shall store all data relating to system operation in relational databases. The system's database manager shall support standard commands and queries and shall be capable of performing all necessary system functions.

Data transferred from a device or system shall not be purged or written over until a successful transfer is confirmed.

Features shall be provided to ensure that all system-created files are uniquely identified, and that no files are lost or missed during data transfer.

Verification features shall be provided to confirm that there has been no loss of data at any point in the system.

Verification features shall be provided to confirm that there have been no unauthorized changes to, or destruction of, data.

Features shall be provided to automatically detect, correct and prevent the propagation of invalid or erroneous data throughout the system.

The Contractor shall prepare a comprehensive data backup and recovery plan.

The Contractor shall provide a data backup system for data archiving and recovery.

The Contractor shall provide tools to enable scheduling of data archiving and batch processing.

The data backup system shall include capabilities for the Department to back up data through network-wide backup.

It shall be possible to recover and transfer data files in the event of a primary data storage failure through a secondary standardized PC interface such as an RS-232 port.

In the event of a primary data storage failure and/or backup data storage battery failure, an indication on the display shall alert the system administrator.

An alternate process for initiating data extraction and/or alternate means of removing data records may be provided which shall be subject to review and approval by the Engineer.

The Contractor shall provide a detailed description of alternate process for initiating data extraction and/or alternate means of removing data records and the technical details necessary for evaluation by the Engineer.

2.7. General Data Communications Requirements

All data communication networks shall be either in accordance with a nationally recognized interface standard, such as those published by SAE, IEEE or ISO, or shall be published to the Department with the following minimum information:

- Protocol requirements for all timing issues (bit, byte, packet, inter-packet timing, idle line timing, etc.) packet sizes, error checking and transport (bulk transfer of data to/from the device).
- Data definition requirements that ensure access to diagnostic information and performance characteristics.
- The capability and procedures for uploading new application or configuration data.
- Access to revision levels of data, application software and firmware.
- The capability and procedures for uploading new firmware or application software.
- Evidence that applicable data shall be broadcast to the network in an efficient manner such that the overall network integrity is not compromised.

Any electronic vehicle components used on a network shall be conformance tested to the corresponding network standard.

The data network cabling shall be selected and installed according to the selected protocol requirements. The physical layer of all network communication systems shall not be used for any purpose other than communication between the system components, unless provided for in the network specifications.

Communications networks that use power line carriers (e.g., data modulated on a 24V-power line) shall meet the most stringent applicable wiring and terminal specifications.

2.8. General Functional Requirements

The Contractor shall provide all hardware and software to provide fully integrated ITS and Communications Systems that perform the functions as specified in this specification and all other equipment specifications for the CT***fastrak*** ITS and Communications Systems.

2.9. General Non-Functional (Performance) Requirements (e.g.: reliability)

Unless otherwise specified in the subsystem specifications, all on-board equipment shall have a minimum 25,000 hours mean time between failures (MTBF).

Unless otherwise specified in the subsystem specifications, all indoor equipment shall have a minimum 10,000 hours MTBF.

Unless otherwise specified in the subsystem specifications, all outdoor equipment shall have a minimum 10,000 hours MTBF.

System availability of all central system hardware and software shall be 99.9% or better, computed as follows: availability shall be determined by comparing the total out-of-service time to the total operating time. Out-of-service time shall include reboots and system maintenance, excluding planned and approved preventative maintenance. The Contractor shall employ industry-standard methods and tools to measure and monitor system performance and compliance with these system availability requirements throughout the term of the Contract, including all ongoing Technical Support and Warranty periods.

2.10. External Interface Requirements

The ITS and Communications Systems shall interface with the following external systems:

- Scheduling system through the Department's LAN (which may or may not include vehicle lists);
- Revenue vehicle on-board systems, including voice radio, DVR, headsigns, PA System, and fareboxes through the MDC;
- Dedicated telephone lines for emergency calls made on ECBs;
- Department's GIS-based mapping software through the Department's LAN; and
- Credit and debit card processing systems through the Department's LAN (or other communications method approved by the Department).

3. CONSTRUCTION METHODS

3.1. Delivery, Storage, and Handling

The Contractor shall provide adequate surveillance of and instructions for handling, storing, preserving, packaging, packing, marking, and shipping to protect quality of products.

The Contractor shall be responsible for protecting finished surfaces from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall provide a covered, protected facility for storage of materials before installation. The Contractor shall be responsible for replacing any damaged hardware and software.

All transporting equipment is to be insured and properly lighted as required by the Connecticut Department of Motor Vehicles (DMV). All equipment is to be equipped with warning devices. The cost of transporting equipment to and from the area in which it will be used will be the responsibility of the Contractor. No transportation charges, setup or breakdown fees or charges shall be allowed.

3.2. Installation and Interconnection

The Contractor shall arrange for access and approval to complete relevant installations, including any necessary staging areas, to be granted by the Engineer.

The Contractor shall provide all labor, materials, parts, cables, software, documentation, instructions, warranty and maintenance in accordance with the intent of these specified system requirements.

All modules and assemblies shall be connected using standardized durable, positive-locking, indexed quick disconnect connectors. Weatherproof connectors shall be supplied for all connections exposed to the exterior environment.

All equipment shall be installed in a manner that allows for simple replacement in the event of failure.

4. SPARE PARTS, MAINTENANCE MATERIALS, AND START-UP SUPPORT

4.1. Spare Parts and Maintenance Materials

For purposes of the Price Proposal, a required number of spare parts shall be requested by the Department. Upon Contractor selection, the Contractor shall be responsible for reviewing the required spare parts and providing a revised list that includes Contractor-recommended spare quantities required to allow the Contractor to meet technical support and warranty requirements, with justification. The Contractor shall develop and submit this revised list of spare parts and maintenance materials to the Department for review and approval as part of its Design Documentation submittal. The Department will review this spare parts and maintenance materials list and work with the Contractor to adjust the Contract as needed.

Upon written approval of spare parts quantities, and upon successful completion of the Prototype Demonstration Test, the Contractor shall then procure the spare parts in factory new and working order. All spare equipment shall be shipped in manufacturer's original, unopened and undamaged product packaging and containers. For the duration of the Technical Support and Warranty period, including any optional extensions that are exercised, the Contractor shall be responsible for storing and maintaining this quantity of spare parts. The Contractor may use these spare parts to replace faulty equipment in the field, in order to meet technical support and warranty response times and requirements. If a spare part is used to replace equipment in the field, the Contractor shall procure a replacement spare part at no additional cost to the Department. Upon conclusion of the Technical Support and Warranty period, the Contractor shall provide the entirety of the approved quantity of spare equipment in factory new and

working order to the Department. Again, all spare equipment shall be shipped in manufacturer's original, unopened and undamaged product packaging and containers to the Department, as directed by the Engineer.

Unless otherwise directed by the Engineer, the Contractor shall also provide all maintenance materials and sufficient operating stock (ticket stock, paper, printer ink, etc.) to allow for anticipated normal operations of the entire CT***fastrak*** system for a three (3) month period following start of full bus service operations on the busway. This maintenance material and operating stock shall be provided to the Department following successful completion of the Integration Testing, as directed by the Engineer.

4.2. **Start-up Support**

The Contractor shall be responsible for maintaining the equipment from the time that it is installed throughout the successful completion of the Acceptance Test, defined as the "start-up" period.

During this "start-up" period, the Contractor shall continue to maintain all system components in good working condition in accordance with the contract specifications and shall provide all preventive and routine maintenance and any required repairs. Routine maintenance shall comply with the manufacturers' recommendations. During this "start-up" period, the Contractor shall also supply sufficient maintenance material and operating stock to fully equip all devices and to facilitate testing and assessment of the operations of all system equipment.

During this "start-up" period, all requests for service shall be responded to in a timely fashion but in no event shall the response time for maintenance personnel to reach the site and be ready to start work exceed four (4) hours from the time of the service request, including weekends and holidays.

During the project and prior to Final Acceptance, the Contractor shall perform all modifications to the computer hardware and software that may be required to meet or exceed the requirements of system specifications.

Following Final Acceptance, the Contractor shall maintain the ITS and Communications Systems for CT***fastrak*** in accordance with the requirements in Specification 400 – Technical Support and Warranty Services.

5. MEASUREMENT AND PAYMENT

For implementation services rendered as part of all work associated with the implementation of the ITS and Communications System for CT***fastrak***, compensation shall be made based on a negotiated total lump sum implementation cost. The total lump sum implementation cost shall consist of the sum total of the unit prices and lump sum costs as indicated by the Contractor in the negotiated contract for each of the equipment items included in these specifications, as well as include all documentation, design, coordination, procurement, delivery, installation, integration, configuration, calibration, testing, training, direct salary, overhead, profit, direct

expenses, and all other costs necessary for the Contractor to successfully implement the system in accordance with these specifications and the Terms and Conditions of the Contract.

The release of payment for this Work shall be based on a milestone completion schedule. The payment schedule shall be based on milestones as follows:

Milestone Completion Schedule

Milestone	**% Payment**	**Cumulative %**
Approval of Final Design Documentation	10	10
Approval of FAT Documentation	10	20
Approval of PDT Documentation	10	30
Approval of On-board Equipment Pilot Test Documentation	10	40
Approval of SDT Documentation	10	50
Approval of Installation Test Documentation	10	60
Approval of Integration Test and As-Built Documentation	20	80
Approval of O& M Documentation	5	85
Completion of Training	5	90
Issuance of Final Acceptance	10	100

In addition to the lump sum implementation cost, payment for several additional implementation items will be paid in accordance with the payment schedule described in their individual specifications. These implementation items include:

- Specification 102 – Construction Field Office, Large
- Specification 104 – Trafficperson (Municipal Police Officer)
- Specification 105 – Trafficperson (Uniformed Flagger)
- Specification 106 – Construction Communication Equipment
- Specification 107 – Environmental Health and Safety
- Specification 108 – Contractor Quality Control Program
- Specification 109 – Document Control Specialist
- Specification 206 – Software Integration

The Contractor and the Department shall negotiate a separate lump sum cost for the initial two (2) year period of Technical Support and Warranty Services (Specification 401). The Contractor and the Department shall also negotiate a separate lump sum cost for each of the two optional one (1) year extensions of Technical Support and Warranty Services (Specifications 402 and 403).

The release of payment for all work associated with Technical Support and Warranty Services of the CT***fastrak*** ITS and Communications Systems shall be based on the negotiated lump sum cost, divided into equal amounts and dispersed quarterly over the technical support period. Quarterly payments shall take into account any credits or penalties applied by the Department. Refer to equipment specifications, and Specification 400 – Technical Support and Warranty Services for more information.

Payment and schedule for other options procured as part of this work shall also be separately negotiated between the Contractor and the Department. These options may be incorporated into the lump sum total implementation cost by mutual agreement.

Payment and schedule for other options procured as part of this contract shall be individually negotiated between the Contractor and the Department. These options may be incorporated into the lump sum total implementation cost by mutual agreement.

SPECIFICATION 101 – PROJECT COORDINATOR

DESCRIPTION

Under this item the Contractor shall furnish the services of one of his administrative employees, entitled the Project Coordinator for this project, who will coordinate and expedite all phases of the work required for the project to ensure that the construction schedule is maintained. The Project Coordinator shall be designated by name, in writing with a resume of his qualifications, submitted within the requirements of Section 2.2 – Form 816/Construction Contract and shall not be changed without prior written notice to the Department for the Department to review and approve. The Project Coordinator qualifications must include having completed Primavera Training Course Nos. 102 (Project Management Module – Basic Course) and 106P (Project Management Module – Advanced Course), including successful completion of at least 2 constructions projects of similar complexity, where he served in a lead scheduling capacity. If, in the judgment of the Engineer, the Project Coordinator is not sufficiently experienced and versatile in the preparation, interpretation and modification of the construction schedules, the Contractor shall engage the services of a Consultant, subject to the approval of the Engineer, for the scheduling work required. If a Consultant is engaged, the Consultant shall be present at the first meeting, along with the Project Coordinator, prepared to discuss, in detail, the proposed methods and techniques to be used. Thereafter, the Project Coordinator or the Consultant responsible for updating the CPM (Critical Path Method) schedule shall attend all meetings between the Contractor, their Subcontractors, and any other meetings, which may affect the CPM schedule. The Project Coordinator shall be knowledgeable of the status of all aspects of the work throughout the length of the Contract. The Contractor shall prepare and maintain CPM schedules utilizing Release 7 (or later version, if required by the Engineer) of Primavera P6 Project Management software.

SCHEDULE REQUIREMENTS

1. The Contractor shall prepare a computerized CPM schedule in accordance with the pertinent provisions of "Section 2.3- Liquidated Damages" and "Section 2.4 New Third Party Contract Clauses Required by FTA Circular 4220.1f" of the CTDOT Standard Specifications. The schedules shall incorporate the stages and sequence of construction as outlined on the Plans and in the Specifications, from Contract award until the final completion of all work. All other limiting factors that affect construction shall be incorporated into the schedules.

The Contractor is advised that its schedules and reports, as specified herein, will be an integral part of the Department's management program and will be used to monitor project progress, plan the level-of-effort by its own work forces and consultants, and as a critical decision making tool. Accordingly, the Contractor shall ensure that it complies fully with the requirements specified herein and that its schedules are both timely and accurate throughout the life of the project. The Contractor's schedules shall be used by the Department and the Contractor for the following purposes as well as any other purpose where the issue of Time is relevant:

- To communicate to the Department the Contractor's current plan for performing and completing the Work

- To identify Work items and paths that are critical to the timely completion of the Work
- To identify upcoming activities on the critical path(s)
- To evaluate the best course of action for recovering schedule delays
- As the basis for progress payments to the Contractor
- As the basis for analyzing the Time impact of changes in the Work.
- To identify when submittals will be submitted by the Contractor for the Department's review
- To aid in prioritizing the Department's review of submittals
- To document the actual progress of the Work
- To aid in integrating the Work with the operational requirements of the Department, Amtrak and other third-parties
- To facilitate efforts to complete the Work in a timely manner
- Assignment of responsibility for performing specific activities
- Access to and availability of work areas
- Identification of interfaces and dependencies with proceeding, concurrent and follow-on contractors
- Actual tests, submission of test reports and approval of test results
- Planning for start of revenue operations of the program

2. Acceptance of the construction schedule by the Department shall not relieve the Contractor from compliance with the requirements of the Contract Documents, or result in the approval of any variation from the Contract Documents. In the event of a conflict between the requirements of the contract documents and the information provided or shown on an accepted schedule, the requirements of the Contract Documents shall take precedence.

3. All milestones or constrained dates within the schedule shall be clearly indicated. Milestones shall be as designated by the Contract or as directed by the Engineer. The addition of Contractor milestones must be approved by the Engineer.

4. The critical path shall be defined as any continuous sequence of activities in the progress schedule that control achievement of a corresponding Contract Time or Milestone(s). Critical activities shall be defined as those on the longest path. Changes that do not affect the controlling operation on the critical path will not be considered as the basis for a time extension.

5. In order to retain the ability to roll up and summarize data into higher levels and to allow for easier management of the major portions of the work, the CPM schedule shall be organized utilizing an Enterprise Project Structure (EPS) and separated into subprojects as specified in the tables below.

EPS ID	EPS Name	Level
BWAY-PROG	New Britain-Hartford Busway Program	1

PROJECT ID	PROJECT Name	Level
Contract 7	Busway Contract 7	Project

6. The schedule shall indicate the scope and logic of the work for all work elements under the Contract, such as the planned mobilization of equipment, sequences of operations or assembly, procurement of materials and equipment, duration of activities, type of relationship, and such other information as it is necessary to present a clear statement of the intended activities.

7. All milestones and level of effort activities shall be incorporated at the Project Level. All major and long lead procurement items shall be identified in the schedule. For this project, the elements that are to be included, but are not limited to the following items:

a. Notice to Proceed
b. Mobilization
c. Field Office
d. Permit Acquisition
e. Schedule of Submittals
f. Submittals required by permit or project spec.
g. Preliminary Design Review & Final Design Review
h. Submittals for third party approval (railroad, utilities, CT Department of Environmental Protection, etc.)
i. All Required Testing , including but not limited to
   - Factory Acceptance Testing
   - Prototype Testing
   - System Demonstration Testing
   - Installation Testing
   - Integration Testing
   - Acceptance Testing
j. Identification of any manpower, material, or equipment restrictions, as well as any activity requiring unusual shift work, such as double shifts, 6-day weeks, specified overtime, or work at times other than regular days or hours
k. Required system outages (e.g. power, communications, life safety, track) and new system tie-ins to existing site systems/networks.
l. Start and Finish Milestones:
   - as designated under “Contract Time and Liquidated Damages”
   - Fiber Optic Communication System
   - Stations Installation (each station installation shall have a separate start and finish milestone)
   - On-Board Equipment Installation
   - Busway Operation Center
   - Training
   - Substantial Completion
m. Identification of interfaces and dependencies with preceding, concurrent, and follow-on contractors, CTDOT, railroads, and utilities as shown on the plans or specified in the specifications including:
   - Adjacent work by Others (work under a separate contract or by Others that requires interface, space sharing, or facilitates work to be done by the Contractor)

- Department activities (any Department activity that must occur to facilitate the Contract 2 contractor's work)
- Department Special Inspections
- Contractor off-site staging

n. Site Preparation
o. Clean-up (as-builts, delivery of spare parts, O&M Manuals)

8. The development of the Baseline Schedule and its subsequent updates will be the sole responsibility of the Contractor. Although the Contractor shall be the sole entity allowed to modify schedule data, formatting the project schedule within the Primavera Project Management software is of critical importance to ensure consistency between different projects within the New Britain-Hartford Busway Program and to allow efficient updates to the Program Master Schedule. For that reason, the Department may request that the Contractor incorporate layouts, filters, custom data items, milestones, level of effort activities, reports, and calendar ID's (although not the calendar itself), etc that do not affect the established activity dates or schedule logic.

9. All documents, which require review and approval by the Department, shall be coded to be clearly identified within the schedule. The submissions within the schedule should correspond with the Section 1.4 – Submittals and Control of Materials of the General Provisions and Specification 109 – Document Control Specialist. Review and response times to be allocated to the Department and other agencies for various types of submittals are referenced in the above mentioned specifications. Submittal review time shall commence upon receipt by the Engineer of all pertinent documents and data required to perform the review. All submittals designated by the Department as "Revise and Resubmit" shall require that the Contractor insert new submittal and review activities with appropriate logic and review/response times into the schedule. The Department shall not be held responsible for any delay associated with the approval or rejection of any substitution or other revisions proposed by the Contractor.

10. The schedule shall consist of a network technique of planning, scheduling and control; be a clear statement of the logical sequence of work to be done; and be prepared in such a manner that the Contractor's work sequence is optimized between early start and late start constraints. All schedule activities shall have at least one predecessor and one successor activity, except for the project start and finish milestones. The work shall be broken out into sufficient detail such that in general no activity has duration less than five (5) business days or greater than ten (10) business days, unless approved by the Engineer. The Contractor shall utilize the same criteria in a consistent manner throughout the term of the project. If, at any time, the Contractor alters his logic, original durations, and descriptions, adds activities or activity codes, or in any way modifies the Baseline Schedule, he must notify the Engineer of the change(s), in writing, presenting the reason(s) for the change(s) in detail. The Engineer reserves the right to accept or reject any such change(s).

11. The Contractor shall not:

- arrange the critical path through activities more susceptible to State-caused delay
- sequester float through strategies including, but not limited to:

i. falsely extending activity duration estimates
ii. use of preferential logic (creating logic between activities for the purpose of suppressing float and/or manipulating the critical path; sequencing of schedule activities in a way other than in the manner the work is physically and logically required to be built)

- use float suppression techniques
- use special lead/lag logic restraints
- use zero total float or free float constraints
- impose constraint dates other than as required by the contract

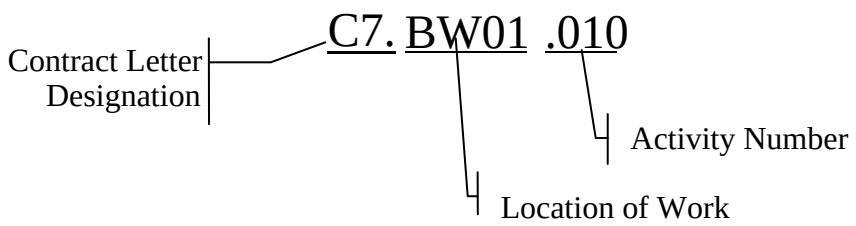
The use of these manipulations shall be cause for rejection of the project Baseline Schedule or its updates.

12. Float available in the schedule, at any time shall not be considered for the exclusive use of either the Department or the Contractor, but must be used in the best interest of completing the project within the Contract Time. During the course of contract execution, any float generated due to the efforts of either party will be available for use by the party needing that float (i.e., first come, first served). In the event neither party needs the float at that time, it shall be held in reserve until such time as either party needs the time. Project float will be a resource available to both the Department and the Contractor as described above.

13. Lags will not be allowed when the creation of an activity will perform the same function. Lag durations contained in the schedule shall not have a negative value. The Contractor shall identify any lag proposed and provide an explanation for the purpose of the lag in the narrative report.

14. The use of Activity Steps (breaking activities down into smaller units within an activity) is prohibited.

15. Activity ID numbers shall strictly adhere to the following format. The first two digits shall designate the Contract Number followed by a period. The next four digits of the activity ID number shall be utilized to designate the location of the work being performed (i.e. structure, station location, etc.) followed by a period. The remaining three digits may be used to provide unique, orderly, and sequential ID numbers for each activity. The following is an example Activity ID format to be used where "C7" represents Busway Contract 7, "BW01" represents Busway Section 1, and "010" is the activity number.



"Location of Work" coding shall be formatted to start with the general location designation as the first two characters as follows:

Milestones	MS
Busway	BW
Stations	ST
Testing	TS

16. Each Activity shall have a narrative description consisting of a verb or work function (i.e. form, pour, excavate, etc), an object (i.e. slab, footing, wall, etc.), and a location (i.e. Station Offset, etc).

17. Activity codes shall conform to the following table and must be entered exactly as shown (spelling, letter case, etc.). No additional activity codes will be allowed without the approval of the Engineer. Each activity in all project schedules shall be assigned specific values for the following:

Activity Code Name	Activity Code Type	Use
C7-RESP	PROJECT	Assign by party responsible for the activity; activities shall not belong to more than one responsible party; responsible parties include, but are not limited to: the Contractor, subcontractors, the Department, suppliers, Amtrak and utilities
C7-ADMIN	PROJECT	Designate whether the activity is a submittal (SUB), review & approval process (RA), material fabrication (FAB), delivery process (DEL), Construction Activity (CON), Testing (TST), or Training (TRN)
C7-AREA	PROJECT	Assign the general location within the project (may or may not be used depending on WBS arrangement)
C7-LOC	PROJECT	Assign a more specific location within the project (may or may not be used depending on WBS arrangement)
C7-PHASE	PROJECT	Assign a construction phase name or number as applicable

18. Activities that are modified or added by construction order shall be identified in the activity notebook. The construction order number, as issued by the Engineer, and the date the activity was modified or added shall be clearly recorded.

19. Calendars shall conform to the following table and must be entered exactly as shown (spelling, letter case, type, etc.). No additional calendars will be allowed without the approval of the Engineer. All Calendars must strictly adhere to Form 816, Section 1.08.04, Limitations of Operations, and the Standard Specifications as applicable.

Calendar Name	Calendar Type	Calendar Description
C7 – Contractor Holidays	Project	Includes all Contractor Holidays
C7 – 4 Day Work Week	Project	4 Day Work Week
C7 - 5 Day Work Week	Project	5 Day Work Week
C7 - 6 Day Work Week	Project	6 Day Work Week
C7 - 7 Day Work Week	Project	7 Day Work Week
C7 – Railroad Restricted	Project	Includes imposed restrictions or restricted work periods in the vicinity of the railroad or ROW

SUBMITTALS

1. The Contractor shall submit to the Department notification that the project schedule is available for review by the Department. Notification shall be via Primavera Contract Manager software (PCM, formerly known as Primavera Expedition) submittal/transmittal and shall have the following electronic requirements attached:

- an .XER backup of the entire schedule and .PLF files for each report layout required
- Gantt charts in Adobe Acrobat PDF file format, formatted to fit ANSI Size D paper (24 inches x 36 inches), and showing the Activity ID, Activity Description, Original Duration, Remaining Duration, Total Float, Early Start and Finish Dates, and Calendar ID. Types of Gantt Charts to be included are:
  - The project critical (longest) path;
  - The project top 3 near-critical paths (excluding critical path activities);
  - All uncompleted work activities as of the data date;
- Reports in Adobe Acrobat PDF file format, formatted to fit letter sized paper (8.5 inches x 11 inches), to include:
  - Schedule Narrative
  - Schedule/Leveling Report which includes the scheduling/leveling settings, statistics, errors, warnings, results, and exceptions
  - A listing of all activities, by activity code, with early & late starts and total float
  - A Claim Digger Report that details changes between the current schedule submittal and the previous month's update submittal (The Department shall provide parameters for the types of changes to be detailed in the report)
  - Detailed Predecessor/Successor Report which includes a listing of all activities that immediately precede and immediately succeed that activity in the schedule logic.

2. The Contractor shall also submit a hard-copy version of the aforementioned submittal requirements as follows:

- Three (3) compact discs that each include; the .XER backup file, all .PLF layout files for report layouts created and all Adobe Acrobat PDF Gantt Charts and reports specified above;

- Three (3) paper copies of each Gantt chart and report on the paper size specified above

3. Schedule submittals will only be considered complete when all documents and data have been provided as described below.

4. The Project Coordinator shall be required to prepare and submit the following documents:

a. Initial Work Breakdown Structure - Within five (5) business days after contract award, the Contractor shall prepare and submit for review the proposed detailed work breakdown structure. At a minimum, the highest project level should include:
   - Milestones
   - Level of Effort Activities
   - Submittal Activities
   - Work by Others
   - Testing
   - Fabrication
   - Installation
   - Integration
   - Training

b. Schedule Coordination Meeting – A schedule coordination meeting shall be held following the submission of the WBS to discuss at a minimum: the contractor's planned approach to the project, contract milestones, schedule specifications, third party work items, phasing/staging, site access, subcontractor schedules, coding, updates, and change orders.

c. Baseline Schedule
   Within forty (40) business days after contract award, the Contractor shall submit to the Engineer, for review and acceptance, a detailed Project CPM Schedule for all contract work. This schedule shall be prepared in accordance with all requirements of this specification. As a guide, 30 to 50 activities should be provided per $1 million of contract work. Construction work activities, excluding the preparation, submission, review and approval of submittals shall represent 75% of the minimum required activities.

   The Contractor shall require each major subcontractor and major supplier to submit in writing a statement certifying that the major subcontractor or major supplier has concurred with the Contractor's CPM Schedule, including major updates, and that the major subcontractor's or major supplier's related schedule has been incorporated accurately, including the duration of activities, cost loading and crew/equipment allocations. The definition of a "major subcontractor" is one that provides services valued in excess of five percent (5%) of the contract value. The definition of "major supplier" is one that provides material(s) or services valued in excess of one (1%) of the contract

value. Failure of the contractor to provide the required information will delay the approval of the baseline schedule.

The Contractor will provide a narrative to accompany the Baseline Schedule. The narrative shall include:

- The Contractor's transmittal letter
- Identification of unusual conditions or restrictions regarding labor, equipment, or material; including multiple shifts, 6-day work weeks, specified overtime or work at times other than regular days or hours, or work that has the potential in any way to affect the Owner, adjacent projects or 3rd parties.
- Description of the critical path
- Description of the near critical paths, defined as those activities not on the critical path with total float less than ten (10) business days.
- Reasons for an early or late scheduled completion date in comparison to the contract completion date
- Description of Contractor's site management plan (e.g. lay down, staging, traffic, parking, etc.)
- Compliance with winter weather requirements

The Baseline Schedule shall reflect the Work as awarded and shall purposely exclude any Delays, Change Orders, "or equal" materials and equipment and substitutions of any kind. Additionally, the Contractor is to ensure that the schedule submission is in complete conformance with the intent of the Contract Documents; no proposed alternates will be accepted until presented to the Engineer after the full Baseline Schedule has been accepted.

The Engineer shall be the sole judge as to whether the schedule is sufficiently detailed. Once the Baseline Schedule is returned to the Contractor as "Accepted", with or without comments or objections noted, it shall become the As-Planned Schedule of Record. Once established, the As-Planned Schedule shall be used as the basis for the Progress Schedule Submittals (i.e. Monthly Schedule Updates). The acceptance of a Baseline Schedule shall in no way waive the requirements of the contract nor shall it excuse the Contractor from any obligations under the contract.

In no instance will the Contractor be permitted to commence work on any significant portion of the work for which a Baseline Schedule has not been accepted. If the Contractor fails to submit a Baseline Schedule acceptable to the Department for any portion of the work, the Contractor may be found in violation of Form 816, Article 1.02.02 of the Standard Specifications "for having failed to prosecute work continuously, diligently and cooperatively in an orderly sequence."

d. Revised Baseline Schedule

If, in the opinion of the Engineer, there have been significant changes to a previously accepted Baseline Schedule or Revised Baseline Schedule, the Engineer may direct the Contractor to prepare a "Revised Baseline Schedule"

which fully recognizes and accounts for all major changes to the project. The Revised Baseline Schedule shall be submitted for review and acceptance within fifteen (15) business days of the Engineer's request. Revised Baseline Schedules shall be prepared in compliance with this specification in all other respects.

The Contractor will provide a narrative to accompany the revised baseline schedule. The narrative shall include:

- The Contractor's transmittal letter
- A listing of all changes made to the schedule since the baseline schedule or previous revised baseline schedule
- Identification of unusual conditions or restrictions regarding labor, equipment, or material; including multiple shifts, 6-day work weeks, specified overtime or work at times other than regular days or hours, or work that has the potential in any way to affect the Owner, adjacent projects or 3rd parties.
- Description of the current critical path
- Changes to the critical path, intermediate and completion milestones
- Description of the near critical path, defined as those activities not on the critical path with total float less than ten (10) business days.
- Current or anticipated delays
  - Cause of delay
  - Impact of delay on other activities, milestones, and completion dates
  - Corrective action and schedule adjustments to correct the delay
- Reasons for an early or late scheduled completion date in comparison to the contract completion date

The acceptance of a Revised Baseline Schedule shall in no way waive the requirements of the contract nor shall it excuse the Contractor from any obligations under the contract.

e. Monthly Updates

The Contractor shall update and progress the CPM schedule through the last day of each month (the Data Date is the 1st day of the month). Updating and progressing the CPM schedule shall be completed and submitted by the fifth (5th) business day each month. Except as otherwise authorized by the Engineer, monthly submissions received after the due date are considered late.

Monthly Update Submissions shall commence upon approval of the Baseline Schedule and must be submitted for every month starting after Notice to Proceed. Prior to Baseline Schedule acceptance, draft monthly updates shall be submitted to status the Initial Baseline Schedule. Final monthly updates will be required upon acceptance of the full Baseline Schedule.
The Project ID shall remain the same for the entire project and the previous updated schedule shall be saved as a new baseline of type "Last Performance Update".

The schedule shall be updated to show the work actually accomplished during the preceding month including: actual start dates for activities, actual completion dates for activities, remaining duration for any activity that has been started but not completed, and percent complete. The updating of the percent complete and the remaining duration of any activity shall be independent functions; program features that calculate one of these parameters from the other shall be disabled. "Out of sequence progress", activities that have posted progress without predecessors being completed, are not allowed without written approval of the Engineer. The Contractor shall not utilize "Progress Override" (schedule calculation) unless written approval is provided by Engineer. The monthly update shall include revisions to the schedule based on review comments by the Engineer or as necessitated by revisions to the project, which have been directed by the Engineer during the month preceding the update. Similarly, any changes to the schedule due to Contractor influences shall also be included within the schedule. All changes (i.e. duration changes, logic changes, new logic, new or modified activities, changes in work sequence, etc) shall be recorded and a note added to the activity notebook, and fully described in the narrative submission. The notebook record shall include at a minimum, the date and reason for the change, and description of the change. The Engineer reserves the right to accept or reject any such changes.

The Contractor will provide a narrative to accompany the monthly update. The narrative shall include:

a) The Contractor's transmittal letter
b) A discussion of work completed during the period
c) A listing of all changes made to the schedule since the prior monthly update, with specific descriptions/explanation for the following:
    i Changes in activities and logic
    ii Changes to shifts, non-business days and calendars
    iii Changes to equipment or resource loading to be used on remaining Work
    iv Changes to the critical path, intermediate and completion milestones
d) Description of the current critical path
e) Description of the near critical path, defined as those activities not on the critical path with total float less than ten (10) business days.
f) Description of problem areas
g) Current or anticipated delays
    i Cause of delay
    ii Impact of delay on other activities, milestones, and completion dates
    iii Corrective action and schedule adjustments to correct the delay
h) Pending items and status thereof:
    i Permits
    ii Submittals
    iii Testing

iv Change orders & Time adjustments
v Non-compliance notices

i) Reasons for an early or late scheduled completion date in comparison to the contract completion date
j) Identification of any potential/future/pending changes in access to or availability of work areas.

f. Two Week Look Ahead Schedules

The Contractor shall be required to produce and submit to the Engineer a biweekly schedule, to be updated and submitted the first business day of each week. Except as otherwise authorized by the Engineer, submissions received after the due date are considered late.

This short-term schedule must be submitted in electronic format (i.e. .pdf, .xls, .doc, etc.) and shall clearly indicate all work planned for the two-week period. The short-term schedule should be of sufficient detail to identify specific work crew activities by location.

Gantt Charts, reports, and the XER backup file are not required for the Two Week Look Ahead submission.

g. Time Impact Analysis

The Contractor shall submit a written time impact analysis (TIA) to the Engineer when the Contractor or Engineer considers that a major change may impact the critical path or contract progress. A change may be considered of major nature if the estimated time required or actually used for an activity or the network logic is varied from the Baseline Schedule to a degree that there is a reasonable doubt as to the effect on the contract completion date, intermediate milestone dates, or stage completion dates. Changes that affect activities with adequate float time shall be considered a major change when their cumulative effect could extend the contract completion date. The TIA shall illustrate the impact of each change on the current scheduled stage or project completion date or other Contract milestone, as appropriate. The analysis shall use the schedule update that has a data date closest to and prior to the event. If the Engineer determines that the schedule update used does not appropriately represent the conditions prior to the event, the schedule shall be progressed to the day before the event being analyzed. The TIA shall include an impact schedule developed from incorporating the event into the schedule by adding or deleting activities, or by changing durations or logic of existing activities. Each TIA shall include a Fragmentary Network (fragnet) demonstrating how the Contractor proposes to incorporate the impact into the project schedule. A fragnet is defined as the sequence of new activities and/or activity revisions, logic or resource changes that are proposed to be added to the existing schedule to demonstrate the influence of delay and the method for incorporating delays and impacts into the schedule as they are encountered. The fragnet shall identify the predecessors to the new activities and demonstrate the impacts to successor activities. The TIA shall include a narrative report describing the effects of the new activities and relationships to

interim and contract completion dates. The fragnet shall be presented with resource and cost loading as well.

The Contractor shall submit a TIA within fifteen (15) business days of receiving a written request for a TIA from the Engineer. The Engineer will withhold remaining payment on the Project Coordinator Item if a TIA is requested by the Engineer and not submitted by the Contractor within fifteen (15) working days. The Project Coordinator Item payment will resume on the next estimate after the requested TIA is submitted. The Contractor shall allow the Engineer twenty (20) business days after receipt to approve or reject the submitted TIA. All approved TIA schedule changes shall be incorporated on the next monthly schedule update and shall be submitted for approval as a Revised Baseline Schedule.

If the TIA submitted by the Contractor is rejected, the Contractor shall meet with the Engineer to discuss and resolve issues related to the TIA. If an agreement is not reached, the Contractor shall not show unapproved changes related to the TIA in subsequent schedule updates.

Compensation for the submission of any TIA is included in the per month cost for the services of the Project Coordinator.

h. Recovery Schedules

If, in the opinion of the Engineer, the Monthly Update indicates that the Contractor has fallen behind schedule, or that a revision in sequence of operations may be necessary for any other reason, the Contractor shall within five (5) business days of receiving a written request to perform "Recovery" from the Engineer, immediately institute all necessary steps to improve his progress and shall submit such revised network diagrams, tabulations, operational plans and any supplementary information, as may be deemed necessary by the Engineer, to demonstrate the manner in which an acceptable rate of progress will be regained.

Should the Contractor's "Recovery" efforts not demonstrate an ability to regain an acceptable rate of progress, the Engineer shall require the development of a "Recovery Schedule". The Recovery Schedule is to be supplemented with resource allocations for every task activity and include time-scaled resource histograms. The resource allocations shall be shown to a level of detail that facilitates report generation based on labor crafts and equipment classes for the Contractor and subcontractors. The Contractor shall use average composite crews to display the labor loading of onsite construction activities. The Contractor shall optimize and level labor to reflect a reasonable plan for accomplishing the work of the contract and to assure that resources are not over allocated in multiple concurrent activities. The time-scaled resource histograms shall show labor crafts and equipment classes to be utilized on the contract. The Contractor shall submit a Recovery Schedule within fifteen (15) business days of receiving a written request for the Recovery Schedule from the Engineer.

In addition to required submittals the "Recovery Schedule" submission will also include a narrative meeting the requirements of the monthly update, a time-scaled resource histogram and a Monthly Resources Loading Summary Report (tabular) indicating the peak number of resources required for each activity.

The Engineer may review the recovery schedule resource allocations using Means Productivity Standards or equivalent to determine if the schedule is practicable. The Engineer shall be the sole judge as to whether the Recovery Schedule is sufficiently detailed.

Schedule recovery will be excused if the Contractor requests and demonstrates entitlement to an extension in Contract Time, in writing, due to delay(s) not within the control of the Contractor, and the Engineer concurs schedule recovery is not required at that time.

Upon acceptance of this Recovery Schedule, it shall be designated a "Revised Baseline Schedule".

In the event the Engineer is unable to return any Progress Schedule Submittal as "Accepted" and the effect of Delays on Contract Time and Contract Price need evaluation, both the Engineer and Contractor shall employ the As-Planned Schedule and not any *unapproved* Progress Schedule Submittal for such evaluations.

a) The Contractor shall include a subnet demonstrating how the Contractor proposes to incorporate each Change Order into the most recently accepted schedule. A subnet is defined as a sequence of new or revised activities that are proposed to be added to the schedule.

b) The extension of Contract Time shall be considered only if the Contractor demonstrates via the timely submittal of a detailed schedule analysis by using the Contemporaneous Window Analysis method or other similar methodology acceptable to the Engineer. The analysis shall include:

   i. A detailed narrative which clearly describes the events causing the delay and the resulting impacts to the project schedule
   ii. Documentation substantiating and supporting the delay
   iii. Detailed CPM schedules (both electronic and hard copies) clearly delineating the delay
   iv. A matrix showing delays caused by any third party and any force majeure delays
   v. Any additional information reasonably requested by the Engineer, in order to enable the Authority to perform a timely and informed analysis of the request for extension of Contract Time.

Compensation for the development and submission of any Recovery Schedule is included in the per month cost for the services of the Project Coordinator. No additional compensation will be allowed for resource loading the schedule.

i. As-Built Schedule (Final)
Within twenty (20) business days of completion of the project, the Contractor shall submit an "As-Built Schedule" showing the actual progress of all work. The Contractor shall provide a written certificate with this submittal signed by the Contractor's Project Manager and an officer of the company stating, "To my knowledge and belief, the enclosed final update schedule reflects the actual start and finish dates of the actual activities for the project contained herein." An officer of the company may delegate in writing the authority to sign the certificate to a responsible manager.

SCHEDULE REVIEW AND EVALUATION MEETINGS

The Contractor, represented by the Project Coordinator and/or the Consultant, shall participate with the Engineer, at the Engineer's request, in the review and evaluation of the Initial Baseline Schedule, Baseline Schedule, Revised Baseline Schedule, Recovery Schedule, and As-Built Schedule submittals. Any and all revisions made necessary as a result of these reviews shall be made by the Contractor and a revised Initial Baseline Schedule, Baseline Schedule, Revised Baseline Schedule, Recovery Schedule, or As-Built Schedule will be submitted within ten (10) business days of the date of the meeting. Any further revisions required thereafter shall also be submitted for acceptance within ten (10) business days of the request for revisions by the Engineer.

The Contractor, represented by the Project Coordinator and/or the Consultant, shall participate with the Engineer, at the Engineer's request, in the review and evaluation of each Monthly CPM Schedule Update. Items of discussion will include, but are not limited to, near-term schedule activities, long-term schedule issues, and any relevant technical issues that are schedule related.

METHOD OF MEASUREMENT

This work shall be measured for payment by the lump sum contract price for the Project Coordinator services. The contract price of this item shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

The negotiated contract price for Project Coordinator services shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the ITS and Communications Systems for CT***fastrak*** shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 102 – CONSTRUCTION FIELD OFFICE, LARGE

DESCRIPTION

Under this item, adequate weatherproof office quarters will be provided by the Contractor for the duration of the installation and testing work, and if required, for a maximum of ninety (90) days thereafter, for the exclusive use of CTDOT forces and others who may be engaged to augment CTDOT forces with relation to the contract. The office quarters shall be located convenient to the work site and installed in accordance with Form 816, Article 1.08.02; this office shall be separated from any office occupied by the Contractor. Ownership and liability of the office quarters shall remain with the Contractor.

MATERIALS

Materials shall be in like new condition for the purpose intended and shall be approved by the Engineer.

Office Requirements: The Contractor shall furnish the office quarters and equipment as described below.

	Description:
1,000 SF	Sq. Ft. of floor space with a minimum ceiling height of 7 ft. and shall be partitioned as shown on building floor plan as provided by the Engineer.
2 EA	Minimum number of exterior entrances.
10 EA	Minimum number of parking spaces.

Office layout: The office shall have a minimum square footage as indicated in the table above, and shall be partitioned as shown on building floor plan as provided by the Engineer. The underside of the office shall be fully skirted to the ground.

Lavatory Facilities: The Contractor shall furnish a minimum of two (2) separate lavatories and toilet facilities ("men" and "women"), in separately enclosed rooms that are properly ventilated and comply with applicable sanitary codes. The Contractor shall provide each lavatory with hot and cold running water and flush-type toilets. He shall also supply lavatory and sanitary supplies as required.

Windows and Entrances: The windows shall be of a type that will open and close conveniently, shall be sufficient in number and size to provide adequate light and ventilation, and shall be fitted with locking devices, blinds and screens. The entrances shall be secure, screened, and fitted with a lock for which four (4) keys shall be furnished. All keys to the construction field office shall be furnished to the Department and will be kept in their possession while State personnel are using the office. Any access to the entrance ways shall meet applicable building codes and be slip resistant, with appropriate handrails.

Lighting: The Contractor shall equip the office interior with electric lighting that provides a minimum illumination level of 100 foot-candles at desk level height, and electric outlets for each desk and drafting table. The Contractor shall also provide exterior lighting that provides a minimum illumination level of 2 foot-candles throughout the parking area and for a minimum distance of 10 ft. on each side of the field office.

The Contractor shall provide the following additional equipment, facilities, and/or services at the Field Office on this project to include at least the following to the satisfaction of the Engineer:

Parking Facility: The Contractor shall provide adequate parking spaces with adequate illumination on a paved surface, with surface drainage if needed. If paved parking does not exist adjacent to the field office, the Contractor shall provide a parking area of sufficient size to accommodate the number of vehicles indicated in the table above. Construction of the parking area and driveway, if necessary, will consist of a minimum of 6 inches of processed aggregate base graded to drain. The base material will be extended to the office entrance.

Field Office Security: Physical Barrier Devices - This shall consist of physical means to prevent entry, such as: 1) All windows shall be barred or security screens installed; 2) All field office doors shall be equipped with dead bolt locks and regular day operated door locks; and 3) Other devices as directed by the Engineer to suit existing conditions.

Electric Service: The field office shall be equipped with an electric service panel to serve the electrical requirements of the field office, including: lighting, general outlets, computer outlets, calculators etc., and meet the following minimum specifications:

A. 120/240 volt, 1 phase, 3 wire.
B. Ampacity necessary to serve all equipment. Service shall be a minimum 100 amp dedicated to the construction field office.
C. The electrical panel shall include a main circuit breaker and branch circuit breakers of the size and quantity required.
D. Additional 120 volt, single phase, 20 amp, isolated ground dedicated power circuit with dual NEMA 5-20 receptacles will be installed at each computer workstation location.
E. Additional 120 volt, single phase, 20 amp, isolated ground dedicated power circuit with dual NEMA 5-20 receptacles will be installed, for use by the Telephone Company.
F. Additional 120-volt circuits and duplex outlets as required meeting National Electric Code requirements.
G. One exterior (outside) wall mounted GFI receptacle, duplex, isolated ground, 120 volt, straight blade.
H. After work is complete and prior to energizing, the State's CTDOT electrical inspector, must be contacted at 860-594-2240. (Do Not Call Local Town Officials)
I. Prior to field office removal the CTDOT Data Communications office must be notified to deactivate the communications equipment.

Heating, Ventilation and Air Conditioning (HVAC): The field office shall be equipped with sufficient heating, air conditioning and ventilation equipment to maintain a temperature range of 68^{o}-80^{o} Fahrenheit within the field office.

The Following Furnishings and Equipment Shall Be Provided In The Applicable Field Office Type:

Qty	Description:
5 EA	Office desks (2.5 ft x 5 ft) with drawers, locks, and matching desk chairs that have pneumatic seat height adjustment and dual wheel casters on the base.
10 EA	Office Chairs.
2 EA	Fire resistant cabinets (legal size/4 drawer), locking.
2 EA	Non-fire resistant cabinets (legal size/4 drawer), locking.
1 EA	Storage racks to hold 3 ft x 5 ft display charts.
1 EA	Mail slot bin - legal size.
1 EA	Drafting type tables (3 ft x 6 ft) and supported by wall brackets and legs; and matching drafters stool that have pneumatic seat height adjustment, seat back and dual wheel casters on the base.
1 EA	Flat file (4/drawers).
4 EA	Personal computer tables (4 ft x 2.5 ft).
1 EA	Hot and cold water dispensing unit and supply of cups and bottled water shall be supplied by the Contractor for the duration of the project.
2 EA	Electronic office type printing calculators capable of addition, subtraction, multiplication and division with memory and a supply of printing paper.
4 EA	Telephone.
1 EA	Telephone answering machine.
1 EA	Multifunction color copier/scanner/facsimile/printer machine with auto document feeder and sorter/stapler. All supplies, paper and maintenance shall be provided by the Contractor. Specified below under Computer Hardware and Software.
4 EA	Computer systems as specified below under Computer Hardware and Software. All supplies and maintenance shall be provided by the Contractor.
1 EA	Laser printer as specified below under Computer Hardware and Software. All supplies, paper and maintenance shall be provided by the Contractor.
3 EA	Digital Camera as specified below under Computer Hardware and Software. All supplies and maintenance shall be provided by the Contractor.
1 EA	Wastebaskets - 30 gal., including plastic waste bags.
6 EA	Wastebaskets - 5 gal., including plastic waste bags.
2 EA	Electric pencil sharpeners.
* EA	Fire extinguishers - provide and install type and number to meet applicable State and local codes for size of office indicated, including a fire extinguisher suitable for use on a computer terminal fire.
6 EA	Interior partitions - 6 ft x 6 ft, soundproof type, portable and freestanding.
2 EA	Vertical plan racks for 2 sets of 2 ft x 3 ft plans for each rack..
1 EA	Double door supply cabinet with 4 shelves and a lock - 6 ft x 4 ft.
1 EA	Easel/chalkboard.
2 EA	Open bookcases - 3 shelves - 3 ft long.
1 EA	Infrared Thermometer, including certified calibration, case, cleaning wipes.
1 EA	Concrete Curing Box as specified below under Concrete Testing Equipment.
1 EA	Concrete Air Meter as specified below under Concrete Testing Equipment.
1 EA	Concrete Slump Cone as specified below under Concrete Testing Equipment.

The furnishings and equipment required herein shall remain the property of the Contractor. Any supplies required to maintain or operate the above listed equipment or furnishings shall be provided by the Contractor for the duration of the project.

Telephone Service: This shall consist of two (2) telephone lines: one (1) line for phone/voice service and one (1) line dedicated for the facsimile machine. The Contractor shall provide unlimited local and long-distance telephone service.

Data Communications Facility Wiring: Contractor shall install a Category 5e 468B patch panel in a central wiring location and Cat 5e cable from the patch panel to each PC station, terminating in a (category 5e 468B) wall or surface mount data jack. The central wiring location shall also house either the data circuit with appropriate power requirements or a category 5 cable run to the location of the installed data circuit. The central wiring location will be determined by the CTDOT Data Center staff in coordination with the designated field office personnel as soon as the facility is in place. The CTDOT Project Engineer will provide the Contractor with a copy of the current PC specifications, approved printer list and data wiring schematic as soon as possible after the contract is awarded.

Contractor to run a CAT 5e LAN cable a minimum length of 25 feet for each computer to LAN switch area leaving an additional 10 feet of cable length on each side with terminated RJ45 connectors. Each run / jack shall be clearly labeled with an identifying Jack Number.

The installation of a data communication circuit between the field office and the CTDOT Data Communication Center in Newington will be coordinated between the CTDOT District staff, CTDOT Office of Information Systems and the local phone company. The CTDOT District staff will coordinate the installation of the data communication service with CTDOT PC Support once the field office phone number is issued. The Contractor shall provide the field office telephone number(s) to the CTDOT Project Engineer as soon as possible to facilitate data line and computer installations.

Computer Hardware and Software:

The CTDOT Project Engineer will provide the Contractor with a copy of the current PC specifications, approved printer list and data wiring schematic as soon as possible after the contract is awarded.

Before ordering the computer hardware and software, the Contractor must submit a copy of their proposed PC specifications and the type of printer to the CTDOT Project Engineer for review by the CTDOT Data Center. If the specification meets or exceeds the minimum specifications listed below, then the Contractor will be notified that the order may be placed.

Before any equipment is delivered to the Data Center, arrangements must be made a minimum of 24 hours in advance by contacting 860-594-3500. All software, hardware and licenses listed below shall be clearly labeled, specifying the (1) Project No., (2) Contractor Name, (3) Project Engineer's Name and (4) Project Engineer's Phone No., and shall be delivered to the CTDOT Data Center, 2710 Berlin Turnpike, Newington, CT, where it will be configured and prepared for

field installation. Installation will then be coordinated with CTDOT field personnel and the computer system specified will be stationed in the Department's project field office.

The computer system furnished shall have all software and hardware necessary for the complete installation of the latest versions of the software listed, and therefore supplements the minimum specifications below. The Engineer reserves the right to expand or relax the specification to adapt to the software and hardware limitations and availability, the compatibility with current agency systems, and to provide the Department with a computer system that can handle the needs of the project. This requirement is to ensure that the rapid changing environment that computer systems have experienced does not leave the needs of the project orphan to what has been specified. There will not be any price adjustment due to the change in the minimum system requirements.

The Contractor shall provide the Engineer with a licensed copy registered in the Department's name of the latest versions of the software listed and maintain customer support services offered by each software producer for the duration of the Contract. The Contractor shall deliver to the Engineer all supporting documentation for the software and hardware including any instructions or manuals. The Contractor shall provide original backup media for the software.

The Contractor shall provide the computer system with all required supplies, maintenance and repairs (including labor and parts) throughout the Contract life.

Once the Contract has been completed, the computer will remain the property of the Contractor. Prior to the return of any computer(s) to the Contractor, field personnel will coordinate with the Data Center personnel for the removal of Department owned equipment, software, data, and associated equipment.

A) Computer – Minimum Specification:

Processor – Intel® Core 2 Duo Processor (2.00 GHz, 800 MHz FSB 2MB L2 Cache)
Memory – 2 GB DIMM DDR2 667MHz.
Monitor – Dual 24.0 inch LCD color monitor.
Graphics – Intel Graphics Media Accelerator 3100. or equivalent.
Hard Drive – 160 GB Ultra ATA hard drive (Western Digital, IBM or Seagate).
Floppy Drive – 3.5 inch 1.44MB diskette drive.
Optical Drive – CD-RW/DVD-RW Combo.
Multimedia Package – Integrated Sound Blaster Compatible AC97 Sound and speakers.
Case – Small Form or Mid Tower, capable of vertical or horizontal orientation.
Integrated Network Adapter – comparable to 3COM PCI 10/100 twisted pair Ethernet.
Keyboard – 104+ Keyboard.
Mouse – Optical 2-button mouse with scroll wheel.
Operating System – Windows XP Professional Service Pack 2; Windows Vista Capable.
Application Software – MS Office 2007 Professional Edition.
Additional Software (Latest Releases, including subscription services for the life of the Contract.–

- Norton Anti-Virus and CD/DVD burning software (ROXIO or NERO),
- Adobe Acrobat Professional

Resource or Driver CD/DVD – CD/DVD with all drivers and resource information so that computer can be restored to original prior to shipment back to the contractor.

Uninterrupted power supply – APC Back-UPS 500VA.

Note A1: All hardware components must be installed before delivery. All software documentation and CD-ROMs/DVD for Microsoft Windows XP Professional, Microsoft Office 2007 Professional Edition, and other software required software must be provided. Computer Brands are limited to Dell, Gateway and HP brands only. No other brands will be accepted. The CTDOT Project Engineer will provide the Contractor with a copy of the current PC specifications and approved printer list as soon as possible after the contract is awarded.

Note A2: As of June 30, 2008, Microsoft will no longer distribute Windows XP for retail sale, although the date for specific computer manufacturers may be different. Please consult your manufacturer for details. The Department still requires Windows XP on all PCs. Microsoft has stated that any PCs that are purchased with either Windows Vista Business, or Vista Ultimate are automatically entitled to "downgrade rights", which allow the PC to be rolled back to Windows XP. Please consult the specific manufacturer for details on downgrading new PCs to Microsoft Windows XP after June 30, 2008.

B) Laser Printer – Minimum Specification:

Print speed – 35 ppm.
Resolution – 1,200 x 1,200 dpi.
Paper size – Up to 216 mm x 355 mm (8.5 in x 14 in).
RAM – 128 MB.
Print Drivers – Must support HP PCL6 and HP PCL5e.
Printer cable – 1.8 m (6 ft).
Capable of automatic duplex printing (two-sided)

Note B1: Laser printer brand is limited to Hewlett-Packard only. The CTDOT Project Engineer will provide the Contractor with a copy of the current PC specifications and approved printer list as soon as possible after the contract is awarded.

C) Digital Camera – Minimum Specification:

Optical – 5 mega pixel, with 3x optical zoom.
Memory – 2 GB.
Features – Date/time stamp feature.
Connectivity – USB cable or memory card reader.
Software – Must be compatible with Windows XP and Vista.
Power – Rechargeable battery and charger.

D) Multifunction color copier/scanner/facsimile – Minimum Specification:

Copy speed – 20 ppm.
Resolution – 600 x 600 dpi.
Paper size – Up to 12 in x 18 in
Print Drivers – Must support HP PCL6 and HP PCL5e.
Printer cable – 1.8 m (6 ft).
Capable of duplex printing (two-sided)

Note D1: Multifunction brands are limited to Savin only. The CTDOT Project Engineer will provide the Contractor with a copy of the current PC specifications and approved printer list as soon as possible after the contract is awarded.

The Contractor is responsible for service and repairs to all computer hardware. All repairs must be performed with-in 48 hours. If the repairs require more than a 48 hours then a replacement must be provided. All supplies, paper and maintenance for the computers, laptops, printers, copiers, and fax machines shall be provided by the Contractor.

Concrete Testing Equipment: If the Contract includes items that require compressive strength cylinders for concrete, in accordance with the Schedule of Minimum Testing Requirements for Sampling Materials for Test, the Contractor shall provide the following. All testing equipment will remain the property of the Contractor at the completion of the project.

A) Concrete Cylinder Curing Box – meeting the requirements of Section 6.12 of the Standard Specifications.

B) Air Meter – The air meter provided shall be in good working order and will meet the requirements of AASHTO T 152.

C) Slump Cone Mold – Slump cone, base plate, and tamping rod shall be provided in like-new condition and meet the requirements of AASHTO T119, Standard Test Method for Slump of Hydraulic-Cement Concrete.

Insurance Policy: The Contractor shall provide a separate insurance policy, with no deductible, in the minimum amount of forty thousand dollars ($40,000.00) in order to insure all State-owned data equipment and supplies used in the office against all losses. The Contractor shall be named insured on that policy, and the Department shall be an additional named insured on the policy. These losses shall include, but not be limited to: theft, fire, and physical damage. The Department will be responsible for all maintenance costs of Department owned computer hardware. In the event of loss, the Contractor shall provide replacement equipment in accordance with current Department equipment specifications, within seven days of notice of the loss. If the Contractor is unable to provide the required replacement equipment within seven days, the Department may provide replacement equipment and deduct the cost of the equipment from monies due or which may become due the Contractor under the contract or under any other contract. The Contractor's financial liability under this paragraph shall be limited to the amount of the insurance coverage required by this paragraph. If the cost of equipment replacement required by this paragraph should exceed the required amount of the insurance coverage, the Department will reimburse the Contractor for replacement costs exceeding the amount of the required coverage.

Maintenance: During the occupancy by the Department, the Contractor shall maintain all facilities and furnishings provided under the above requirements, and shall maintain and keep the office quarters clean through the use of weekly professional cleaning to include, but not limited to, washing & waxing floors, cleaning restrooms, removal of trash, etc. Exterior areas shall be mowed and clean of debris. A trash receptacle (dumpster) with weekly pickup (trash removal) shall be provided. Snow removal, sanding and salting of all parking, walkway, and entrance ways areas shall be accomplished during a storm if on a workday during work hours, immediately after a storm and prior to the start of a workday. If snow removal, salting and

sanding are not completed by the specified time, the State will provide the service and all costs incurred will be deducted from the next payment estimate.

METHOD OF MEASUREMENT

The furnishing and maintenance of the construction field office will be measured for payment by the number of calendar months that the office is in place and in operation, measured to the nearest month.

There will not be any price adjustment due to any change in the minimum computer system requirements.

BASIS OF PAYMENT

The furnishing and maintenance of the construction field office will be paid at the listed unit price per month for the respective item "Construction Field Office, Large", which price shall include all material, equipment, labor, utility services and work incidental thereto.

The cost of providing the parking area, external illumination, trash removal and snow and ice removal shall be included in the monthly unit price for the respective item "Construction Field Office, Large".

The State will be responsible for payment of data communication user fees and for toll calls by State personnel.

The lump sum price shall not be included in the negotiated total system implementation cost as defined in Specification 100 – General Provisions.

SPECIFICATION 103 – MAINTENANCE AND PROTECTION OF TRAFFIC

DESCRIPTION

Under this item, the Contractor shall provide for maintenance and protection of traffic in accordance with Form 816, Section 9.71.

Form 816, Article 9.71.01 – Description is supplemented by the following:

The Contractor shall maintain and protect traffic as follows and as limited in the Special Provision "Prosecution and Progress":

RAMPS & TURNING ROADWAYS

The Contractor shall maintain and protect existing traffic operations on all ramps and turning roadways within the construction limits.

Excepted therefrom will be those periods, during the allowable periods, when the Contractor is actively working, at which time the Contractor will be allowed to maintain and protect one lane of traffic on a paved travelpath not less than 12 feet in width.

ALL ROADWAYS

The Contractor shall maintain and protect the existing number of lanes of traffic, including turning lanes, each lane on a paved travelpath not less than 11 feet in width.

Excepted therefrom will be those periods, during the allowable periods, when the Contractor is actively working, at which time the Contractor will be allowed to maintain and protect at least one lane of through traffic in each direction, each lane on a paved travelpath not less than 11 feet in width.

COMMERCIAL AND RESIDENTIAL DRIVEWAYS

The Contractor shall maintain access to and egress from all commercial and residential driveways throughout the project limits. The Contractor will be allowed to close said driveways to perform the required work during those periods when the businesses are closed unless permission is granted from the business owner to close the driveway during business hours. If a temporary closure of a residential driveway is necessary, the Contractor shall coordinate with the owner to determine the time period of the closure.

CONSTRUCTION METHOD

Form 816, Article 9.71.03 - Construction Method is supplemented as follows:

SIGNING

The Contractor shall maintain all existing overhead and side-mounted signs throughout the project limits during the duration of the project. The Contractor shall temporarily relocate signs and sign supports as many times as deemed necessary and install temporary sign supports and foundations if necessary and as directed by the Engineer. The temporary relocation of signs and supports, and the furnishing, installation and removal of any temporary supports and foundations, shall be paid for under the item "Maintenance and Protection of Traffic." Temporary overhead sign supports and foundations shall be paid for under the appropriate item(s).

When the necessary construction is completed, the Contractor shall remove existing signs and install new signs as shown on the Signing and Pavement Marking Plans contained in the contract plans.

TRAFFIC SIGNALS

The Contractor shall keep each traffic signal in the project limits operational at all times during construction in accordance with the Special Provision "Temporary Signalization."

The Contractor shall install final pavement markings and signing prior to the proposed traffic signal being made fully operational.

REQUIREMENTS FOR WINTER

The Contractor shall schedule a meeting with representatives of the Engineer, Maintenance, Traffic, and the Town/City to determine what interim traffic control measures the Contractor must accomplish for the winter to provide safety to the motorist and permit adequate snow removal procedures. This meeting shall be held prior to October 31 of each year and will include, but not be limited to, discussion of the status and schedule of the following items: lane and shoulder widths, pavement restoration, traffic signal work, pavement markings, and signing.

SIGNING PATTERNS

The Contractor shall erect and maintain all signing patterns in accordance with the traffic control plans contained herein. Proper distances between advance warning signs and proper taper lengths are mandatory. 42 Inch Traffic Cones or Traffic Drums are to be utilized to continue a lane closure on expressways.

Pavement Markings - Limited Access Highways, Turning Roadways and Ramps
During construction, the Contractor shall maintain all pavement markings throughout the limits of the project.

Pavement Markings -Non-Limited Access Multilane Roadways
Secondary and Local Roadways
During construction, the Contractor shall maintain all pavement markings on paved surfaces on all roadways throughout the limits of the project.

TRAFFIC CONTROL DURING CONSTRUCTION OPERATIONS

The following guidelines shall assist field personnel in determining when and what type of traffic control patterns to use for various situations. These guidelines shall provide for the safe and efficient movement of traffic through work zones and enhance the safety of work forces in the work area.

TRAFFIC CONTROL PATTERNS: Traffic control patterns shall be used when a work operation requires that all or part of any vehicle or work area protrudes onto any part of a travel lane or shoulder. For each situation, the installation of traffic control devices shall be based on the following:

Speed and volume of traffic
Duration of operation
Exposure to hazards

Traffic control patterns shall be uniform, neat and orderly so as to command respect from the motorist.

In the case of a horizontal or vertical sight restriction in advance of the work area, the traffic control pattern shall be extended to provide adequate sight distance for approaching traffic.

If a lane reduction taper is required to shift traffic, the entire length of the taper should be installed on a tangent section of roadway so that the entire taper area can be seen by the motorist.

Any existing signs that are in conflict with the traffic control patterns shall be removed, covered, or turned so that they are not readable by oncoming traffic.

When installing a traffic control pattern, a Buffer Area should be provided and this area shall be free of equipment, workers, materials and parked vehicles.

Typical CTDOT traffic control plans may be used for moving operations such as line striping, pot hole patching, mowing, or sweeping when it is necessary for equipment to occupy a travel lane.

Traffic control patterns will not be required when vehicles are on an emergency patrol type activity or when a short duration stop is made and the equipment can be contained within the shoulder. Flashing lights and appropriate trafficperson shall be used when required.

Although each situation must be dealt with individually, conformity with the typical traffic control plans contained herein is required. In a situation not adequately covered by the typical traffic control plans, the Contractor must contact the Engineer for assistance prior to setting up a traffic control pattern.

PLACEMENT OF SIGNS: Signs must be placed in such a position to allow motorists the opportunity to reduce their speed prior to the work area. Signs shall be installed on the same side of the roadway as the work area. On multi-lane divided highways, advance warning signs may be installed on both sides of the highway. On directional roadways (on-ramps, off-ramps, one-way roads), where the sight distance to signs is restricted, these signs should be installed on both sides of the roadway.

Allowable Adjustment of Signs and Devices Shown on the Traffic Control Plans

The traffic control plans contained herein show the location and spacing of signs and devices under ideal conditions. Signs and devices should be installed as shown on these plans whenever possible.

The proper application of the traffic control plans and installation of traffic control devices depends on actual field conditions.

Adjustments to the traffic control plans shall be made only at the direction of the Engineer to improve the visibility of the signs and devices and to better control traffic operations. Adjustments to the traffic control plans shall be based on safety of work forces and motorists, abutting property requirements, driveways, side roads, and the vertical and horizontal curvature of the roadway.

The Engineer may require that the traffic control pattern be located significantly in advance of the work area to provide better sight line to the signing and safer traffic operations through the work zone.

Table I indicates the minimum taper length required for a lane closure based on the posted speed limit of the roadway. These taper lengths shall only be used when the recommended taper lengths shown on the traffic control plans cannot be achieved.

TABLE I – MINIMUM TAPER LENGTHS

POSTED SPEED LIMIT MILES PER HOUR	MINIMUM TAPER LENGTH IN FEET FOR A SINGLE LANE CLOSURE
30 OR LESS	180
35	250
40	320
45	540
50	600
55	660
65	780

SECTION 1. WORK ZONE SAFETY MEETINGS

1.a) Prior to the commencement of work, a work zone safety meeting will be conducted with representatives of CTDOT Construction, Connecticut State Police (Local Barracks), Municipal Police, the Contractor (Project Superintendent) and the Traffic Control Subcontractor (if different than the prime Contractor) to review the traffic operations, lines of responsibility, and operating guidelines which will be used on the project. Other work zone safety meetings during the course of the project should be scheduled as needed.

1.b) A Work Zone Safety Meeting Agenda, (see Form 816, Section 9), shall be developed and used at the meeting to outline the anticipated traffic control issues during the construction of this project. Any issues that can't be resolved at these meetings will be brought to the attention of the District Engineer and the Office of Construction.

SECTION 2. INSTALLING AND REMOVING TRAFFIC CONTROL PATTERNS

2.a) Lane Closures shall be installed beginning with the advanced warning signs and proceeding forward toward the work area.

2.b) Lane Closures shall be removed in the reverse order, beginning at the work area, or end of the traffic control pattern, and proceeding back toward the advanced warning signs.

2.c) Stopping traffic may be allowed:

- As per the contract for such activities as blasting, steel erection, etc.
- During paving, milling operations, etc. where, in the middle of the operation, it is necessary to flip the pattern to complete the operation on the other half of the roadway and traffic should not travel across the longitudinal joint or difference in roadway elevation.
- To move slow moving equipment across live traffic lanes into the work area.

2.d) Under certain situations when the safety of the traveling public and/or that of the workers may be compromised due to conditions such as traffic volume, speed, roadside obstructions, or sight line deficiencies, as determined by the Engineer and/or State Police, traffic may be briefly impeded while installing and/or removing the advanced warning signs and the first ten traffic cones/drums only. Appropriate measures shall be taken to safely slow traffic. If required, State Police may use traffic slowing techniques, including the use of Truck Mounted Impact Attenuators (TMAs) as appropriate, for a minimum of one mile in advance of the pattern starting point. Once the advanced warning signs and the first ten traffic cones/drums are installed/removed, the two TMAs and sign crew should continue to install/remove the pattern as described in Form 816, Section 4c and traffic shall be allowed to resume their normal travel.

2.e) The Contractor must adhere to using the proper signs, placing the signs correctly, and ensuring the proper spacing of signs.

2.f) Additional devices are required on entrance ramps, exit ramps, and intersecting roads to warn and/or move traffic into the proper travelpath prior to merging/exiting with/from the

main line traffic. This shall be completed before installing the mainline pattern past the ramp or intersecting roadway.

2.g) Prior to installing a pattern, any conflicting existing signs shall be covered with an opaque material. Once the pattern is removed, the existing signs shall be uncovered.

2.h) On limited access roadways, workers are prohibited from crossing the travel lanes to install and remove signs or other devices on the opposite side of the roadway. Any signs or devices on the opposite side of the roadway shall be installed and removed separately.

SECTION 3. USE OF HIGH MOUNTED INTERNALLY ILLUMINATED FLASHING ARROW

3.a) On limited access roadways, one Flashing Arrow shall be used for each lane that is closed. The Flashing Arrow shall be installed concurrently with the installation of the traffic control pattern and its placement shall be as shown on the traffic control plan. For multiple lane closures, one Flashing Arrow is required for each lane closed. If conditions warrant, additional Flashing Arrows should be employed (i.e.: curves, major ramps, etc.).

3.b) On non-limited access roadways, the use of a Flashing Arrow for lane closures is optional. The roadway geometry, sight line distance, and traffic volume should be considered in the decision to use the Flashing Arrow.

3.c) The Flashing Arrow shall not be used on two lane, two-way roadways for temporary alternating one-way traffic operations.

3.d) The Flashing Arrow board display shall be in the “arrow” mode for lane closure tapers and in the “caution” mode (four corners) for shoulder work, blocking the shoulder, or roadside work near the shoulder. The Flashing Arrow shall be in the “caution” mode when it is positioned in the closed lane.

3.e) The Flashing Arrow shall not be used on a multi-lane roadway to laterally shift all lanes of traffic, because unnecessary lane changing may result.

3.f) If the required number of Flashing Arrows is not available, the traffic control pattern shall not be installed.

SECTION 4. USE OF TRUCK MOUNTED IMPACT ATTENUATOR VEHICLES (TMAs)

4.a) For lane closures on limited access roadways, a minimum of two TMAs shall be used to install and remove traffic control patterns. If two TMAs are not available, the pattern shall not be installed.

4.b) On non-limited access roadways, the use of TMAs to install and remove patterns closing a lane(s) is optional. The roadway geometry, sight line distance, and traffic volume should be considered in the decision to utilize the TMAs.

4.c) Generally, to establish the advance and transition signing, one TMA shall be placed on the shoulder and the second TMA shall be approximately 1,000 feet ahead blocking the lane. The flashing arrow board mounted on the TMA should be in the "flashing arrow" mode when taking the lane. The sign truck and workers should be immediately ahead of the second TMA. In no case shall the TMA be used as the sign truck or a work truck. Once the transition is in place, both TMAs shall travel in the closed lane until all Changeable Message Signs, signs, Flashing Arrows, and cones/drums are installed. The flashing arrow board mounted on the TMA should be in the "caution" mode when traveling in the closed lane.

4.d) A TMA shall be placed prior to the first work area in the pattern. If there are multiple work areas within the same pattern, then additional TMAs may be positioned at each additional work area as needed. The flashing arrow board mounted on the TMA should be in the "caution" mode when in the closed lane.

4.e) TMAs shall be positioned a sufficient distance prior to the workers or equipment being protected to allow for appropriate vehicle roll-ahead in the event that the TMA is hit, but not so far that an errant vehicle could travel around the TMA and into the work area. For additional placement and use details, refer to the specification entitled "Type 'D' Portable Impact Attenuation System". Some operations, such as paving and concrete repairs, do not allow for placement of the TMA(s) within the specified distances. In these situations, the TMA(s) should be placed at the beginning of the work area and shall be advanced as the paving or concrete operations proceed.

4.f) TMAs should be paid in accordance with how the unit is utilized. When it is used as a TMA and is in the proper location as specified, then it should be paid at the specified hourly rate for "Type 'D' Portable Impact Attenuation System". When the TMA is used as a Flashing Arrow, it should be paid at the daily rate for "High Mounted Internally Illuminated Flashing Arrow". If a TMA is used to install and remove a pattern and then is used as a Flashing Arrow, the unit should be paid as a "Type 'D' Portable Impact Attenuation System" for the hours used to install and remove the pattern, typically 2 hours (1 hour to install and 1 hour to remove), and is also paid for the day as a "High Mounted Internally Illuminated Flashing Arrow".

4.g) If the required number of TMAs is not available, the pattern shall not be installed.

SECTION 5. USE OF STATE POLICE OFFICERS

5.a) On limited access highways, the Engineer may determine that State Police Officers will be utilized for regional work zone traffic safety and enforcement operations in addition to project-related work zone assignments. State Police Officers shall be

uniformed off-duty sworn Connecticut State Police Officers. Their services will also include the use of official State Police vehicles and associated equipment. State Police Officers will be used on all limited access highways. State Police Officers will not be used on non-limited access highways unless specifically under their jurisdiction or authorized in writing by the Engineer. State Police Officers with official State Police vehicles will be used at such locations and for such periods as the Engineer deems necessary to control traffic operations and promote increased safety to motorists through the construction sites.

5.b) On a weekly basis, the Contractor shall submit to the Engineer the state police request form (DPS-0691-C) as an indication of their scheduled operations for the following week. This form shall be submitted no later than Wednesday Morning of the week prior to the scheduled operations. The Engineer shall review this schedule and approve the type and number of Officers required by signing off under the "Completed by DOT's Authorized Representative" line on Department of Public Safety Form DPS-0691-C. Once the Engineer has approved the number of Officers requested the Engineer will fax the order to the Department of Public Safety's Overtime Office.

5.c) Prior to the start of operations, a meeting will be held with the Contractor, Trooper in charge and Engineer to review the Trafficperson operations, lines of responsibility, and operating guidelines which will be used for the scheduled work.

5.d) At least one Officer should be used per critical sign pattern. Shoulder closures and right lane closures can generally be implemented without the presence of a State Police Officer. Likewise in areas with moderate traffic and wide, unobstructed medians, left lane closures can be implemented without State Police presence. Certain situations may require State Police presence, if one is available, even though the general guidelines above indicate otherwise. Examples of this include: nighttime lane closures; left lane closures with minimal width for setting up advance signs and staging; lane and shoulder closures on turning roadways/ramps or mainline where sight distance is minimal; and closures where extensive turning movements or traffic congestion regularly occur.

5.e) Once the pattern is in place, the State Police Officer should be positioned in a non-hazardous location at the beginning of the pattern or at one of the work areas not protected by a TMA. If traffic backs up beyond the beginning of the pattern, then the State Police Officer should be repositioned prior to the backup to give warning to the oncoming motorists. Where State Police Officer and TMA are in close proximity to each other, the TMA should be placed to protect the State Police Officer's vehicle from oncoming traffic.

5.f) Other functions of the State Police Officer(s) shall include:

- *Assisting entering/exiting construction vehicles within the work area.
- *Enhancing worker visibility/safety for workers in close proximity to the open travel lane(s).
- Speed control of traffic within the work area.
- Enforcement of speed and other motor vehicle laws within the work area.

Typically, the State Police Officer should be out of the vehicle for the functions marked with an asterisk (*).

5.g) State Police Officers assigned to a work site are to only take direction from the Engineer.

5.h) **There will be no separate payment to the Contractor for State Police Services. The direct cost of such services will be paid by the Department. Indirect costs associated with scheduling and coordinating State Police shall be included under the Item – Maintenance and Protection of Traffic.**

SECTION 6. USE OF (REMOTE CONTROLLED) CHANGEABLE MESSAGE SIGNS

6.a) For lane closures on limited access roadways, one Changeable Message Sign shall be used in advance of the traffic control pattern. Prior to installing the pattern, the Changeable Message Sign shall be installed and in operation, displaying the appropriate lane closure information (i.e.: Left Lane Closed - Merge Right). The Changeable Message Sign shall be positioned ½ - 1 mile ahead of the lane closure taper. If the nearest Exit ramp is greater than the specified ½ - 1 mile distance, than an additional Changeable Message Sign shall be positioned a sufficient distance ahead of the Exit ramp to alert motorists to the work and therefore offer them an opportunity to take the exit.

6.b) On non-limited access roadways, the use of Changeable Message Signs for lane closures is optional. The roadway geometry, sight line distance, and traffic volume should be considered in the decision to use the Changeable Message Sign.

6.c) The advance Changeable Message Sign is typically placed off the right shoulder, 5 feet from the edge of pavement. In areas where the Changeable Message Sign cannot be placed beyond the edge of pavement, it may be placed on the paved shoulder with a minimum of five (5) traffic drums placed in a taper in front of it to delineate its position. The advance Changeable Message Sign shall be adequately protected if it is used for a continuous duration of 36 hours or more.

6.d) When the Changeable Message Signs are no longer required, they should be removed from the clear zone and have the display screen cleared and turned 90° away from the roadway.

6.e) The Changeable Message Sign generally should not be used for generic messages (ex: Road Work Ahead, Bump Ahead, Gravel Road, etc.).

6.f) The Changeable Message Sign should be used for specific situations that need to command the motorist's attention which cannot be conveyed with standard construction signs (Examples include: Exit 34 Closed Sat/Sun - Use Exit 35, All Lanes Closed - Use Shoulder, Workers on Road - Slow Down).

6.g) Messages that need to be displayed for long periods of time, such as during stage construction, should be displayed with construction signs. For special signs, please coordinate with the Office of Construction and the Division of Traffic Engineering for the proper layout/dimensions required.

6.h) Form 816, Section 11 contains the messages that are allowed on the Changeable Message Sign. For any other message(s), approval must be received from the Office of Construction prior to their use. No more than two (2) displays shall be used within any message cycle.

6.i) If the required number of Changeable Message Signs is not available, the pattern shall not be installed.

SECTION 7. USE OF (REMOTE CONTROLLED) CHANGEABLE MESSAGE SIGNS WITH RADAR

7.a) (Remote Controlled) Changeable Message Signs with Radar shall be used when specified, or as directed by the Engineer.

7.b) The typical placement of a (Remote Controlled) Changeable Message Sign with Radar is in the work zone portion of the traffic control pattern.

7.c) The typical usage of the (Remote Controlled) Changeable Message Sign with Radar is to display a message when a preset speed is exceeded. The sign will blank when no vehicles are present.

7.d) The preset speed for activating the message should be set 5-10 MPH above the posted, or desired, speed.

7.e) Form 816, Section 12 contains the messages that are allowed on the (Remote Controlled) Changeable Message Sign with Radar. For any other message(s), approval must be received from the Office of Construction prior to their use. No more than two (2) displays shall be used within any message cycle.

SECTION 8. USE OF TRAFFIC DRUMS AND TRAFFIC CONES

8.a) Traffic drums shall be used for taper channelization on limited-access roadways, ramps, and turning roadways and to delineate raised catch basins and other hazards.

8.b) Traffic drums shall be used in place of traffic cones in traffic control patterns that are in effect for more than a 72-hour duration.

8.c) Traffic Cones less than 42 inches in height shall not be used on limited-access roadways or on non-limited access roadways with a posted speed limit of 45 mph and above.

8.d) Typical spacing of traffic drums and/or cones shown on the Traffic Control Plans in the Contract are maximum spacings and may be reduced to meet actual field conditions as required.

SECTION 9. GENERAL

9.a) If the required minimum number of signs and equipment (i.e. one High Mounted Internally Illuminated Flashing Arrow for each lane closed, two TMAs, Changeable Message Sign, etc.) are not available, the traffic control pattern shall not be installed.

9.b) The Contractor shall have back-up equipment (TMAs, High Mounted Internally Illuminated Flashing Arrow, Changeable Message Sign, construction signs, cones/drums, etc.) available at all times in case of mechanical failures, etc. The only exception to this is in the case of sudden equipment breakdowns in which the pattern may be installed but the Contractor must provide replacement equipment within 24 hours.

9.c) Failure of the Contractor to have the required minimum number of signs and equipment, which results in the not being installed, shall not be a reason for a time extension.

9.d) In cases of legitimate differences of opinion between the Contractor and the Inspection staff, the Inspection staff shall err on the side of safety. The matter shall be brought to

the District Office for resolution immediately or, in the case of work after regular business hours, on the next business day.

SECTION 10. WORK ZONE SAFETY MEETING AGENDA

1) Review Project scope of work and time.
2) Review Form 816, Section 1.08, Prosecution and Progress of the Special Provisions.
3) Review Form 816, Section 9.70, Trafficperson of the Specifications.
4) Review Form 816, Section 9.71, Maintenance and Protection of Traffic of the Special Provisions, including "Work Zone Safety Procedures".
5) Review Contractor's schedule and method of operations.
6) Review areas of special concern: ramps, turning roadways, medians, lane drops, etc.
7) Open discussion of work zone questions and issues.
8) Discussion of review and approval process for changes in contract requirements as they relate to work zone areas.

SECTION 11. WORK ZONE SAFETY PROCEDURES - ALLOWABLE MESSAGES FOR CHANGEABLE MESSAGE SIGNS

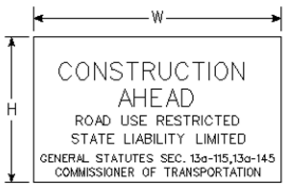
Message No.	Frame 1	Frame 2	Message No.	Frame 1	Frame 2
1	LEFT LANE CLOSED	MERGE RIGHT	9	LANES CLOSED AHEAD	REDUCE SPEED
2	2 LEFT LANES CLOSED	MERGE RIGHT	10	LANES CLOSED AHEAD	USE CAUTION
3	LEFT LANE CLOSED	REDUCE SPEED	11	WORKERS ON ROAD	REDUCE SPEED
4	2 LEFT LANES CLOSED	REDUCE SPEED	12	WORKERS ON ROAD	SLOW DOWN
5	RIGHT LANE CLOSED	MERGE LEFT	13	EXIT XX CLOSED	USE EXIT YY
6	2 RIGHT	MERGE	14	EXIT XX	FOLLOW

	LANES CLOSED	LEFT		CLOSED USE YY	DETOUR
7	RIGHT LANE CLOSED	REDUCE SPEED	15	2 LANES SHIFT AHEAD	USE CAUTION
8	2 RIGHT LANES CLOSED	REDUCE SPEED	16	3 LANES SHIFT AHEAD	USE CAUTION

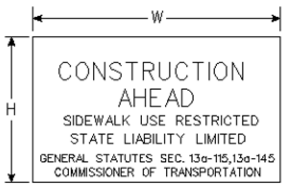
SECTION 12. WORK ZONE SAFETY PROCEDURES - ALLOWABLE MESSAGES FOR CHANGEABLE MESSAGE SIGN WITH RADAR

Message No.	Frame 1	Frame 2	Message No.	Frame 1	Frame 2
1	TOO FAST	SLOW DOWN	4		
2	TOO FAST SLOW DOWN		5		
3	YOU'RE SPEEDING	FINES DOUBLE	6		

SERIES 16 SIGNS



		W H
16-E	80-1605	84" x 60"
16-H	80-1608	60" x 42"
16-M	80-1613	30" x 24"



		W H
16-S	80-1619	48" x 30"

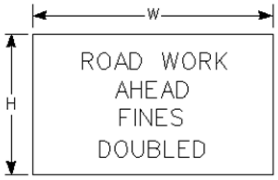
THE 16-S SIGN SHALL BE USED ON ALL PROJECTS THAT REQUIRE SIDEWALK RECONSTRUCTION OR RESTRICT PEDESTRIAN TRAVEL ON AN EXISTING SIDEWALK.

SERIES 16 SIGNS SHALL BE INSTALLED IN ADVANCE OF THE TRAFFIC CONTROL PATTERNS TO ALLOW MOTORISTS THE OPPORTUNITY TO AVOID A WORK ZONE. SERIES 16 SIGNS SHALL BE INSTALLED ON ANY MAJOR INTERSECTING ROADWAYS THAT APPROACH THE WORK ZONE. ON LIMITED- ACCESS HIGHWAYS, THESE SIGNS SHALL BE LOCATED IN ADVANCE OF THE NEAREST UPSTREAM EXIT RAMP AND ON ANY ENTRANCE RAMPS PRIOR TO OR WITHIN THE WORK ZONE LIMITS.

THE LOCATION OF SERIES 16 SIGNS CAN BE FOUND ELSEWHERE IN THE PLANS OR INSTALLED AS DIRECTED BY THE ENGINEER.
SIGNS 16-E AND 16-H SHALL BE POST MOUNTED.
SIGN 16-E SHALL BE USED ON ALL EXPRESSWAYS.
SIGN 16-H SHALL BE USED ON ALL RAMPS, OTHER STATE ROADWAYS, AND MAJOR TOWN/CITY ROADWAYS.
SIGN 16-M SHALL BE USED ON OTHER TOWN ROADWAYS.

REGULATORY SIGN "ROAD WORK AHEAD, FINES DOUBLED"

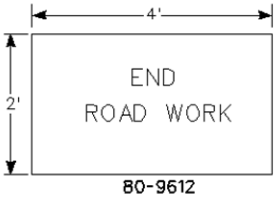
THE REGULATORY SIGN "ROAD WORK AHEAD, FINES DOUBLED" SHALL BE INSTALLED FOR ALL WORK ZONES THAT OCCUR ON ANY STATE HIGHWAY IN CONNECTICUT WHEN THERE ARE WORKERS ON THE HIGHWAY OR WHEN THERE IS OTHER THAN EXISTING TRAFFIC OPERATIONS.
THE "ROAD WORK AHEAD, FINES DOUBLED" REGULATORY SIGNS SHALL NOT BE INSTALLED ON TOWN ROADS.
THE "ROAD WORK AHEAD FINES DOUBLED" REGULATORY SIGN SHALL BE PLACED AFTER THE SERIES 16 SIGN AND IN ADVANCE OF THE "ROAD WORK AHEAD" SIGN.



	W H
31-1906	48" x 42"

"END ROAD WORK" SIGN

THE LAST SIGN IN THE PATTERN MUST BE THE "END ROAD WORK" SIGN.



80-9612

REV'D 1-02

CONNECTICUT
DEPARTMENT OF TRANSPORTATION
BUREAU OF ENGINEERING & HIGHWAY OPERATIONS
DIVISION OF TRAFFIC ENGINEERING

CONSTRUCTION
TRAFFIC CONTROL PLAN

REQUIRED SIGNS

APPROVED J.Carey PRINCIPAL ENGINEER DATE 1-02

NOTES FOR TRAFFIC CONTROL PLANS

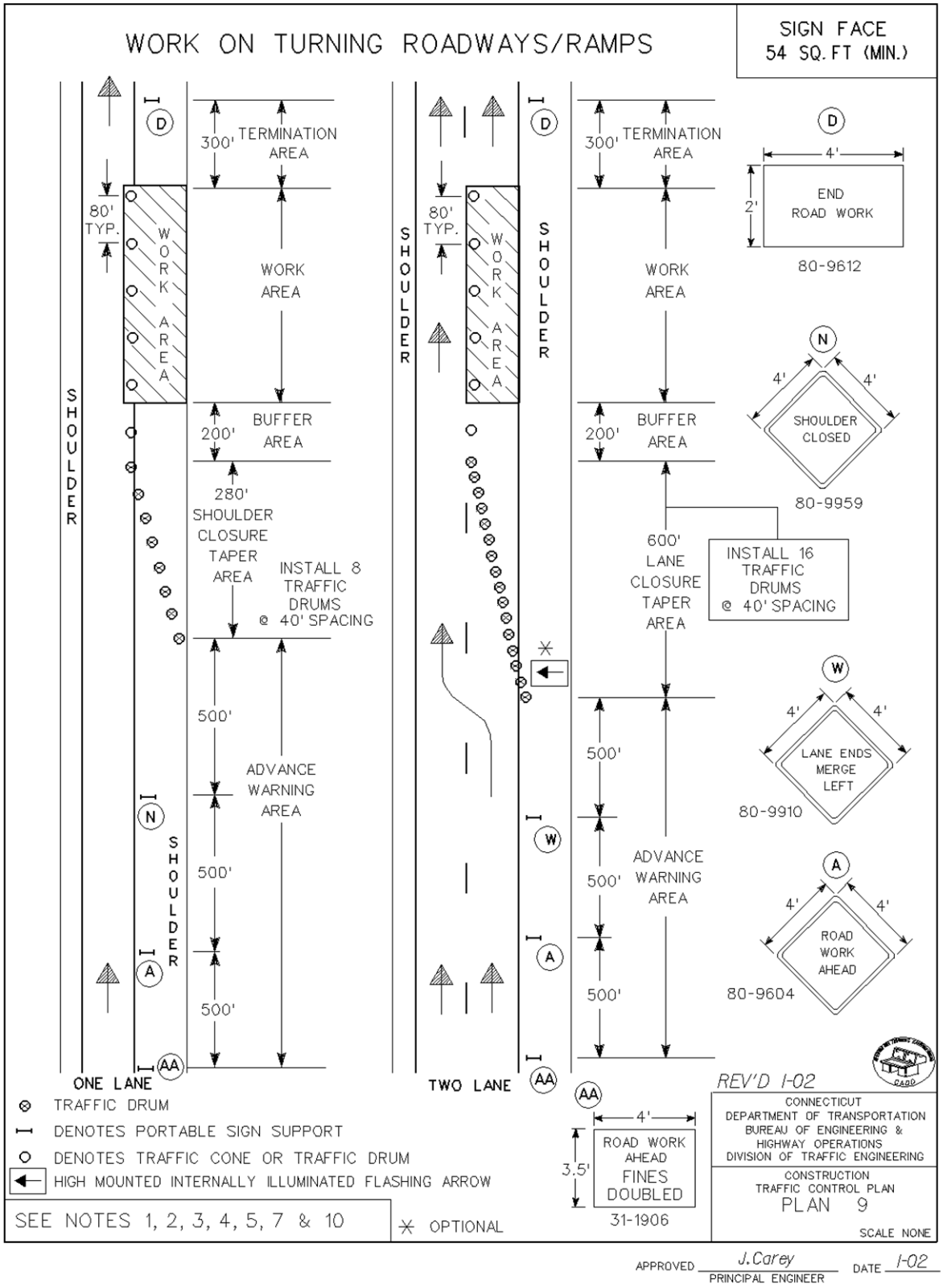
1. IF A TRAFFIC STOPPAGE OCCURS IN ADVANCE OF SIGN (A), THEN AN ADDITIONAL SIGN (A) SHALL BE INSTALLED IN ADVANCE OF THE STOPPAGE.
2. SIGNS (AA), (A) AND (D) SHOULD BE OMITTED WHEN THESE SIGNS HAVE ALREADY BEEN INSTALLED TO DESIGNATE A LARGER WORK ZONE THAN THE WORK ZONE THAT IS ENCOMPASSED ON THIS PLAN.
3. SEE TABLE #1 FOR ADJUSTMENT OF TAPERS IF NECESSARY.
4. A CHANGEABLE MESSAGE SIGN MAY BE UTILIZED ONE HALF TO ONE MILE IN ADVANCE OF THE LANE CLOSURE TAPER.
5. IF THIS PLAN REMAINS IN CONTINUOUS OPERATION FOR MORE THAN 72 HOURS, THEN TRAFFIC DRUMS SHALL BE USED IN PLACE OF TRAFFIC CONES.
6. ANY LEGAL SPEED LIMIT SIGNS WITHIN THE LIMITS OF A ROADWAY / LANE CLOSURE AREA WILL BE COVERED WITH AN OPAQUE MATERIAL WHILE THE CLOSURE IS IN EFFECT AND UNCOVERED WHEN THE ROADWAY / LANE CLOSURE IS REOPENED TO ALL LANES OF TRAFFIC.
7. IF THIS PLAN REMAINS IN CONTINUOUS OPERATION FOR MORE THAN 36 HOURS, THEN THE EXISTING CONFLICTING PAVEMENT MARKINGS SHALL BE ERADICATED OR COVERED AND TEMPORARY PAVEMENT MARKINGS THAT DEPICT THE PROPER TRAVELPATHS SHALL BE INSTALLED.
8. DISTANCES BETWEEN SIGNS IN THE ADVANCE WARNING AREA MAY BE REDUCED TO 200' ON LOW SPEED URBAN ROADS (SPEED LIMIT < 40 MPH).
9. FOR LANE CLOSURES ONE (1) MILE OR LONGER, A "REDUCE SPEED TO 45 MPH" SIGN SHALL BE PLACED AT THE ONE MILE POINT AND AT EACH MILE THEREAFTER.
10. IF THIS PLAN IS TO REMAIN IN OPERATION DURING THE HOURS OF DARKNESS, INSTALL BARRICADE WARNING LIGHTS - HIGH INTENSITY ON ALL POST-MOUNTED DIAMOND SIGNS IN THE ADVANCE WARNING AREA.
11. A CHANGEABLE MESSAGE SIGN SHALL BE INSTALLED ONE HALF TO ONE MILE IN ADVANCE OF THE LANE CLOSURE TAPER.

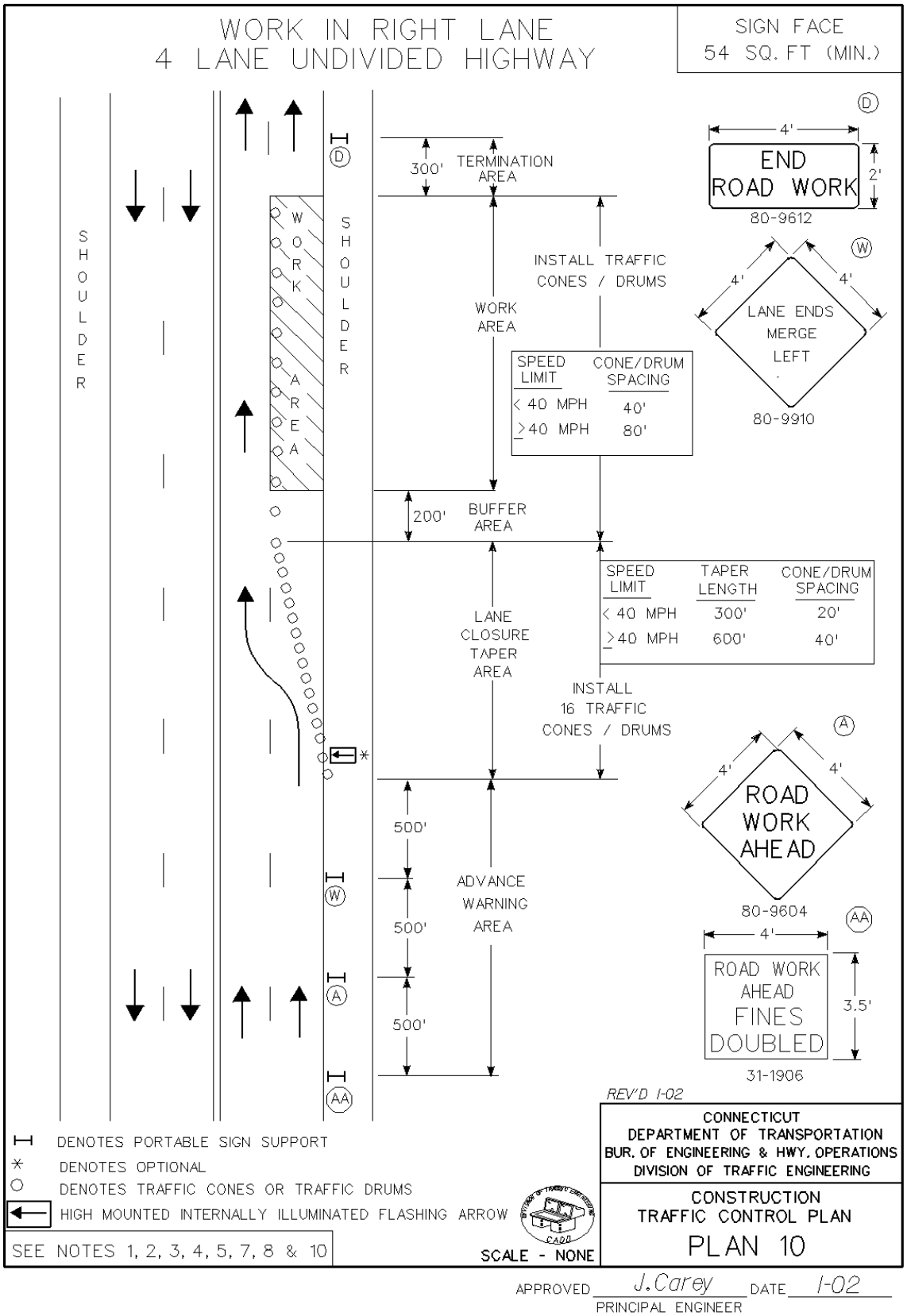
REV'D 1-02

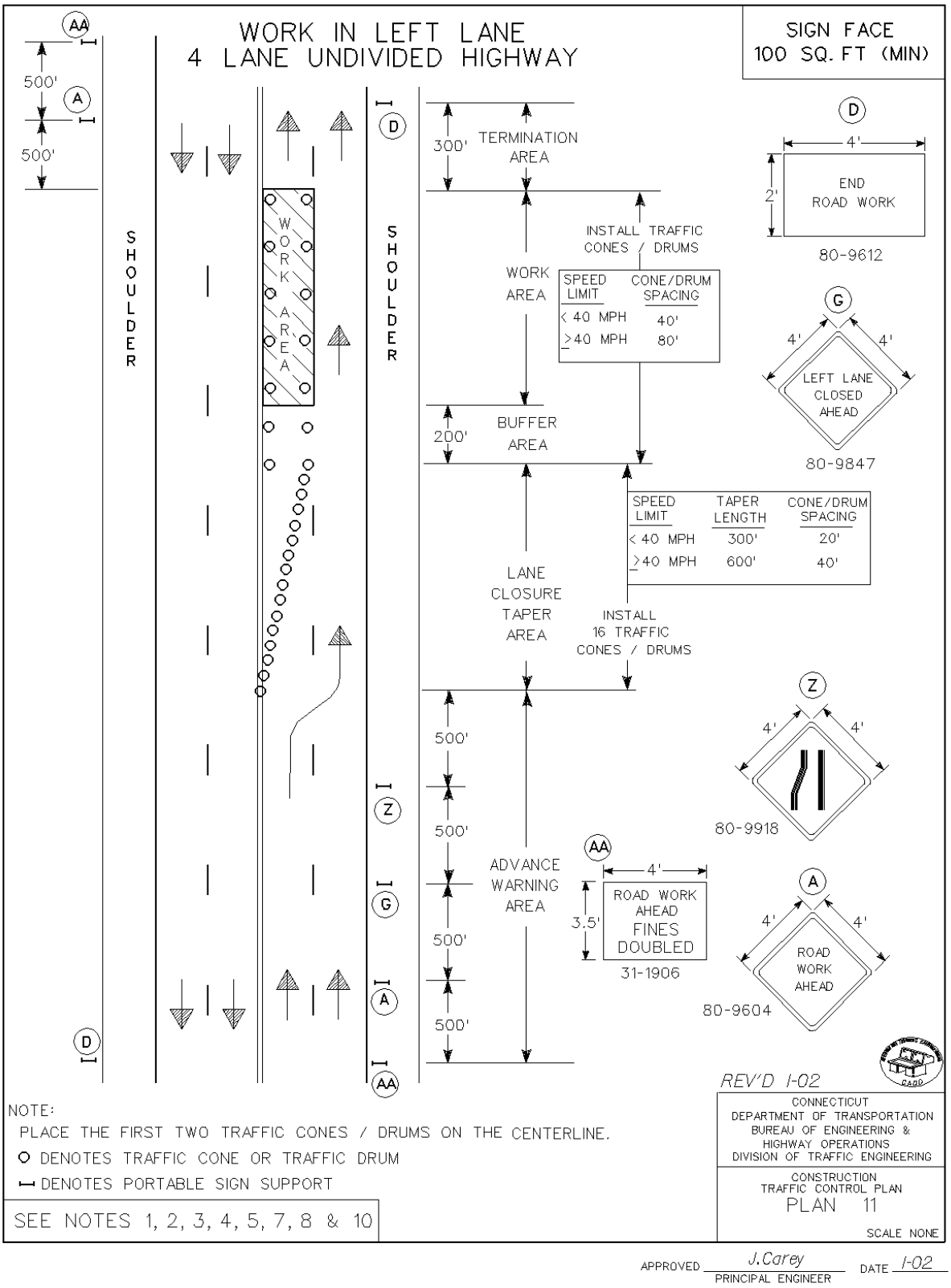
CONNECTICUT
DEPARTMENT OF TRANSPORTATION
BUREAU OF ENGINEERING & HIGHWAY OPERATIONS
DIVISION OF TRAFFIC ENGINEERING

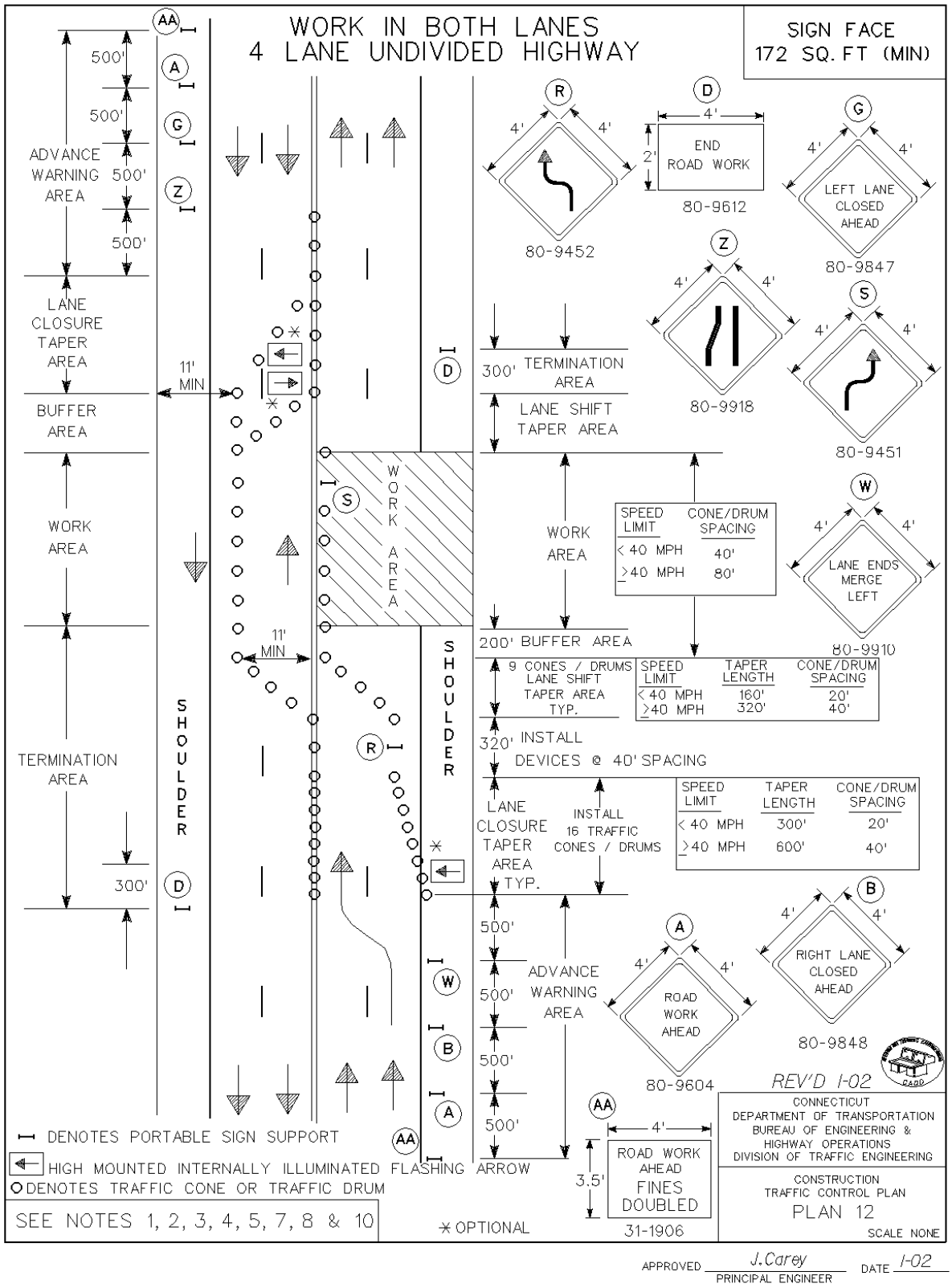
CONSTRUCTION
TRAFFIC CONTROL PLAN
NOTES

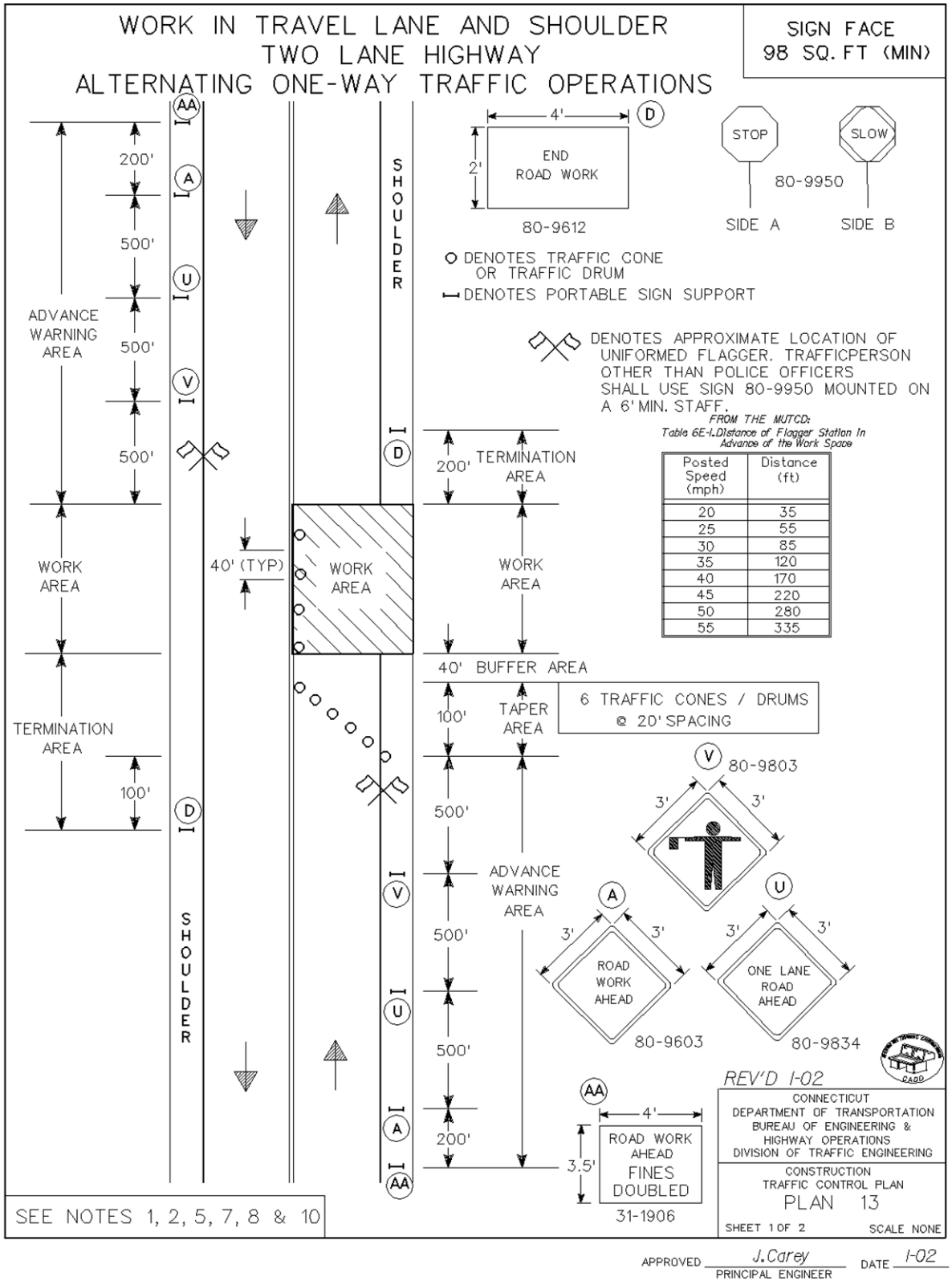
NOTES.DGN


WORK ON TURNING ROADWAYS/RAMPS
SIGN FACE
54 SQ. FT (MIN.)
SHOULDER
80' TYP.
WORK AREA
300' TERMINATION AREA
WORK AREA
200' BUFFER AREA
280' SHOULDER CLOSURE TAPER AREA
INSTALL 8 TRAFFIC DRUMS @ 40' SPACING
500'
ADVANCE WARNING AREA
500'
500'
ONE LANE
TWO LANE
600' LANE CLOSURE TAPER AREA
INSTALL 16 TRAFFIC DRUMS @ 40' SPACING
END ROAD WORK
80-9612
SHOULDER CLOSED
80-9959
LANE ENDS MERGE LEFT
80-9910
ROAD WORK AHEAD
80-9604
ROAD WORK AHEAD FINES DOUBLED
31-1906
TRAFFIC DRUM
DENOTES PORTABLE SIGN SUPPORT
DENOTES TRAFFIC CONE OR TRAFFIC DRUM
HIGH MOUNTED INTERNALLY ILLUMINATED FLASHING ARROW
SEE NOTES 1, 2, 3, 4, 5, 7 & 10
OPTIONAL
REV'D 1-02
CONNECTICUT DEPARTMENT OF TRANSPORTATION
BUREAU OF ENGINEERING & HIGHWAY OPERATIONS
DIVISION OF TRAFFIC ENGINEERING
CONSTRUCTION TRAFFIC CONTROL PLAN
PLAN 9
SCALE NONE
APPROVED J. Carey PRINCIPAL ENGINEER DATE 1-02


WORK IN RIGHT LANE
4 LANE UNDIVIDED HIGHWAY
SIGN FACE
54 SQ. FT (MIN.)
SHOULDER
WORK AREA
SHOULDER
300' TERMINATION AREA
WORK AREA
INSTALL TRAFFIC CONES / DRUMS
SPEED LIMIT | CONE/DRUM SPACING
< 40 MPH 40'
≥ 40 MPH 80'
200' BUFFER AREA
LANE CLOSURE TAPER AREA
SPEED LIMIT | TAPER LENGTH | CONE/DRUM SPACING
< 40 MPH 300' 20'
≥ 40 MPH 600' 40'
INSTALL 16 TRAFFIC CONES / DRUMS
500'
500'
500'
ADVANCE WARNING AREA
4' END ROAD WORK 2'
80-9612
4' 4' LANE ENDS MERGE LEFT
80-9910
4' 4' ROAD WORK AHEAD
80-9604
4' ROAD WORK AHEAD FINES DOUBLED 3.5'
31-1906
REV'D 1-02
CONNECTICUT DEPARTMENT OF TRANSPORTATION
BUR. OF ENGINEERING & HWY. OPERATIONS
DIVISION OF TRAFFIC ENGINEERING
CONSTRUCTION TRAFFIC CONTROL PLAN
PLAN 10
I DENOTES PORTABLE SIGN SUPPORT
* DENOTES OPTIONAL
○ DENOTES TRAFFIC CONES OR TRAFFIC DRUMS
HIGH MOUNTED INTERNALLY ILLUMINATED FLASHING ARROW
SEE NOTES 1, 2, 3, 4, 5, 7, 8 & 10
SCALE - NONE
APPROVED J. Carey DATE 1-02
PRINCIPAL ENGINEER


WORK IN LEFT LANE
4 LANE UNDIVIDED HIGHWAY
SIGN FACE
100 SQ. FT (MIN)
AA
500'
A
500'
SHOULDER
WORK AREA
SHOULDER
D
300'
TERMINATION AREA
INSTALL TRAFFIC CONES / DRUMS
WORK AREA
SPEED LIMIT
CONE/DRUM SPACING
< 40 MPH 40'
≥ 40 MPH 80'
200'
BUFFER AREA
LANE CLOSURE TAPER AREA
SPEED LIMIT
TAPER LENGTH
CONE/DRUM SPACING
< 40 MPH 300' 20'
≥ 40 MPH 600' 40'
INSTALL 16 TRAFFIC CONES / DRUMS
500'
Z
500'
ADVANCE WARNING AREA
G
500'
A
500'
AA
D
4'
2'
END ROAD WORK
80-9612
G
4'
4'
LEFT LANE CLOSED AHEAD
80-9847
Z
4'
4'
80-9918
AA
4'
3.5'
ROAD WORK AHEAD
FINES DOUBLED
31-1906
A
4'
4'
ROAD WORK AHEAD
80-9604
REV'D 1-02
CONNECTICUT
DEPARTMENT OF TRANSPORTATION
BUREAU OF ENGINEERING &
HIGHWAY OPERATIONS
DIVISION OF TRAFFIC ENGINEERING
CONSTRUCTION
TRAFFIC CONTROL PLAN
PLAN 11
SCALE NONE
NOTE:
PLACE THE FIRST TWO TRAFFIC CONES / DRUMS ON THE CENTERLINE.
O DENOTES TRAFFIC CONE OR TRAFFIC DRUM
I DENOTES PORTABLE SIGN SUPPORT
SEE NOTES 1, 2, 3, 4, 5, 7, 8 & 10
APPROVED J.Carey PRINCIPAL ENGINEER
DATE 1-02


WORK IN BOTH LANES
4 LANE UNDIVIDED HIGHWAY
SIGN FACE
172 SQ. FT (MIN)
ADVANCE WARNING AREA
500'
500'
500'
LANE CLOSURE TAPER AREA
BUFFER AREA
WORK AREA
TERMINATION AREA
300'
11' MIN
11' MIN
SHOULDER
SHOULDER
WORK AREA
300' TERMINATION AREA
LANE SHIFT TAPER AREA
WORK AREA
200' BUFFER AREA
9 CONES / DRUMS LANE SHIFT TAPER AREA TYP.
320' INSTALL DEVICES @ 40' SPACING
LANE CLOSURE TAPER AREA TYP.
INSTALL 16 TRAFFIC CONES / DRUMS
ADVANCE WARNING AREA
500'
500'
500'
500'
SPEED LIMIT
CONE/DRUM SPACING
< 40 MPH 40'
≥40 MPH 80'
SPEED LIMIT
TAPER LENGTH
CONE/DRUM SPACING
< 40 MPH 160' 20'
≥40 MPH 320' 40'
SPEED LIMIT
TAPER LENGTH
CONE/DRUM SPACING
< 40 MPH 300' 20'
≥40 MPH 600' 40'
END ROAD WORK
80-9612
80-9452
LEFT LANE CLOSED AHEAD
80-9847
80-9918
80-9451
LANE ENDS MERGE LEFT
80-9910
ROAD WORK AHEAD
80-9604
RIGHT LANE CLOSED AHEAD
80-9848
ROAD WORK AHEAD FINES DOUBLED
31-1906
I DENOTES PORTABLE SIGN SUPPORT
HIGH MOUNTED INTERNALLY ILLUMINATED FLASHING ARROW
DENOTES TRAFFIC CONE OR TRAFFIC DRUM
SEE NOTES 1, 2, 3, 4, 5, 7, 8 & 10
* OPTIONAL
REV'D 1-02
CONNECTICUT DEPARTMENT OF TRANSPORTATION
BUREAU OF ENGINEERING & HIGHWAY OPERATIONS
DIVISION OF TRAFFIC ENGINEERING
CONSTRUCTION TRAFFIC CONTROL PLAN
PLAN 12
SCALE NONE
APPROVED J.Carey PRINCIPAL ENGINEER
DATE 1-02


WORK IN TRAVEL LANE AND SHOULDER
TWO LANE HIGHWAY
ALTERNATING ONE-WAY TRAFFIC OPERATIONS
SIGN FACE
98 SQ. FT (MIN)
4'
2'
END
ROAD WORK
80-9612
STOP
SLOW
80-9950
SIDE A
SIDE B
O DENOTES TRAFFIC CONE OR TRAFFIC DRUM
I DENOTES PORTABLE SIGN SUPPORT
DENOTES APPROXIMATE LOCATION OF UNIFORMED FLAGGER. TRAFFICPERSON OTHER THAN POLICE OFFICERS SHALL USE SIGN 80-9950 MOUNTED ON A 6' MIN. STAFF.
FROM THE MUTCD:
Table 6E-1.Distance of Flagger Station In Advance of the Work Space
Posted Speed (mph) | Distance (ft)
20 | 35
25 | 55
30 | 85
35 | 120
40 | 170
45 | 220
50 | 280
55 | 335
ADVANCE WARNING AREA
200'
500'
500'
500'
WORK AREA
TERMINATION AREA
100'
40' (TYP)
SHOULDER
SHOULDER
WORK AREA
200' TERMINATION AREA
WORK AREA
40' BUFFER AREA
100' TAPER AREA
6 TRAFFIC CONES / DRUMS @ 20' SPACING
500'
ADVANCE WARNING AREA
500'
500'
200'
80-9803
3'
3'
ROAD WORK AHEAD
80-9603
ONE LANE ROAD AHEAD
80-9834
3.5'
4'
ROAD WORK AHEAD
FINES DOUBLED
31-1906
SEE NOTES 1, 2, 5, 7, 8 & 10
REV'D 1-02
CONNECTICUT
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BUREAU OF ENGINEERING & HIGHWAY OPERATIONS
DIVISION OF TRAFFIC ENGINEERING
CONSTRUCTION
TRAFFIC CONTROL PLAN
PLAN 13
SHEET 1 OF 2
SCALE NONE
APPROVED J.Carey PRINCIPAL ENGINEER
DATE 1-02

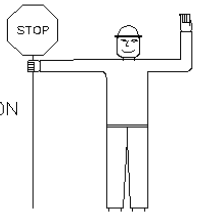
WORK IN TRAVEL LANE AND SHOULDER
TWO LANE HIGHWAY
ALTERNATING ONE-WAY TRAFFIC OPERATIONS

HAND SIGNAL METHODS TO BE USED BY UNIFORMED FLAGGERS

THE FOLLOWING METHODS FROM SECTION 6E.04 FLAGGER PROCEDURES IN THE "MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES" SHALL BE USED BY UNIFORMED FLAGGERS WHEN DIRECTING TRAFFIC THROUGH A WORK AREA. THE STOP/SLOW SIGN PADDLE (SIGN NO. 80-9950) SHOWN ON THE TYPICAL DETAIL SHEET ENTITLED "SIGNS FOR CONSTRUCTION AND PERMIT OPERATIONS" SHALL BE USED.

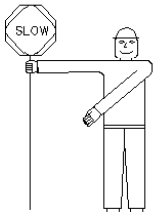
A. TO STOP TRAFFIC

TO STOP ROAD USERS, THE FLAGGER SHALL FACE ROAD USERS AND AIM THE STOP PADDLE FACE TOWARD ROAD USERS IN A STATIONARY POSITION WITH THE ARM EXTENDED HORIZONTALLY AWAY FROM THE BODY. THE FREE ARM SHALL BE HELD WITH THE PALM OF THE HAND ABOVE SHOULDER LEVEL TOWARD APPROACHING TRAFFIC.



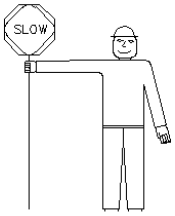
B. TO DIRECT TRAFFIC TO PROCEED

TO DIRECT STOPPED ROAD USERS TO PROCEED, THE FLAGGER SHALL FACE ROAD USERS WITH THE SLOW PADDLE FACE AIMED TOWARD ROAD USERS IN A STATIONARY POSITION WITH THE ARM EXTENDED HORIZONTALLY AWAY FROM THE BODY. THE FLAGGER SHALL MOTION WITH THE FREE HAND FOR ROAD USERS TO PROCEED.



C. TO ALERT OR SLOW TRAFFIC

TO ALERT OR SLOW TRAFFIC, THE FLAGGER SHALL FACE ROAD USERS WITH THE SLOW PADDLE FACE AIMED TOWARD ROAD USERS IN A STATIONARY POSITION WITH THE ARM EXTENDED HORIZONTALLY AWAY FROM THE BODY. TO FURTHER ALERT OR SLOW TRAFFIC, THE FLAGGER HOLDING THE SLOW PADDLE FACE TOWARD ROAD USERS MAY MOTION UP AND DOWN WITH THE FREE HAND, PALM DOWN.



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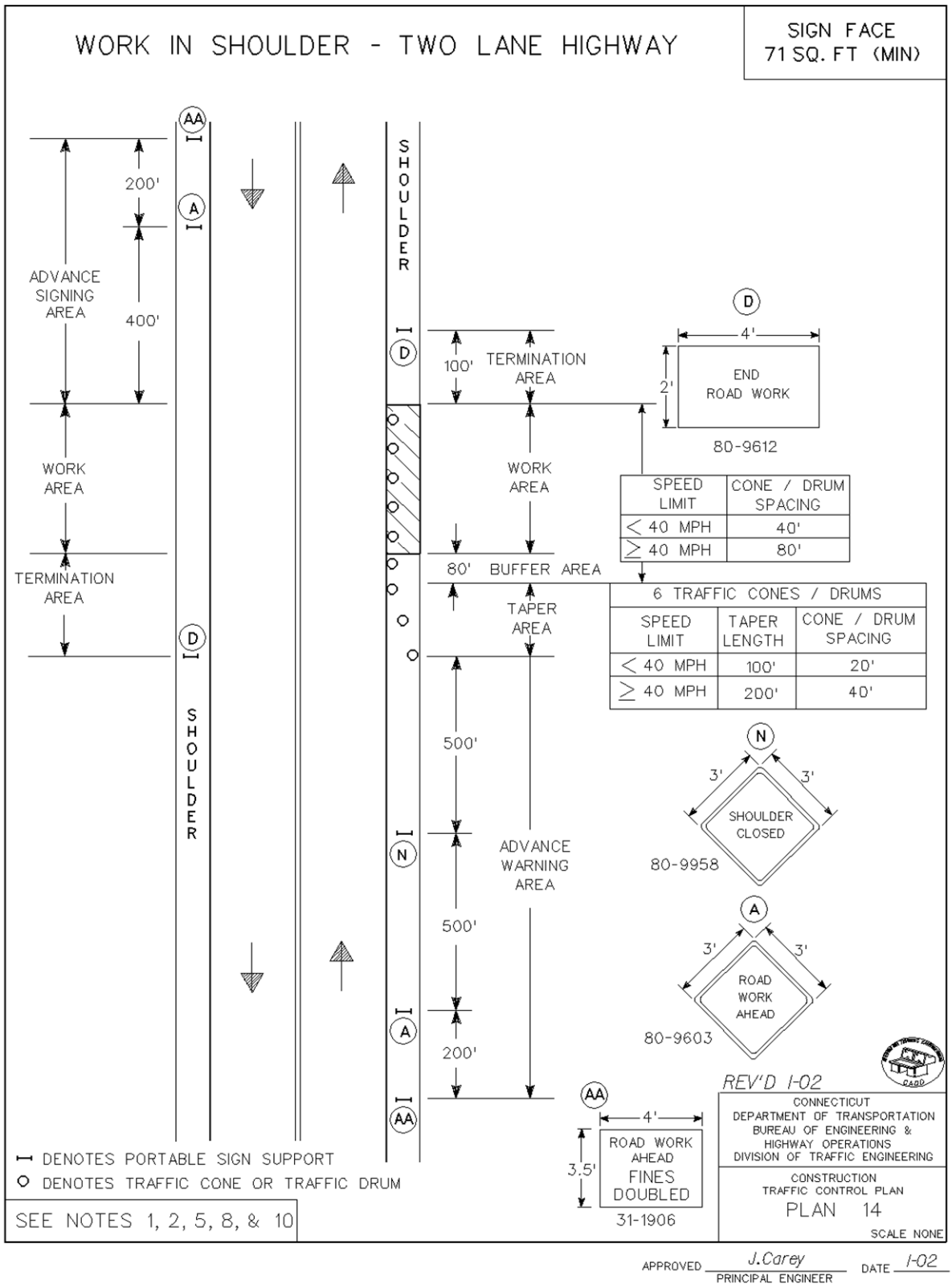
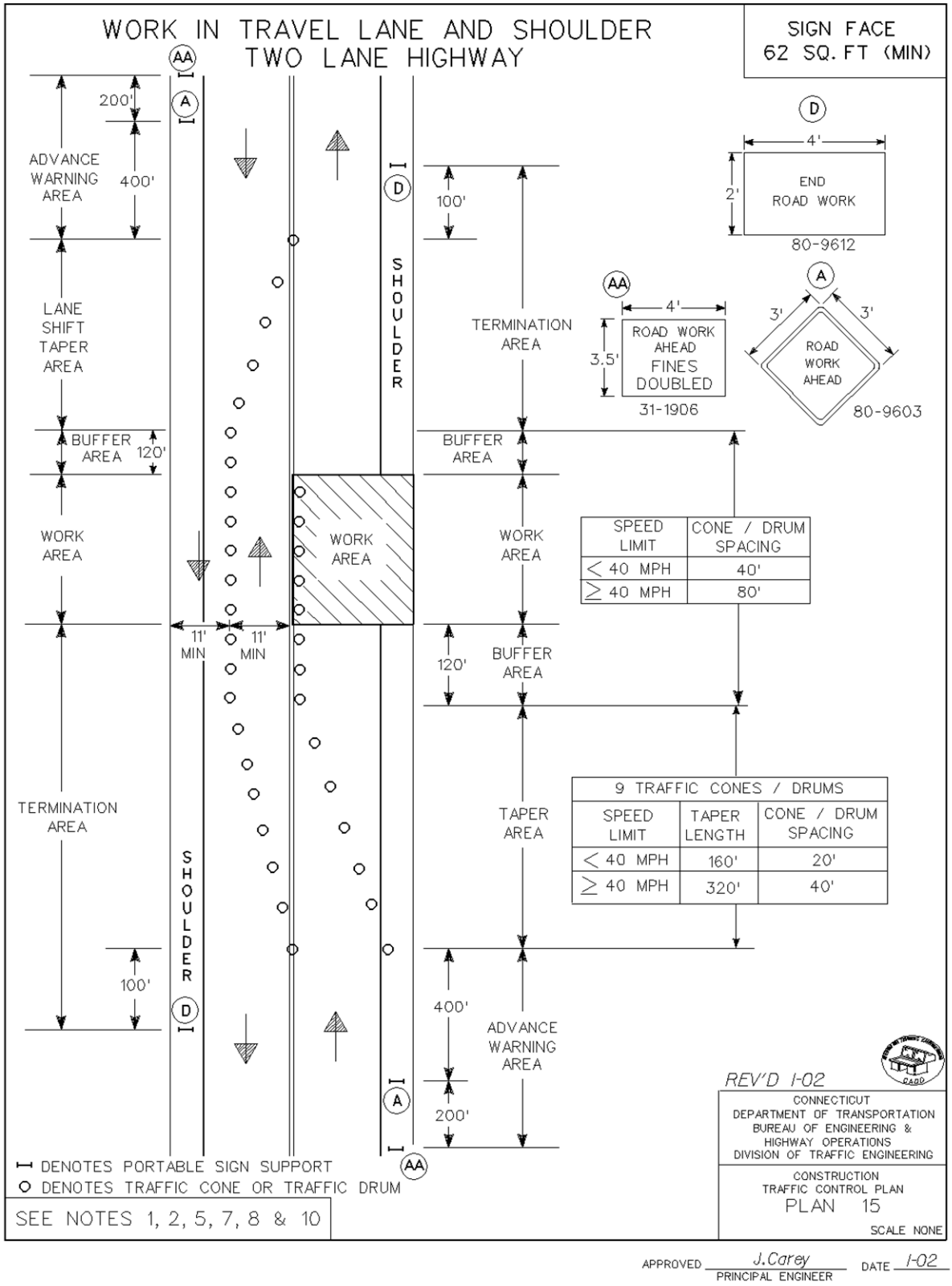
CONNECTICUT
DEPARTMENT OF TRANSPORTATION
BUREAU OF ENGINEERING &
HIGHWAY OPERATIONS
DIVISION OF TRAFFIC ENGINEERING

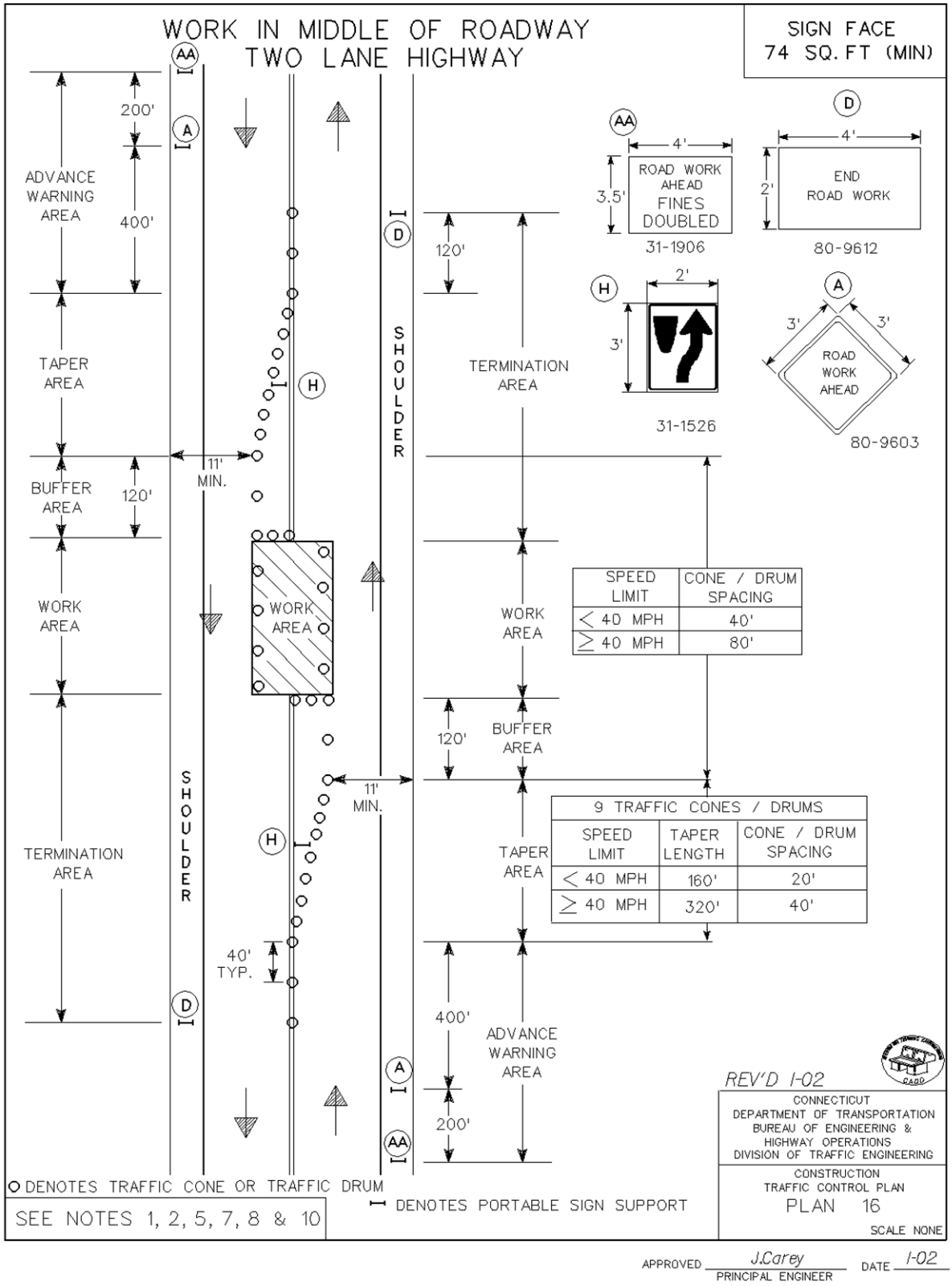
CONSTRUCTION
TRAFFIC CONTROL PLAN
PLAN 13
SHEET 2 OF 2 SCALE NONE

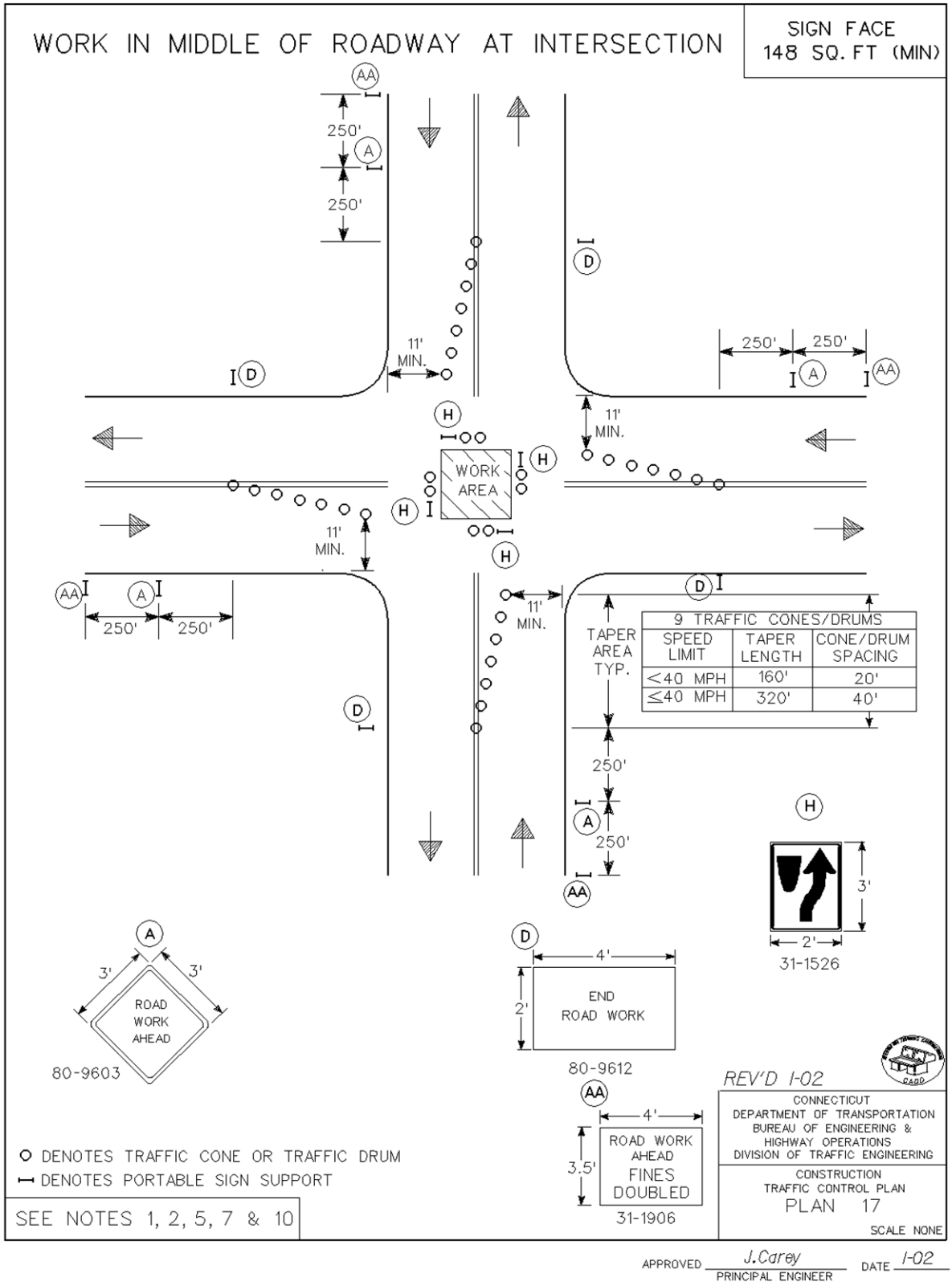
SEE NOTES 1, 2, 5, 7, 8 & 10

APPROVED J. Carey PRINCIPAL ENGINEER DATE 1-02


WORK IN SHOULDER - TWO LANE HIGHWAY
SIGN FACE
71 SQ. FT (MIN)
ADVANCE SIGNING AREA
200'
400'
WORK AREA
TERMINATION AREA
SHOULDER
SHOULDER
100'
TERMINATION AREA
WORK AREA
80' BUFFER AREA
TAPER AREA
500'
500'
200'
ADVANCE WARNING AREA
4'
END ROAD WORK
2'
80-9612
SPEED LIMIT
CONE / DRUM SPACING
< 40 MPH
40'
≥ 40 MPH
80'
6 TRAFFIC CONES / DRUMS
SPEED LIMIT
TAPER LENGTH
CONE / DRUM SPACING
< 40 MPH
100'
20'
≥ 40 MPH
200'
40'
3'
3'
SHOULDER CLOSED
80-9958
ROAD WORK AHEAD
80-9603
4'
ROAD WORK AHEAD
FINES DOUBLED
3.5'
31-1906
I DENOTES PORTABLE SIGN SUPPORT
O DENOTES TRAFFIC CONE OR TRAFFIC DRUM
SEE NOTES 1, 2, 5, 8, & 10
REV'D 1-02
CONNECTICUT DEPARTMENT OF TRANSPORTATION
BUREAU OF ENGINEERING & HIGHWAY OPERATIONS
DIVISION OF TRAFFIC ENGINEERING
CONSTRUCTION TRAFFIC CONTROL PLAN
PLAN 14
SCALE NONE
APPROVED J.Carey PRINCIPAL ENGINEER
DATE 1-02


WORK IN TRAVEL LANE AND SHOULDER
TWO LANE HIGHWAY
SIGN FACE
62 SQ. FT (MIN)
ADVANCE WARNING AREA
200'
400'
LANE SHIFT TAPER AREA
BUFFER AREA
120'
WORK AREA
TERMINATION AREA
100'
SHOULDER
11' MIN
11' MIN
WORK AREA
TERMINATION AREA
BUFFER AREA
120'
TAPER AREA
400'
ADVANCE WARNING AREA
200'
SHOULDER
4'
2'
END ROAD WORK
80-9612
ROAD WORK AHEAD
FINES DOUBLED
3.5'
31-1906
3'
3'
ROAD WORK AHEAD
80-9603
SPEED LIMIT
CONE / DRUM SPACING
< 40 MPH
40'
≥ 40 MPH
80'
9 TRAFFIC CONES / DRUMS
SPEED LIMIT
TAPER LENGTH
CONE / DRUM SPACING
< 40 MPH
160'
20'
≥ 40 MPH
320'
40'
I DENOTES PORTABLE SIGN SUPPORT
O DENOTES TRAFFIC CONE OR TRAFFIC DRUM
SEE NOTES 1, 2, 5, 7, 8 & 10
REV'D 1-02
CONNECTICUT
DEPARTMENT OF TRANSPORTATION
BUREAU OF ENGINEERING & HIGHWAY OPERATIONS
DIVISION OF TRAFFIC ENGINEERING
CONSTRUCTION
TRAFFIC CONTROL PLAN
PLAN 15
SCALE NONE
APPROVED J.Carey PRINCIPAL ENGINEER
DATE 1-02


WORK IN MIDDLE OF ROADWAY
TWO LANE HIGHWAY
SIGN FACE
74 SQ. FT (MIN)
ADVANCE WARNING AREA
200'
400'
TAPER AREA
BUFFER AREA
120'
WORK AREA
TERMINATION AREA
11' MIN.
SHOULDER
WORK AREA
40' TYP.
ROAD WORK AHEAD
FINES DOUBLED
3.5'
4'
31-1906
END ROAD WORK
2'
80-9612
2'
3'
31-1526
ROAD WORK AHEAD
80-9603
SPEED LIMIT
CONE / DRUM SPACING
< 40 MPH
40'
≥ 40 MPH
80'
9 TRAFFIC CONES / DRUMS
SPEED LIMIT
TAPER LENGTH
CONE / DRUM SPACING
< 40 MPH
160'
20'
≥ 40 MPH
320'
40'
O DENOTES TRAFFIC CONE OR TRAFFIC DRUM
I DENOTES PORTABLE SIGN SUPPORT
SEE NOTES 1, 2, 5, 7, 8 & 10
REV'D 1-02
CONNECTICUT DEPARTMENT OF TRANSPORTATION
BUREAU OF ENGINEERING & HIGHWAY OPERATIONS
DIVISION OF TRAFFIC ENGINEERING
CONSTRUCTION TRAFFIC CONTROL PLAN
PLAN 16
SCALE NONE
APPROVED J.Carey PRINCIPAL ENGINEER
DATE 1-02


WORK IN MIDDLE OF ROADWAY AT INTERSECTION
SIGN FACE
148 SQ. FT (MIN)
250'
250'
11' MIN.
WORK AREA
9 TRAFFIC CONES/DRUMS
SPEED LIMIT
TAPER LENGTH
CONE/DRUM SPACING
≤40 MPH
160'
20'
≥40 MPH
320'
40'
TAPER AREA TYP.
31-1526
ROAD WORK AHEAD
80-9603
END ROAD WORK
80-9612
ROAD WORK AHEAD
FINES DOUBLED
31-1906
REV'D 1-02
CONNECTICUT DEPARTMENT OF TRANSPORTATION
BUREAU OF ENGINEERING & HIGHWAY OPERATIONS
DIVISION OF TRAFFIC ENGINEERING
CONSTRUCTION TRAFFIC CONTROL PLAN
PLAN 17
SCALE NONE
O DENOTES TRAFFIC CONE OR TRAFFIC DRUM
DENOTES PORTABLE SIGN SUPPORT
SEE NOTES 1, 2, 5, 7 & 10
APPROVED J.Carey PRINCIPAL ENGINEER
DATE 1-02

METHOD OF MEASUREMENT

The provision of maintenance and protection of traffic will be measured for by the contract price for the completion of "Maintenance and Protection of Traffic" work. The contract price of this item shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Form 816, Article 9.71.05 – Basis of Payment is supplemented by the following:

The contract lump sum price for "Maintenance and Protection of Traffic" shall also include temporarily relocating existing signs and sign supports as many times as deemed necessary by the Engineer and furnishing, installing, and removing temporary sign supports and foundations if necessary during the construction of the project.

The negotiated contract price for "Maintenance and Protection of Traffic" shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the ITS and Communications Systems for CT***fastrak*** shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 104 – TRAFFICPERSON (MUNICIPAL POLICE OFFICER)

SPECIFICATION 105 – TRAFFICPERSON (UNIFORMED FLAGGER)

DESCRIPTION

Under this item the Contractor shall provide the services of Trafficpersons of the type and number, and for such periods, as the Engineer approves for the control and direction of vehicular traffic and pedestrians. Traffic persons requested solely for the contractor's operational needs will not be approved for payment.

CONSTRUCTION METHOD

Prior to the start of operations on the project requiring the use of Trafficpersons, a meeting will be held with the Contractor, Trafficperson agency or firm, Engineer, and State Police, if applicable, to review the Trafficperson operations, lines of responsibility, and operating guidelines which will be used on the project. A copy of the municipality's billing rates for Municipal Police Officers and vehicles, if applicable, will be provided to the Engineer prior to start of work.

On a weekly basis, the Contractor shall inform the Engineer of their scheduled operations for the following week and the number of Trafficpersons requested. The Engineer shall review this schedule and approve the type and number of Trafficpersons required. In the event of an unplanned, emergency, or short term operation, the Engineer may approve the temporary use of properly clothed persons for traffic control until such time as an authorized Trafficperson may be obtained. In no case shall this temporary use exceed eight (8) hours for any particular operation.

If the Contractor changes or cancels any scheduled operations without prior notice of same as required by the agency providing the Trafficpersons, and such that Trafficperson services are no longer required, the Contractor will be responsible for payment at no cost to the Department of any show-up cost for any Trafficperson not used because of the change. Exceptions, as approved by the Engineer, may be granted for adverse weather conditions and unforeseeable causes beyond the control and without the fault or negligence of the Contractor.

Trafficpersons assigned to a work site are to only take direction from the Engineer.

Trafficpersons shall wear a high visibility safety garment that complies with OSHA, MUTCD, ASTM Standards and the safety garment shall have the words "Traffic Control" clearly visible on the front and rear panels (minimum letter size 2 inches (50 millimeters)). Worn/faded safety garments that are no longer highly visible shall not be used. The Engineer shall direct the replacement of any worn/faded garment at no cost to the State.

A Trafficperson shall assist in implementing the traffic control specified in the Maintenance and Protection of Traffic contained elsewhere in these specifications or as directed by the Engineer. Any situation requiring a Trafficperson to operate in a manner contrary to the Maintenance and Protection of Traffic specification shall be authorized in writing by the Engineer.

Trafficpersons shall consist of the following types:

Uniformed Law Enforcement Personnel: Law enforcement personnel shall wear the high visibility safety garment provided by their law enforcement agency. If no high visibility safety garment is provided, the Contractor shall provide the law enforcement personnel with a garment meeting the requirements stated for the Uniformed Flaggers' garment.

Law Enforcement Personnel may be also be used to conduct motor vehicle enforcement operations in and around work areas as directed and approved by the Engineer.

Municipal Police Officers: Uniformed Municipal Police Officers shall be sworn Municipal Police Officers or Uniformed Constables who perform criminal law enforcement duties from the Municipality in which the project is located. Their services will also include an official Municipal Police vehicle when requested by the Engineer. Uniformed Municipal Police Officers will be used on non-limited access highways. If Uniformed Municipal Police Officers are unavailable, other Trafficpersons may be used when authorized in writing by the Engineer.
Uniformed Municipal Police Officers and requested Municipal Police vehicles will be used at such locations and for such periods as the Engineer deems necessary to control traffic operations and promote increased safety to motorists through the construction sites.

Uniformed Flagger: Uniformed Flaggers shall be persons who have successfully completed flagger training by the American Traffic Safety Services Association (ATSSA), National Safety Council (NSC) or other programs approved by the Engineer. A copy of the Flagger's training certificate shall be provided to the Engineer before the Flagger performs any work on the project. Uniformed Flaggers shall conform to Chapter 6E, Flagger Control, in the Manual of Uniformed Traffic Control Devices (MUTCD) and shall wear high-visibility safety apparel, use a STOP/SLOW paddle that is at least 18 inches (450 millimeters) in width with letters at least 6 inches (150 millimeters) high. The paddle shall be mounted on a pole of sufficient length to be 6 feet (1.8 meters) above the ground as measured from the bottom of the sign.

Uniformed Flaggers will only be used on non-limited access highways to control traffic operations when authorized in writing by the Engineer.

METHOD OF MEASUREMENT

Services of Trafficpersons will be measured for payment by the actual number of hours for each person rendering services approved by the Engineer. These services shall include, however, only such trafficpersons as are employed within the limits of construction, project right of way of the project or along detours authorized by the Engineer to assist the motoring public through the construction work zone. Services for continued use of a detour or bypass beyond the limitations approved by the Engineer, for movement of construction vehicles and equipment, or at locations

where traffic is unnecessarily restricted by the Contractor's method of operation, will not be measured for payment.

Trafficpersons shall not work more than twelve hours in any one twenty-four hour (24 hour) period. In case such services are required for more than twelve (12) hours, additional Trafficpersons shall be furnished and measured for payment. In cases where the Trafficperson is an employee on the Contractor's payroll, payment under the item "Trafficperson (Uniformed Flagger)" will be made only for those hours when the Contractor's employee is performing Trafficperson services.

Travel time will not be measured for payment for services provided by Uniformed Municipal Police Officers or Uniformed Flaggers.

Mileage fees associated with Trafficperson services will not be measured for payment.

Safety garments and STOP/SLOW paddles will not be measured for payment.

BASIS OF PAYMENT

Trafficpersons will be paid in accordance with the schedule described herein. The price shall not be included in the negotiated total system implementation cost as defined in Specification 100 – General Provisions.

There will be no direct payment for safety garments or STOP/SLOW paddles. All costs associated with furnishing safety garments and STOP/SLOW paddles shall be considered included in the general cost of the item.

Uniformed Law Enforcement Personnel: The sum of money shown on the Estimate and in the itemized proposal as "Estimated Cost" for this work will be considered the proposal price even though payment will be made as described below. The estimated cost figure is not to be altered in any manner by the Proposer. Should the Proposer alter the amount shown, the altered figures will be disregarded and the original price will be used to determine the total amount for the contract.

The Department will pay the Contractor its actual costs for "Trafficperson (Municipal Police Officer)" plus an additional 5% as reimbursement for the Contractor's administrative expense in connection with the services provided.

The invoice must include a breakdown of each officer's actual hours of work and actual rate applied. Mileage fees associated with Trafficperson services are not reimbursable expenses and are not to be included in the billing invoice. The use of a municipal police vehicle authorized by the Engineer will be paid at the actual rate charged by the municipality. Upon receipt of the invoice from the municipality, the Contractor shall forward a copy to the Engineer. The invoice will be reviewed and approved by the Engineer prior to any payments. ***Eighty (80%) of the invoice will be paid upon completion of review and approval. The balance (20%) will be paid upon receipt of cancelled check or receipted invoice, as proof of payment.*** The rate charged by

the municipality for use of a uniformed municipal police officer and/or a municipal police vehicle shall not be greater than the rate it normally charges others for similar services.

Uniformed Flagger: Uniformed flaggers will be paid for at the contract unit price per hour for "Trafficperson (Uniformed Flagger)", which price shall include all compensation, insurance benefits and any other cost or liability incidental to the furnishing of the trafficpersons ordered.

SPECIFICATION 106 – CONSTRUCTION COMMUNICATION EQUIPMENT

DESCRIPTION

Under this item, for the duration of all installation and testing work the Contractor shall provide:

- Communication equipment for use by the inspection personnel. This item shall include all necessary equipment, accessories, material and labor to put the system into operation. Provisions shall also be made to maintain all provided communication equipment and any additional communication equipment assigned to the project, as directed by the Engineer.
- A toll-free, reservation-less telephone conference call account for the use of the Engineer.

MATERIALS

The equipment for this item shall comply with the following: A hand held cellular phone capable of communicating digitally between units with two-way radio feature. This item shall include all necessary equipment, accessories (including but not limited to car charger and holster), materials, labor and maintenance to make the system operational. In addition, the phones shall have voice mail, caller ID and call waiting.

CONSTRUCTION METHODS

The Contractor shall submit three (3) proposals for both the communication equipment described herein and forward to the Engineer for approval. The Department will provide the Contractor with the estimated quantity of phones required for inspection personnel.

The three proposals may be for either rental or purchase of equipment that is new or of like-new condition and meeting the specification requirements. Also, the three proposals must indicate the minimum and maximum number of phones that will be allotted. The Engineer will have ten (10) business days from receipt of the proposals to inform the Contractor of its selection. Once approved, the contractor shall order the equipment, and have it installed and operating within fifteen (15) business days.

The Contractor will furnish to the State, a copy of the monthly call record for each phone when submitting the billing invoices for the communication equipment.

All equipment and associated materials will remain the property of the Contractor upon completion of the project unless otherwise specified by the Engineer in writing.

Telephone Conference Call Account: The Contractor shall submit three (3) proposals for the telephone conference call account described herein and forward to the Engineer for approval.

The Engineer will have ten (10) business days from receipt of the proposals to inform the Contractor of its selection. Once approved, the contractor shall activate the account within five (5) working days.

Once activated, the Engineer will act as the "moderator" and control all associated PIN numbers.

The Contractor will furnish to the State, a copy of the detailed monthly account history when submitting the billing invoices for the telephone conference call account.

METHOD OF MEASUREMENT

This work shall be measured for payment by the actual detailed monthly invoices.

BASIS OF PAYMENT

Payment will include all materials, equipment, labor and maintenance associated with this item and shall not be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The sum of money shown on the Estimate and in the itemized proposal as "Estimated Cost" for this work will be considered the proposal price even though payment will be made as described below. The estimated cost figure is not to be altered in any manner by the proposer. Should the proposer alter the amount shown, the altered figures will be disregarded and the original price will be used to determine the total amount for the contract.

The item, "Construction Communication Equipment", shall be paid for at the actual detailed monthly account history for services approved by the Engineer, plus a 5% markup.

SPECIFICATION 107 – ENVIRONMENTAL HEALTH AND SAFETY

DESCRIPTION

Under this Item, the Contractor shall establish protocols and provide procedures to protect the health and safety of its employees and subcontractors as related to the proposed construction activities performed within the Project Areas of Environmental Concerns (AOECs). Work under this Item consists of the development and implementation of a written site-specific Health and Safety Plan (HASP) that addresses the relative risk of exposure to documented hazards present within the Project limits. The HASP shall establish health and safety protocols that address the relative risk of exposure to regulated substances in accordance with 29 CFR 1910.120 and 29 CFR 1926.65. Such protocols shall only address those concerns directly related to site conditions.

Note: The Engineer will prepare a site-specific health and safety plan which is compatible with the Contractor's plan and will be responsible for the health and safety of all Project Inspectors, Department employees and consulting engineers.

MATERIALS

General

The Contractor must provide chemical protective clothing (CPC) and personal protective equipment (PPE) as stipulated in the Contractor's HASP during the performance of work in areas identified as potentially posing a risk to worker health and safety for workers employed by the Contractor and all subcontractors.

CONSTRUCTION METHODS

Existing Information

The Contractor shall utilize all available information and existing records and data pertaining to chemical and physical hazards associated with any of the regulated substances identified in the environmental site investigations to develop the HASP. A list of documents containing this data is found in "Notice to Contractor – Environmental Investigations".

General

The requirements set forth herein pertain to the provision of workers' health and safety as it relates to proposed Project activities when performed in the presence of hazardous or regulated

materials or otherwise environmentally sensitive conditions. THE PROVISION OF WORKER HEALTH AND SAFETY PROTOCOLS WHICH ADDRESS POTENTIAL AND/ OR ACTUAL RISK OF EXPOSURE TO SITE SPECIFIC HAZARDS POSED TO CONTRACTOR EMPLOYEES IS SOLELY THE RESPONSIBILITY OF THE CONTRACTOR.

The Contractor shall be responsible for the development, implementation and oversight of the HASP throughout the performance of work within the limits of the AOECs, as identified in the Contract Documents, and in other areas identified by the Engineer or by the HASP where site conditions may pose a risk to worker health and safety and/or the environment. **No physical aspects of the work within an AOEC shall begin until the HASP is reviewed by the Engineer and is determined to meet the requirements of the specifications.**

Regulatory Requirements

All construction related activities performed by the Contractor within the limits of the AOECs or in other areas where site conditions may pose a risk to worker health and safety and/or the environment shall be performed in conformance with 29 CFR 1926, Safety and Health Regulations for Construction and 29 CFR 1910, Safety and Health Regulations for General Industry. Conformance to 29 CFR 1910.120, Hazardous Waste Site Operations and Emergency Response (HAZWOPER) may also be required, where appropriate.

Regulatory Requirements

Three copies of the HASP shall be submitted to the Engineer as part of Design Documentation (see Specification 100 – General Provisions) or four (4) weeks prior to the start of any work in any AOEC, whichever is first, but not before the Award of the Contract. The HASP shall include copies of the Contractor-designated Health and Safety Officer's (HSO) training certificates as well as a demonstration of the required experience, as indicated in Section 5-HASP Provisions (b) (iii) of this Item.

The HASP shall be developed by a qualified person designated by the Contractor. This qualified person shall be a Certified Industrial Hygienist (CIH), Certified Hazardous Material Manager (CHMM), or a Certified Safety Professional (CSP). He/she shall have review and approval authority over the HASP and be identified as the Health and Safety Manager (HSM). The HASP shall bear the signature of said HSM indicating that the HASP meets the minimum requirements of 29 CFR 1910.120 and 29 CFR 1926.65.

The Engineer will review the HASP within four (4) weeks of submittal and provide written comments as to deficiencies in and/or exceptions to the plan, if any, to assure consistency with the specifications, applicable standards, policies and practices, and appropriateness given potential or known site conditions. Items identified in the HASP which do not conform to the specifications will be brought to the attention of the Contractor, and the Contractor shall revise the HASP to correct the deficiencies and resubmit it to the Engineer for determination of compliance with this Item. The Contractor shall not be allowed to commence work activities in the AOEC(s), as shown on the Plans, or where site conditions exist which may pose a risk to worker health and safety and/or the environment, until the HASP has been reviewed and accepted

by the Engineer. No claim for delay in the progress of work will be considered for the Contractor's failure to submit a HASP that conforms to the requirements of the Contract.

HASP Provisions

(a) General Requirements: The Contractor shall prepare a HASP covering all Project site work regulated by 29 CFR 1910.120(b)/1926.65(b) to be performed by the Contractor and all subcontractors under this Contract. The HASP shall establish in detail, the protocols necessary for the recognition, evaluation, and control of all hazards associated with each task performed under this Contract. The HASP shall address site-specific safety and health hazards of each phase of site operation and include the requirements and procedures for employee protection. The level of detail provided in the HASP shall be tailored to the type of work, complexity of operations to be performed, and hazards anticipated. Details about some activities may not be available when the initial HASP is prepared and submitted. Therefore, the HASP shall address, in as much detail as possible, all anticipated tasks, their related hazards and anticipated control measures.

The HASP shall interface with the Contractor's Safety and Health Program. Any portions of the Safety and Health Program that are referenced in the HASP shall be included as appendices to the HASP. All topics regulated by the 29 CFR 1910.120(b)(4) and those listed below shall be addressed in the HASP. Where the use of a specific topic is not applicable to the Project, the HASP shall include a statement to justify its omission or reduced level of detail and establish that adequate consideration was given the topic.

(b) Elements:

(i) Site Description and Contamination Characterization: The Contractor shall provide a site description and contaminant characterization in the HASP that meets the requirements of 29 CFR 1910.120/1926.65.

(ii) Safety and Health Risk Analysis/Activity Hazard Analysis: The HASP shall address the safety and health hazards on this site for every operation to be performed. The Contractor shall review existing records and data to identify potential chemical and physical hazards associated with the site and shall evaluate their impact on field operations. Sources, concentrations (if known), potential exposure pathways, and other factors as noted in CFR 1910.120/126.65, paragraph (c)(7) employed to assess risk shall be described. The Contractor shall develop and justify action levels for implementation of engineering controls and PPE upgrades and downgrades for controlling worker exposure to the identified hazards. If there is no permissible exposure limit (PEL) or published exposure level for an identified hazard, available information from other published studies may be used as guidance. Any modification of an established PEL must be fully documented.

The HASP shall include a comprehensive section that discusses the tasks and objectives of the site operations and logistics and resources required to complete

each task. The hazards associated with each task shall be identified. Hazard prevention techniques, procedures, and/or equipment shall be identified to mitigate each of the hazards identified.

(iii) Staff Organization, Qualifications and Responsibilities: The HASP shall include a list of personnel expected to be engaged in site activities and certify that said personnel have completed the educational requirements stipulated in 29 CFR 1910.120 and 29 CFR 1926.65, are currently monitored under a medical surveillance program in compliance with those regulations, and that they are fit for work under "level C" conditions.

The Contractor shall assign responsibilities for safety activities and procedures. An outline or flow chart of the safety chain of command shall be provided in the HASP. Qualifications, including education, experience, certifications, and training in safety and health for all personnel engaged in safety and health functions shall be documented in the HASP. Specific duties of each on-site team member should be identified. Typical team members include but are not limited to Team Leader, Scientific Advisor, Site Safety Officer, Public Information Officer, Security Officer, Record Keeper, Financial Officer, Field Team Leader, and Field Team members.

The HASP shall also include the name and qualifications of the individual proposed to serve as Health and Safety Officer (HSO). The HSO shall have full authority to carry out and ensure compliance with the HASP. The Contractor shall provide a competent HSO on-site who is capable of identifying existing and potential hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees and who has authorization to take prompt corrective measures to eliminate or control them. The qualifications of the HSO shall include completion of OSHA 40-hour HAZWOPER training (including current 8-hour refresher training); 8-hour HAZWOPER supervisory training; a minimum of one (1) year of working experience with the regulated compounds that have been documented to exist within Project limits; a working knowledge of Federal and State safety regulations; specialized training or documented experience (one (1) year minimum) in personal and respiratory protective equipment program implementation; the proper use of air monitoring instruments, air sampling methods, and procedures; and certification training in first aid and CPR by a recognized, approved organization such as the American Red Cross.

The primary duties of the HSO shall be those associated with worker health and safety. The Contractor's HSO responsibilities shall be detailed in the written HASP and shall include, but not be limited to the following:

(A) Directing and implementing the HASP.

(B) Ensuring that all Project personnel have been adequately trained in the recognition and avoidance of unsafe conditions and the regulations

applicable to the work environment to control or eliminate any hazards or other exposure to illness or injury (29 CFR 1926.21). All personnel shall be adequately trained in procedures outlined in the Contractor's written HASP.

(C) Authorizing Stop Work Orders which shall be executed upon the determination of an imminent health and safety concern.

(D) Contacting the Contractor's HSM and the Engineer immediately upon the issuance of a Stop Work order when the HSO has made the determination of an imminent health and safety concern.

(E) Authorizing work to resume, upon approval from the Contractor's HSM.

(F) Directing activities, as defined in the Contractor's written HASP, during emergency situations; and

(G) Providing personal monitoring where applicable and as identified in the HASP.

(iv) Employee Training Assignments: The Contractor shall develop a training program to inform employees, supplier's representatives, and official visitors of the special hazards and procedures (including PPE, its uses and inspections) to control these hazards during field operations. Official visitors include but are not limited to Federal Agency Representatives, State Agency Representatives, Municipal Agency Representatives, Contractors, subcontractors, etc. This program shall be consistent with the requirements of 29 CFR 1910.120 and 29 CFR 1926.65.

(v) Personal Protective Equipment: The plan shall include the requirements and procedures for employee protection and should include a detailed section on respiratory protection. The Contractor shall describe in detail and provide appropriate PPE to insure that workers are not exposed to levels greater than the action level for identified hazards for each operation stated for each work zone. The level of protection shall be specific for each operation and shall be in compliance with all requirements of 29 CFR 1910 and 29 CFR 1926. The Contractor shall provide, maintain, and properly dispose of all PPE.

(vi) Medical Surveillance Program: All on-site Contractor personnel engaged in 29 CFR 1910.120/1926.65 operations shall have medical examinations meeting the requirements of 29 CFR 1910.120(f) prior to commencement of work.

The HASP shall include certification of medical evaluation and clearance by the physician for each employee engaged in 29 CFR 1910.120/1926.65 operations at the site.

(vii) Exposure Monitoring/Air Sampling Program: The Contractor shall submit an Air Monitoring Plan as part of the HASP which is consistent with 29 CFR 1910.120, paragraphs (b)(4)(ii)(E), (c)(6), and (h). The Contractor shall identify specific air

sampling equipment, locations, and frequencies in the air-monitoring plan. Air and exposure monitoring requirements shall be specified in the Contractor's HASP. The Contractor's CIH shall specify exposure monitoring/air sampling requirements after a careful review of the contaminants of concern and planned site activities.

(viii) Site Layout and Control: The HASP shall include a map, work zone delineation (support, contamination, reduction, and exclusion), on/off-site communications, site access controls, and security (physical and procedural).

(ix) Communications: Written procedures for routine and emergency communications procedures shall be included in the Contractor's HASP.

(x) Personal Hygiene, Personal Decontamination and Equipment Decontamination: Decontamination facilities and procedures for PPE, sampling equipment, and heavy equipment shall be discussed in detail in the HASP.

(xi) Emergency Equipment and First Aid Requirements: The Contractor shall provide appropriate emergency first aid kits and equipment suitable to treat exposure to the hazards identified, including chemical agents. The Contractor will provide personnel that have certified first aid/CPR training on-site at all times during site operations.

(xii) Emergency Response Plan and Spill Containment Program: The Contractor shall establish procedures in order to take emergency action in the event of immediate hazards (i.e., a chemical agent leak or spill, fire or personal injury). Personnel and facilities supplying support in emergency procedures will be identified. The emergency equipment to be present on-site and the Emergency Response Plan (ERP) procedures, as required 29 CFR 1910.120, paragraph (1)(1)(ii) shall be specified in the ERP. The ERP shall be included as part of the HASP. This ERP shall include written directions to the closest hospital as well as a map showing the route to the hospital.

(xiii) Logs, Reports and Record Keeping: The Contractor shall maintain safety inspections, logs, and reports, accident/incident reports, medical certifications, training logs, monitoring results, etc. All exposure and medical monitoring records are to be maintained according to 29 CFR 1910 and 29 CFR 1926. The format of these logs and reports shall be developed by the Contractor to include training logs, daily logs, weekly reports, safety meetings, medical surveillance records, and a phase-out report. These logs, records, and reports shall be maintained by the Contractor and be made available to the Engineer.

The Contractor shall immediately notify the Engineer of any accident/incident. Within two business days of any reportable accident, the Contractor shall complete and submit to the Engineer an accident report.

(xiv) Confined space entry procedures: Confined space entry procedures, both permit required and non permit required, shall be discussed in detail.

(xv) Pre-entry briefings: The HASP shall provide for pre-entry briefings to be held prior to initiating any site activity and at such other times as necessary to ensure that employees are apprised of the HASP and that this plan is being followed.

(xvi) Inspections/audits: The HSM or HSO shall conduct inspections or audits to determine the effectiveness of the HASP. The Contractor shall correct any deficiencies in the effectiveness of the HASP.

HASP Implementation

The Contractor shall implement and maintain the HASP throughout the performance of work. In areas identified as having a potential risk to worker health and safety and in any other areas deemed appropriate by the HSO, the Contractor shall be prepared to immediately implement the appropriate health and safety measures, including but not limited to the use of PPE, and engineering and administrative controls.

If the Engineer observes deficiencies in the Contractor's operations with respect to the HASP, they shall be assembled in a written field directive and given to the Contractor. The Contractor shall immediately correct the deficiencies and respond, in writing, as to how each was corrected. Failure to bring the work area(s) and implementation procedures into compliance will result in a Stop Work Order and a written directive to discuss an appropriate resolution(s) to the matter. When the Contractor demonstrates compliance, the Engineer shall remove the Stop Work Order. If a Stop Work Order has been issued for cause, no delay claims on the part of the Contractor will be honored.

Disposable CPC/PPE, i.e. disposable coveralls, gloves, etc., which come in direct contact with hazardous or potentially hazardous material shall be placed into 55-gallon USDOT 17-H drums and disposed of in accordance with Federal, State, and local regulations. The drums shall be temporarily staged and secured within the WSA until the material is appropriately disposed.

HASP Revisions

The HASP shall be maintained on-site by the Contractor and shall be kept current with construction activities and site conditions under this Contract. The HASP shall be recognized as a flexible document which shall be subject to revisions and amendments, as required, in response to actual site conditions, changes in work methods and/or alterations in the relative risk present. All changes and modifications shall be signed by the Contractor's HSM and shall require the review and acceptance by the Engineer prior to the implementation of such changes.

Should any unforeseen hazard become evident during the performance of the work, the HSO shall bring such hazard to the attention of the Contractor and the Engineer as soon as possible. In the interim, the Contractor shall take action, including Stop Work Orders and/or upgrading PPE as necessary to re-establish and maintain safe working conditions and to safeguard on-site

personnel, visitors, the public, and the environment. The HASP shall then be revised/amended to reflect the changed condition.

METHOD OF MEASUREMENT

Within forty (40) business days of the award of the Contract, the Contractor shall submit to the Engineer for approval a breakdown of the lump sum price for this Item detailing:

- The development costs associated with preparing the HASP in accordance with these Specifications.
- The cost per month for the duration of the Project to implement the HASP and provide the services of the HSM and the HSO.

If the lump sum price breakdown is unacceptable to the Engineer; substantiation showing that the submitted costs are reasonable shall be required.

Upon acceptance of the payment schedule by the Engineer, payments for work performed will be made as follows:

- The lump sum development cost will be certified for payment.
- The Contractor shall demonstrate to the Engineer monthly that the HASP has been kept current and is being implemented and the monthly cost will be certified for payment.
- Any month where the HASP is found not to be current or is not being implemented, the monthly payment for the Environmental Health and Safety Item shall be deferred to the next monthly payment estimate. If the HASP is not current or being implemented for more than twenty (20) business days, there will be no monthly payment.
- Failure of the Contractor to implement the HASP in accordance with this Specification shall result in the withholding of all Contract payments.

BASIS OF PAYMENT

Payment will include all materials, tools, equipment, and labor incidental to the completion of this Item for the duration of the Project to maintain, revise, monitor, and implement the HASP. The lump sum price shall not be included in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. Such costs include providing the services of the HSM and HSO, Contractor employee training, chemical protective clothing (CPC), personal protective equipment (PPE), disposal of PPE and CPC, medical surveillance, decontamination facilities, engineering controls, monitoring, and all other HASP protocols and procedures established to protect the Health and Safety for all on-site workers.

SPECIFICATION 108 – CONTRACTOR QUALITY CONTROL PROGRAM (MINIMUM BID)

DESCRIPTION

Under this item, the Contractor shall furnish the services of one of its management staff to serve as Quality Control Manager (QCM) for the project. The QCM shall have demonstrated experience implementing a QC program, report directly to upper management, and shall have the authority to issue stop work orders. Additional contractor personnel performing Quality Control Program activities shall be experienced and qualified and adhere to the details of the Program.

Submitted as part of the Design Documentation (see Specification 100 – General Provisions), the Contractor shall also establish, maintain, and implement a written Quality Control Program tailored to the complexity and scope of the work. The written Quality Control Program shall provide a comprehensive description of the planning, monitoring and reporting program the Contractor intends to implement to ensure and document the quality of the work. The Quality Control Program shall cover, as a minimum, the following elements: Organization, Document Control, Design Control, Procurement Control, Control of Subcontractors, Special Process Control, Inspection, Non-Conforming Items, and Records. The Quality Control Program shall identify and list critical, major, and routine items, which shall be used to differentiate the level of reporting, inspection, and attention throughout the process. The Program shall be designed to minimize deviations from the contract documents in materials and/or workmanship by monitoring and documenting the quality of the Contractor's services, with particular emphasis on the following basic principles:

- Satisfaction of contractual requirements
- Construction conformance with design

The Quality Control Program shall include a method for identifying and resolving any deviations from the contract documents while maintaining the project schedule. The Quality Control Program shall include a method to prevent similar deviations from occurring once a deviation has been identified and resolved.

The additional Contractor Quality Control requirements described in this section are to be used in conjunction with the Department's Standard Specifications Form 816 "Division I General Provisions." The Quality Control Program is neither intended to relieve the Contractor from its responsibility under the Contract, nor to replace the external inspections of the work carried out by, or on behalf of, the Engineer.

The minimum lump sum price for this item shall be **$125,000** (one hundred and twenty-five thousand dollars)**.** Failure of the Contractor to propose at least the minimum amount will result in the Department adjusting the Contractor's proposal to the minimum amount for this item.

Submittals

(1) The Quality Control Manager shall be designated by name, in writing, with a resume of his qualifications, submitted within the requirements of Notice to Contractors - Specialized Work and Qualifications, for acceptance by the Department. The Quality Control Manager shall not be changed without prior written notice to the Department.

The QCM must be an individual with demonstrated experience implementing a QC program and supervising inspectors. This experience shall include at least 7 years of Quality Control (QC) background in any combination of the following areas:

- Field inspection experience
- Construction phase experience relevant to the type of work and the scope of the project
- Previous experience as a Quality Control Professional
- Substitutions allowed – 4 years for Bachelors Degree in CE, CE Tech., Construction Management, or Construction Engineering; (2 years for Associates Degree in a related field); 4 years for NICET IV certification; (2 years for a NICET III certification)

In addition, the QCM shall have the following special experience:

- Prior supervisory experience
- Documented training in quality control principles

(2) As part of the Design Documentation (see Specification 100 – General Provisions), the Contractor shall prepare and submit for acceptance by the Department, a Quality Control Program, in accordance with all requirements of this specification. The Engineer reserves the right to audit this Program on behalf of the Department. The Contractor shall modify the Program as needed to meet the requirements of this specification. The Quality Control Program shall be recognized as a flexible program that shall be subject to revisions and amendments, as required, in response to actual site conditions, work methods, and in response to deviations encountered and corrected throughout the Project.

Sample forms and reports intended to be used to assure compliance with this Specification shall be included with the initial submittal of the Quality Control Program. Samples forms and reports shall include but are not limited to:

- Sample document control tracking form

- Sample design control tracking form
- Sample material receiving inspection report
- Sample inspection forms
- Sample special process control forms
- Sample non-conformance report
- Sample daily and monthly reports

The QCM, Project Manager and Project Executive shall sign the final QC Program submission and any revisions or amendments thereto. Any revisions or amendments made to the QC Program should be submitted to the Engineer for acceptance.

Subcontractors, fabricators and suppliers, as defined in the QC Program, shall have their own QC Program or an addendum to the Contractor's QC Program, and shall comply with all conditions of this item.

(3) The Contractor shall be required to produce and submit to the Engineer on a monthly basis, daily inspection reports as described in Section 10 of this specification.

The Contractor shall document all methods instituted to ensure compliance with its Quality Control Plan and provide this information to the Department in their monthly submittals.

CONSTRUCTION METHODS

Organization

This section shall describe the Contractor's organization, including reporting relationships within and external to the Contractor's organization. The name of the QCM shall be clearly stated and this individual shall report directly to upper management, independent of manufacturing/construction. Duties and responsibilities within the said organization shall be stated. An organizational chart shall be prepared to graphically depict the Contractor's organizational structure and major reporting lines and relationships. The organization plan shall clearly state the hierarchy between the QCM and upper management and shall define the role of each person in the resolution of QA/QC issues.

Document Control

This section shall describe the methods used by the Contractor and the QCM to control the use of the various design documents, shop drawings, procedures, etc. to assure that only the latest reviewed documents are used and are distributed to the individuals performing the Work. Recall of documents which have been superseded or revised shall be implemented. The Contractor shall describe the process used to determine what submittals are required by the Contract and the system used to track these submittals and their current status. The Contractor's submittal schedule required under Specification 109 – Document Control Specialist (Minimum Bid), shall

be included in the Quality Control Program for reference and use in complying with this section of the specification.

Design Control

This section shall describe how the Contractor and the QCM controls any Design process (i.e. working and shop drawings), for which it is responsible. This should include the selection of design input data; checking for correctness, completeness, compatibility and format, and reviewing and approving design output documents prior to submission to the Department. When submitting working and shop drawings to the Engineer for review, documentation should be provided with evidence that these documents have been reviewed by the Contractor prior to submission including sign off from the person responsible for the review and the QCM.

Procurement Control

This section shall describe the methods used by the Contractor and the QCM to assure that all materials/equipment purchased for the work are as specified. Included shall be provisions for the review of purchase documents to assure that correct details have been specified, including specification, grade, type, color, or other aspects as required by Specifications and Drawings. The Contractor shall describe receiving inspection activities performed, to determine that the correct material/equipment has been delivered. This activity should be documented on a "Material Receiving Inspection Report" and shall include documentation of inspections performed and review of material test reports, certificates of conformance or other documentation required by the Contractor. A list of items requiring a Materials Certificate and/or Material Certified Test Report will be developed by the Contractor and approved by the Engineer. The "Material Receiving Inspection Report" will include the Materials Certificate and/or Material Certified Test Report for all these items.

As a minimum, receiving inspections will be performed on the following materials:

- Materials requiring a Certificate of Compliance
- Source Controlled Material not inspected at the manufacturer
- Job Controlled Materials (other than concrete, bituminous and soils) which require tracking for testing or payment purposes
- Equipment that is to be incorporated into the work.

After completion of receiving inspection activities, the form, along with associated documents, should be submitted to the Engineer.

Control of Subcontractors, Fabricators and Suppliers

Subcontractors, fabricators and suppliers, as defined in the QC Program, shall have their own QC Program or an addendum to the Contractor's QC Program, which shall comply with all conditions of this item. The Contractor shall be responsible for reporting on QC activities performed by subcontractors, fabricators and suppliers working on routine items to assure compliance with this Specification.

It is the Contractor's responsibility to notify all subcontractors, fabricators, and suppliers of the specification requirements of the various Contract Documents. This section shall describe the methods used by the Contractor and the QCM to assure that all the applicable requirements of the Contract are passed on to the subcontractors, fabricators and suppliers. Included in this section are the methods used by the Contractor and the QCM to monitor and control the quality of the work performed by subcontractors, fabricators and suppliers, and obtain the required quality records.

For fabrication under the terms of the Contract, the Contractor must notify the Engineer as to the source of supply and place of fabrication, including component parts. In order to assign inspection personnel, it will be necessary that the notification include the date of beginning of fabrication and the date the material is to be delivered to the project. Any material requiring inspection which is fabricated without notification or approval shall not be incorporated into the work. Properly documented mill test reports must be furnished by suppliers. The Contractor must be aware that the governing specifications prohibit the start of fabrication prior to the submission and review of shop drawings.

Inspection

This section shall describe how the Contractor and the QCM will assure that the specified quality of materials and workmanship has been achieved. The Contractor's program is not related to any inspection carried out by the Engineer on behalf of the Department. Inspection will include the identification and tracking of the quality characteristics (metrics) used to verify that the level of quality of materials and workmanship conforms to the requirements of the contract documents. The Contractor shall describe the system, including but not limited to, checks, inspections, surveillances, or a combination of such methods, to assure that all materials and workmanship are in conformance with the contract documents. The Quality Control Program shall identify the reporting requirements for each, and these reporting requirements will be approved by the Engineer.

The QCM shall be familiar with all aspects of the work and no work shall be performed on these items without the knowledge and oversight of the QCM. The Quality Control Program shall define specific means and methods that will be employed to minimize, identify, resolve and prevent similar deviations from the contract documents in regards to materials and and/or workmanship. Quality control reporting forms shall be developed to document the work performed by the QCM and related staff. The forms shall be signed supervisory field personnel and the QCM to document conformance for the work being performed. All work performed by the QCM and related staff shall be documented and included in the QCM's monthly reports.

It is not expected that a specific quality control report be developed for all items but one shall be implemented when necessary, as determined by the QCM or the Engineer. The Quality Control Program should include specific guidelines for each of these items to show means and methods that will be employed to minimize, identify, resolve and prevent similar deviations from the contract documents in regards to materials and/or workmanship. All work performed by the QCM and related staff shall be documented and included in the QCM's monthly reports.

Special Process Control

This section shall describe the measures used to assure that any special process such as but not limited to: welding, high strength bolting, nondestructive examination, critical coatings, surveys, control of critical tolerances, etc., are controlled by procedures that are described in and comply with the Contractor's approved QC Program, and that the results are properly documented and in conformance with the contract documents. In addition, where required by specification, the process, personnel, and equipment shall be qualified prior to the work activity; the Contractor shall describe the method used to verify, document and track these requirements.

Non-Conforming Items

This section shall describe the protocol(s) for correcting any material and/or workmanship not in compliance with the contract documents, and the reporting requirements for documenting any non-compliance and subsequent corrective measures and issue resolution. The Contractor shall implement the use of non-conformance reports to document actions taken to identify, resolve and prevent similar deviations. The non-conformance reports shall include signatures of the responsible persons for each process of the corrective action taken. Upon resolution of a non-conformance issue, the QC Program shall be revised to identify preventive measures that will be taken to prevent similar deviations. Supervisory field personnel involved in the work shall be informed of any changes implemented to avoid similar deviations.

Non-compliance notices issued by the Engineer shall be addressed and resolved to the satisfaction of the Engineer. Upon resolution, the QC Program shall be revised to identify preventive measures that will be taken to prevent similar deviations. Supervisory field personnel involved in the work shall be informed of any changes implemented to avoid similar deviations.

This section shall also include the provisions for Department or Engineer participation in such resolution when disposition decisions are beyond the competence or authority of the Contractor.

Records

This section shall describe how various records generated by the Contractor are originated and maintained, received, filed, protected, and authenticated. Quality Control Records required for submittal to the Engineer shall be described. Record retention of 5 years after acceptance of the Contract shall be documented.

Reporting

QA/QC Inspection Reports

The Contractor shall be required to produce and submit to the Engineer monthly inspection reports in accordance with all requirements of this specification. The monthly reports shall include the daily inspection reports for that month, as well as other reporting documents as

specified under this item. The Quality Control Program shall clearly define what information will be provided as part of the monthly reports.

Daily reports shall include documentation of all activities performed by the QCM and other personnel specific to this Specification. Any forms utilized relative to this Specification shall be included with daily reports.

The monthly reports shall include a summary of work performed specific to this Specification with attention to document control, design control, procurement control, control of subcontractors, special process control, inspection and non-conforming items. For any month that a non-conformance report is issued, either by the Contractor or the Engineer, actions taken to resolve the non-conformance report shall be reported. Updates in the monthly report shall continue until the non-conformance report is resolved. Once resolved, the monthly report shall document that supervisory field personnel involved in the work have been informed of any changes implemented to avoid similar deviations. Any revisions or amendments made to the QC Program shall be documented in the monthly report, once submitted and accepted by the Engineer.

Monthly reports shall include a one (1) month "look ahead" with expected QC efforts and procedures for critical, major and routine items.

Monthly reports shall be submitted to the Engineer by the fifth (5^{th}) business day each month. Except as otherwise authorized by the Engineer, monthly submissions after the due date are considered late.

QA/QC Meetings: Meetings will be held specific to the Quality Control Program. The Contractor, represented by a minimum of the QCM, shall participate with the Engineer, bi-weekly or at the Engineer's request, in the review an evaluation of all items related to this specification.

METHOD OF MEASUREMENT

Within forty (40) business days of the award of the Contract, the Contractor shall submit to the Engineer for approval a cost breakdown of the lump sum price. The submission must include substantiation showing that the cost breakdowns submitted are reasonable based on the Contractor's lump sum proposal. The cost breakdown shall be in accordance with the following payment schedule:

- The development costs to prepare the Quality Control Program shall not exceed 20% of the total cost of the item.
- The cost to provide the services of the Quality Control Manager and implement the Quality Control Program, including costs for all inspections, monitoring, inventory, daily logs, reports, meetings, record keeping *databases, and all materials, equipment,*

labor and work incidental of this service shall be paid as a per month cost and shall be derived by taking this cost divided by the number of contract months.

Upon approval of the payment schedule by the Engineer, payments for work performed will be made as follows:

- Upon acceptance of the Quality Control Program, the lump sum development cost from the payment schedule will be certified for payment.
- Upon receipt of the reports required each month as per this specification, the per-month cost for "Contractor Quality Control Program" will be certified for payment.

BASIS OF PAYMENT

Payment will include all materials, tools, equipment, and labor incidental to the completion of this Item for the duration of the Project. This service shall be paid for at the contract lump sum price for "Contractor Quality Control Program (Minimum Bid)" complete, which price shall include all inspections, monitoring, inventory, daily logs, reports, meetings, record keeping, and all materials, equipment, labor and work incidental of this service. The lump sum price shall not be included in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The lump sum price will be certified for payment as described in "Method of Measurement" subject to the following conditions:

1. Failure of the Contractor to provide a Quality Control Manager or Quality Control Program, as required by this specification, will result in a Five (5) percent reduction to the monthly payment for each day that is not covered as required by this specification. A day is defined as any twenty four (24) hour period, or any portion thereof. The total deduction for any calendar month may exceed the monthly payment for the item.

2. Any monthly QA/QC report that is submitted late, without authorization from the Engineer, will result in a one (1) percent per day per report reduction of the entire Contractor Quality Control Program monthly payment for each day that the report has been submitted late, up to a maximum of twenty percent (20%) of the monthly payment per report.

3. Should the Contractor fail to continuously provide a Quality Control Manager or Quality Control Program including all reports, as required by this specification, the Engineer may withhold all contract payments until such time as all requirements are satisfied. Contract payments may be withheld when either of the following conditions apply:

    a. If the deduction under Item nos. 1 and/or 2 exceeds the monthly payment for the item in any calendar month
    b. If deductions under Item nos. 1 and/or 2 exceed ten percent (10%) of the monthly payment for the item for any three (3) months in any twelve (12) month period

4. Failure by the Contractor to comply with the requirements of this specification shall result in the replacement of the Quality Control Manager at the Engineer's request. Additionally, the Contractor may be found in violation of Form 816, Article 1.02.02 "for having failed to prosecute work continuously, diligently and cooperatively in an orderly sequence".

5. Only one monthly payment will be made for each calendar month regardless of the number of personnel required to complete the specified work.

6. In the event the project extends beyond the original completion date by more than thirty (30) calendar days, and a time extension is granted to the Contractor, the Department may require the continuation of the "Contractor Quality Control Program" which shall be paid at the per-month cost for "Contractor Quality Control Program".

SPECIFICATION 109 – DOCUMENT CONTROL SPECIALIST (MINIMUM BID)

DESCRIPTION

Under this item the Contractor shall furnish the services of one of its administrative employees, entitled Document Control Specialist, who will ensure that the Contractor and all other parties as designated by the Engineer will prepare, status, electronically file and send all project correspondence and drawings utilizing a document control system as established and maintained by the Department. The primary function of the document control system is to ensure timely processing of all contract documentation in coordination with the project schedule. This document control system will also provide uniform project information and reporting. The Document Control Specialist shall be designated by name, in writing with a resume of their qualifications, within five (5) business days of the award of the Contract and shall not be changed without prior written notice to the Department. This person shall be consistent with the individual identified in the Contractor's proposal or the Contractor shall provide suitable justification for the change.

The Document Control Specialist shall be knowledgeable of the status of all contract documentation aspects of the work throughout the length of the Contract. The Contractor shall prepare and maintain the contract documentation utilizing the latest version of Primavera Contract Manager (PCM) software (formerly known as Primavera Expedition) approved by the Department (currently Version 14). The document control system will be physically located in a secure location designated by the Department. The Contractor will directly access the document control system via the internet. The Department will provide the Contractor access to the latest version of PCM and a common file server. All references to the use of PCM and the common file server below shall refer to the Department's shared document control system as described above. All information that resides on the shared document control system shall become the sole property of the Department.

The minimum lump sum price for this item shall be **$75,000** (seventy-five thousand dollars). Failure of the Contractor to propose at least the minimum amount will result in the Department adjusting the Contractor's proposal to include the minimum amount for this item.

DOCUMENTATION REQUIREMENTS

All correspondence for the project shall be produced and controlled using PCM, including, but not limited to: transmittals, meeting minutes, requests for information (RFI's), requests for change (RFC's), submittals, field memos, notices, letters, and punch lists. All common correspondence files (submittals, requests, answers, changes, reports, minutes, agendas, letters, etc) shall be generated from, and stored within the common file server, including any and all file attachments. Submittals, including shop drawings, working drawings, catalog cuts, material

certifications, and all documentation required by contract, shall be submitted electronically via PCM. The Contractor is responsible for coordinating the overall creation and submission of all project documentation to meet the requirements of the project schedule and specifications. The Contractor is encouraged to supply the Department with corporate logos, formats, Sybase Infomaker files, etc. to facilitate the creation and utilization of custom forms and reports.

The named Document Control Specialist shall be designated as the Submittal Coordinator within PCM and will be responsible for maintaining information related to the responsibility, status, elapsed time since submission, held time, start/finish times, and a history of all submittal revisions. A submittal log must be maintained to indicate the latest construction submittals sent and received and the distribution of these drawings to the Department. Each submittal (shop drawing, working drawing, product data, samples, etc) must be individually entered, tracked, and the status maintained, including all revisions. The Contractor is responsible to utilize the latest approved drawings as identified in the control system. All revisions are to be logged into the control system, describing each change.

All meeting minutes shall be logged into the control system. The Contractor is responsible to utilize meeting minutes and respond (electronically) to meeting minute items assigned to the Contractor.

Documents (letters, logs, shop or working drawings, sketches, payrolls, etc) to be transmitted to the Department by the Contractor, for which the Contractor does not have an electronic version, shall be scanned, converted into an Adobe Acrobat PDF format, and attached accordingly in PCM.

The document control system shall be available for Contractor use at all times unless system maintenance (i.e. backups, upgrades, etc) is being performed. System maintenance will generally be limited to 10:00 PM – 6:00 AM, Monday - Friday and at various times on weekends. In the event a Contractor's authorized user cannot access the control system, the Contractor shall notify the Department's control system representative. In the event the control system becomes unavailable during normal business hours for an extended period of time, the Contractor may issue correspondence requiring immediate attention by the Department in hard copy format. The hard copy correspondence must be entered into the control system immediately upon becoming available again. Inability by the Contractor to gain access to the document control system for any reason shall not be grounds for claim. The use of the database is not required for proprietary cost and contract information.

The Department shall be allocated a minimum of ten (10) business days for review and response to each RFI submitted. RFI's requiring information from outside agencies shall be allocated fifteen (15) business days.

The Department shall be allocated a minimum of twenty (20) business days for review and response to each RFC submitted. RFC's requiring information from outside agencies shall be allocated forty (40) business days.

The Department reserves the right to reject any RFC submitted in the form of an RFI for the purpose of reducing the Department's review and response time. Such documents will not be considered for review by the Department and will be returned to the Contractor for resubmission. Review and response time for such document will commence upon resubmission in the correct format.

The Department shall be allocated a minimum of twenty (20) business days for review and approval of each submittal, unless specified otherwise within the contract documents. Any submittals requiring approval by an outside Agency (ConnDEP, Coast Guard, Army Corps of Engineers, etc.) shall be allocated a minimum of forty (40) business days. Whenever multiple Contractor submittals are under review by the Department, the Contractor shall prioritize the submittals and notify the Department thereof. The Department shall not be held responsible for any delay associated with the approval or rejection of any substitution or other revisions proposed by the Contractor.

All resubmissions shall be numbered with the original submittal number but designated a new revision number. All resubmissions shall be logged into the control system to properly calculate the entire duration required for the submittal process from the original submission date to final approval to indicate total days to process the submittal through all review cycles. Coordination of submittals is required for same work and interfacing work so that one submittal will not delay another.

The submittal log will be developed according to the following format:

Submittal Package

The Package name shall be the three-digit Item Number. The Package Title shall be the corresponding Item Name. For example:

Package	Title
501	Category 6 (Cat 6) Copper Patch Cable
502	Gigabit Ethernet Switch (Type A)
503	Gigabit Ethernet Switch (Type B)

Instances where a submittal requires review by more than one department or agency (i.e. CTDOT – Public Transportation and CTTRANSIT), the multiple reviewers option must be checked so that the individual reviewers can be designated, with each receiving a copy of the submittal for review.

The Package status shall initially be "Unsubmitted". Upon submission of any submittal within the package the status should be changed to "Open". Upon receipt of all final review comments for all package submittals, the status should be changed to "Closed".

Submittal Item

All submittal items, as required by contract, must be individually entered, including shop &

working drawings, product data, samples, etc. All submittals shall be associated with and generated within a specific package. The submittal number shall be the package name followed by a three digit incremental number (i.e. 501-001, 502-001). The Title shall be a clear description the submittal item. In the case of a drawing submittal, the title shall be the exact name of the drawing and the drawing number shall be entered in the Details section. The appropriate Category and Type shall then be selected.

Shop drawings shall be submitted in Adobe Acrobat PDF Package format. Each drawing will be included as a separate file within the package and named in kind with the drawing number. The PDF package shall be listed and attached in PCM to the first submittal. The drawings shall be listed individually thereafter.

Working drawings shall be submitted in Adobe Acrobat PDF format. The PDF package shall be listed and attached in PCM to the first submittal. The drawings shall be listed individually thereafter.

Electronic submittal attachments shall be named in kind with the submittal to which they are attached and include the revision number (i.e. Submittal 501-001 would have a PDF attachment named 501-001-1.pdf).

Submittals requiring signature by a licensed engineer or other party shall be digitally signed utilizing a digital ID obtained from an Adobe partner (see adobe.com for list of partners).

Required Start & Required Finish shall represent the date range for the review process. Required Start shall be the date the submittal is issued by the Contractor for review. Required Finish shall be the completion date for the review cycle as appropriate.

Workflow must be completed for each submittal. Received From shall be the party from which the submittal originated (prime contractor, subcontractor, fabricator, vendor, etc). Sent To and Returned By shall be the primary reviewer as designated by the contract documents. Forwarded To shall be the Contractor's designated submittal coordinator.

Review cycles will be numbered 001, 002, 003, etc. according to the number of resubmissions. Distributions (submittal recipients) must be listed on the transmittal.

Submittal Forecast

In order facilitate the Department's review of the large number of submittals anticipated for this project the Contractor is to provide a submittal schedule. The submittal schedule will be created and maintained in PCM as follows:

A submittal package must be created for each contract item requiring a submittal (note that large submittal items must be broken out as prescribed above). Within each package, a single submittal, numbered 001, will be generated from the submittal package which will be utilized to approximate when submittals for that package will be submitted for review. At a minimum, the submittal Number, Title, Status, Required Start, and Required Finish must be entered, where the

Status is "Unsubmitted" and the Required Start and Required Finish represents the review period for all submittals within this package. The Required Start and Required Finish dates must be coordinated with the project CPM schedule.

DOCUMENTATION CONTROL SYSTEM ACCESS REQUIREMENTS

Within five (5) days of Contract Award, the Contractor shall designate, in writing, up to ten (10) named Contractor personnel, to be approved and authorized by the Engineer to access the document control system. The Contractor shall designate one of the ten authorized personnel to be the Document Control Specialist and act as the document control system contact person for the Contractor. That person shall be experienced and trained in the use of PCM. All Contractor personnel requesting access authorization must complete the minimum training requirements described below and submit a certificate of completion to the Department. Upon receipt of the request (with training certificate(s)) and approval thereof, the Department will issue a username and password to each of the authorized Contractor personnel. The Contractor will ensure that only authorized Contractor personnel access and utilize the control system in a responsible, non-destructive manner. The Contractor shall make every reasonable effort to prevent the disclosure of access information for unauthorized use of the control system. The Department, at its discretion, may revoke access authorization from any user if it is determined that the user: a) has used the control system for any other reason than is intended by this specification; b) is no longer in the Contractor's employ or associated with the project or c) has disclosed their access authorization for use by another person or party for any reason. The Contractor is responsible to ensure their authorized users have access to the public internet from a computer system running any currently supported Microsoft Windows Operating System and Microsoft Internet Explorer Web Browser with a minimum Cipher Strength of 128 bit, version 5.5, 6.0, or 7.0. Minimum modem speed shall be 56K. The Contractor is responsible to ensure that anti-virus software is installed and maintained on any computer accessing the Department's document control system. Additionally, it is the Contractor's sole responsibility to maintain a compatible software system. Compatibility is defined as the ability to send and receive documents in a format viewable by the Department. The Contractor must provide valid individual email addresses for each authorized user to the Department based upon a MAPI compliant email system, such as Microsoft Outlook or Exchange.

TRAINING REQUIREMENTS

Contractor personnel accessing the document control system must fulfill minimum training requirements as follows: personnel must attend a two (2) day project specific PCM training class provided by PL Logic, One Alewife Center, Cambridge, MA 02141, (Tel 617-494-9900, Web site: www.pllogic.com). The Contractor must supply an acceptable training facility within 15 miles of the project site. Training facility shall have a computer workstation for each student in addition to a computer for the instructor. The instructor computer must be able to project to a screen/wall for classroom illustrations via a digital projector or large screen monitor (Minimum 40"). The computer workstations must be a minimum Pentium 2 GHz with 512MB of RAM,

200MB free disk space, running Windows XP/2000/NT 4(Service Pack 6). Additional workstation requirements include Microsoft TCP/IP networking protocol and a valid IP address, Microsoft Internet Explorer 5.50 SP2, 16-bit or higher color video, and 800x600 video resolution minimum. Training facility shall have one (1) database server with the minimum specifications of: Pentium, 1 GHz, 512 MB RAM, 1.5 GB free disk space, running Windows 2000/XP Professional/NT 4 (Service Pack 6), or Novell 5.x. and one (1) web server with the minimum specifications of: Pentium 2 GHz, 1 GB RAM, 200 MB free disk space, running Windows 2000/NT 4 (Service Pack 6), Microsoft TCP/IP networking with a permanent IP address, the port for the web server requests is 80 (the port is configurable, although port 80 is recommended), a local user account (local to the domain) on the server with read rights to the PCM report and forms directories, and access to the database server. Note that the database server and web server cannot run on the same hardware.

Any additional training required as a result of adding additional or replacing existing Contractor staff, including additional costs associated with meeting hardware requirements to run the latest version of the software at that time, shall be included in the total cost of this item.

SUBMITTALS

Within forty (40) business days after award, the Submittal Coordinator shall prepare, in accordance with all requirements of this specification, and submit for review and acceptance, a Submittal Forecast and shall have the following requirements attached:

- Submittal Packages Summary Report
- Submittal Bar Chart Report

METHOD OF MEASUREMENT

Within forty (40) business days of the award of the Contract, the Contractor shall submit to the Engineer for approval a cost breakdown of the lump sum price. The submission must include substantiation showing that the costs breakdown submitted are reasonable based on the Contractor's lump sum price. The cost breakdown shall be in accordance with the following payment schedule:

1) The cost to successfully complete all preparation and training to utilize the document control system in accordance with these specifications. The preparation and training costs shall not exceed 5% of the total cost of the item and shall include costs to establish customized forms or reports, back enter and scan all contract documentation prior to the access authorization, and to furnish and install all specified hardware.

2) The development cost to prepare the Submittal Forecast in accordance with these specifications shall not exceed 5% of the total cost of the item. Payment for this work will be made upon acceptance of the Submittal Forecast by the Engineer.

The cost to provide services of the Document Control Specialist, including costs to maintain the Submittal Forecast; Coordinating the Document Control System submittal information with the CPM Schedule submissions; preparing, submitting, utilizing, maintaining, coordinating and updating document control system items as required by all Contractor personnel with access rights to the system Shall be paid as a per month cost and shall be derived by taking this cost divided by the number of contract months.

BASIS OF PAYMENT

Payment will include all materials, tools, equipment, and labor incidental to the completion of this Item for the duration of the Project. This service shall be paid for at the contract lump sum price for "Document Control Specialist (Minimum Bid)" complete, which price shall include the training, preparation, statusing, electronically scanning, filing, and sending all project correspondence, and the furnishing, maintenance, and supply costs for all required hardware, software, and services as noted above in the utilization of the document control system as established and maintained by the Department. The lump sum price shall not be included in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The lump sum price will be certified for payment as described in "Method of Measurement" subject to the following conditions:

- Failure by the Contractor to utilize and regularly update the specified PCM database in a manner acceptable to the Department or failure to utilize the common file server for the storage of all project related files may result in the withholding of all contract payments until such time as all specification requirements have been satisfied. Failure by the designated Document Control Specialist to update submittal statuses on a regular basis shall result in the replacement of the Document Control Special at the Engineer's request. Additionally, the Contractor may be found in violation of Form 816, Article 1.02.02 of the Standard Specifications "for having failed to prosecute work continuously, diligently and cooperatively in an orderly sequence".

- In the event the project extends beyond the original completion date by more than twenty (20) business days, and a time extension is granted to the Contractor, the Department may require the continued utilization of the Document Control System which shall be paid at the per month cost for the services of the Document Control Specialist.

SPECIFICATION 200 – TESTING

SPECIFICATION 201 – FACTORY ACCEPTANCE TESTS

SPECIFICATION 202 – PROTOTYPE DEMONSTRATION TEST

SPECIFICATION 203 – ON-BOARD EQUIPMENT PILOT TEST

SPECIFICATION 204 – SYSTEM DEMONSTRATION TEST

SPECIFICATION 205 – INSTALLATION TESTS

SPECIFICATION 206 – SOFTWARE INTEGRATION

SPECIFICATION 207 – INTEGRATION TEST

SPECIFICATION 208 – ACCEPTANCE TEST

DESCRIPTION

Introduction

This specification specifies the requirements for the preparation of test plans, procedures, checklists, and test logs; conducting tests; conducting software integration; and reporting test results for the ITS and Communications Systems for CT***fastrak***.

Scope

General

This technical specification applies to the testing of all required equipment Items provided for the ITS and Communications Systems for CT***fastrak***. Individual equipment Item specifications may include additional testing requirements. The Contractor shall be required to meet all the testing requirements in this specification and within each individual Item specification.

Factory Acceptance Tests

Following Department acceptance of the Contractor's Final Design Documentation submittal, the Contractor shall conduct tests, referred to as the Factory Acceptance Tests (FAT), of hardware and software to ensure that the proposed components meet functional and all environmental requirements and specifications. For off-the-shelf products, the FAT may be replaced by stamped quality testing documents provided before the equipment leaves the factory

environment. Custom-manufactured equipment must be assembled and tested in the Contractor's facility. FAT requirements are described in greater detail below.

Prototype Demonstration Test

Following Department acceptance of the Contractor's FAT documentation submittals, and prior to acquiring all required quantities of ITS and Communications Systems equipment, the Contractor shall conduct a test, referred to as the Prototype Demonstration Test (PDT). The PDT shall demonstrate to the Department, using only a representative quantity of equipment, that the ITS and Communications Systems equipment proposed by the Contractor for installation at the BOC, at stations, and along the busway (including any necessary communications equipment components) are compatible, interoperable, and will meet specified functional and performance requirements. A minimum of one (1) quantity of each proposed equipment component shall be included in the PDT. The purpose of the PDT is to demonstrate proposed equipment compatibility and interoperability prior to procurement of all equipment quantities. PDT requirements are described in greater detail below.

On-board Equipment Pilot Test

Following Department acceptance of the Contractor's FAT documentation submittals, and prior to acquiring all required quantities of ITS and Communications Systems equipment, the Contractor shall conduct a test, referred to as the On-board Equipment Pilot Test (OEPT). The OEPT shall be conducted on at least one of each type of transit vehicle and non-revenue vehicle, to be made available to the Contractor by the Department. The OEPT shall demonstrate to the Department that all proposed on-board equipment to be installed as part of the ITS and Communications Systems are compatible with each other to form an integrated on-board system and will meet specified functional and performance requirements, including mobile data communications with the central system as implemented for the FAT. Additionally, the OEPT shall be used to assess the proposed installation plan for installing on-board equipment onto transit vehicles and non-revenue vehicles and identify any potential installation risks or issues. OEPT requirements are described in greater detail below.

System Demonstration Test

Following Department acceptance of the Contractor's PDT and OEPT documentation submittals, the Department may authorize the Contractor to procure all quantities of proposed equipment components for the ITS and Communications Systems. The Contractor shall receive all equipment proposed for installation at the BOC, at stations, and along the busway, (including necessary communications equipment components) and then fully configure and interconnect all this equipment at a CTDOT facility as directed by the Engineer. The Contractor will then conduct a System Demonstration Test (SDT). The SDT shall demonstrate that all equipment is fully functional and has been properly configured and tested prior to installation in the field. The purpose of this test is to identify necessary equipment modifications, repairs, replacements, and any configuration issues prior to installation in the field. The SDT will not include the on-board equipment. SDT requirements are described in greater detail below.

Installation Tests

Following Department acceptance of the Contractor's SDT documentation submittals, the Department may authorize the Contractor to commence installation of equipment and devices in the field, at the BOC, and on-board vehicles not already equipped via the OEPT. After each device or equipment item has been properly installed and configured, but prior to interconnecting the entire ITS and Communication System, the Contractor shall conduct the Installation Test on each device in isolation to demonstrate that each installed device meets the required functionality and has been installed in accordance with specified installation requirements. At a minimum, the installation test for each unit shall include (as applicable): power-up/power-down tests, log-on/log-off tests, verification of major functions, and verification of operational interfaces to other devices. Installation Tests for on-board equipment and field equipment can be carried out independently. Installation Test requirements are described in greater detail below.

Software Integration

Following Department acceptance of the Contractor's SDT documentation submittals, the Contractor shall install, configure and integrate all software provided as part of this Work as described in the Design Documentation, Interface Control Documents (ICDs), and in all software specifications. The Contractor shall successfully integrate all software and demonstrate full functionality and operation of the integrated software to the satisfaction of the Engineer. Integration shall include all automated software interfaces; requiring no manual interventions to accomplish required software functionality.

Integration Test

Following Department acceptance of the Contractor's Installation Test documentation submittals, and following successful installation and integration of all equipment and software (on-board, in the field, and at the BOC), the Contractor shall conduct Integration Tests. The Integration Tests shall demonstrate to the Department that all equipment and devices are fully integrated and comply with all functional and performance requirements. Integration Test requirements are described in greater detail below.

Acceptance Test (30-day Operational Tests)

Following Department acceptance of the Contractor's Integration Tests documentation and all Operations and Maintenance Documentation, and following successful completion of all required training, the Contractor shall conduct an Acceptance Test for a continuous 30-day period, unless otherwise approved by the Engineer. The purpose of this testing is to demonstrate to the Department that the provided complete system is fully functional and stable over an initial "burn-in" period, under real operational conditions. Acceptance Test requirements are described in greater detail below.

Test Plan

As part of the Contractor's Design Documentation submittals, the Contractor shall develop a Test Plan to be approved by the Department. The Test Plan shall include at minimum, the following information:

- A detailed schedule for conducting each stage of testing and for each equipment item. This schedule shall include notifications to the Department to allow for their participation and witnessing of all testing.

- Detailed test descriptions for each test stage identifying how the functional and performance requirements of each item will be demonstrated. The test descriptions shall identify all test procedures to be performed and shall include a description of the test objective, required test equipment, test setup and equipment configuration, success/failure criteria and expected results for each test step, and a detailed description of the step-by-step sequence of testing. The Contractor shall develop and submit equipment wiring and block diagrams as necessary to describe proposed test configurations for the PDT, OEPT and SDT. Test descriptions must be detailed enough to allow the Engineer, or Department designated representative, to approve in advance which requirements will be addressed and to witness and verify test results. Test descriptions must be sufficiently detailed to allow anyone with technical capabilities similar to that of the Contractor to set up and perform the test and obtain the same results (i.e. the test must be repeatable).

- Test report forms, test logs, and checklists for documenting test results for submittal to the Department. This documentation includes equipment manufacturer's Quality Control documentation and factory certified test reports.

Review of Test Procedures and Results

The Department shall review the Contractor's Test Plan and shall have the right to approve or reject the Test Plan. The Contractor shall promptly remedy any identified defects in the Test Plan and promptly resubmit the corrected Test Plan for review and acceptance by the Department. The Contractor shall revise and resubmit the test procedures and documentation as necessary to demonstrate proper system functionality at all stages of testing. The Contractor's Test Plan and overall project schedule shall provide sufficient time for the Department to conduct a thorough review of test documentation and submittals. The Department, or its designated representative(s), reserves the right to participate in and witness all tests. The Contractor shall pay for the required travel costs incurred by the Engineer and up to four (4) Department representatives to witness all tests. In addition, the Department reserves the right to require additional tests as it deems necessary in its sole discretion. A minimum of at least three (3) weeks prior to conducting any test, the Contractor shall notify the Department in writing and receive authorization to proceed from the Engineer. The Contractor shall confirm the test forty-eight (48) hours in advance. Unless otherwise agreed to by the Department, tests to be witnessed by the Department at the request of the Contractor shall be performed during regular business hours, weekdays between the hours of 8:00 AM and 4:00 PM.

Prior to notifying the Department for witnessing of tests, the Contractor shall conduct "dry-run" testing for all test stages, in accordance with the approved test procedures for each stage. The dry-run tests shall be conducted prior to the arrival of the Department's representatives to ensure that successful completion of the formal witnessed tests can be reasonably anticipated. Where

applicable, testing shall be conducted in accordance with equipment manufacturer's standards and recommendations.

If test results, in the sole opinion of the Department, indicate that the ITS and Communications Systems equipment fails to meet functional and performance requirements, the Contractor shall undertake all necessary corrective action, including replacement or upgrade of equipment, at no additional cost to the Department, and shall retest until full compliance with all requirements is demonstrated.

Factory Acceptance Tests (FAT)

General Requirements

The objective of the Factory Acceptance Tests (FAT) for hardware and software, which are to be conducted subsequent to approval of the Design Documentation, is to ensure that the supplied and developed components meet functional, environmental, and performance requirements and specifications. Each requirement listed in the specification shall be tested where possible; if it cannot be tested, compliance shall be demonstrated by corresponding written documentation or certificates. Software FAT may be completed with field devices or components running in simulation mode or with representative field samples.

Custom-manufactured equipment must be assembled and tested in the Contractor's facility. For commercial off-the-shelf products, the FAT may be replaced by certified quality testing documents from a Department-approved testing laboratory before it leaves the manufacturer's production facilities.

FAT Submittals

For each equipment Item, the Contractor shall submit:

- Documentation on Materials, submitted as part of the Design Documentation described in Specification 100 – General Provisions
- Detailed equipment information including type, model number, and serial number of each system component.
- Detailed description of test environment and types of testing performed to verify compliance with all functional, environmental, and performance requirements and specifications.
- Detailed test procedures and test report forms.
- Test results recorded on approved test report forms. For commercial off-the-shelf products, this includes stamped quality testing documents from before it leaves the factory environment.
- Any additional submittals required by the Item specifications.

The Department will review all test submittals, and the Contractor shall modify test equipment, test configurations, and test procedures in accordance with the Department's review comments.

Prototype Demonstration Test (PDT)

General Requirements

The objectives of the Prototype Demonstration Test (PDT) are to demonstrate to the Connecticut Department of Transportation, and/or its designated representative, that the ITS and Communications Systems equipment proposed by the Contractor for installation at the BOC, at stations, and along the busway (including any necessary communications equipment components) are compatible, interoperable, and will meet specified functional and performance requirements prior to procurement of all equipment quantities for installation.

The test shall be conducted at the Contractor's facility, which shall be within the United States (continental 48 states) or Canada.

The duration of the test shall not exceed three (3) consecutive days. The Contractor shall be liable for all travel costs incurred by the Department to witness the PDT, including for travel costs beyond the required three (3) day test period due to Contractor's inability to successfully complete the test within the three (3) day period.

Prototype Demonstration Test Configuration

The Contractor shall assemble all ITS and Communications Systems equipment required for the PDT, with the exception of on-board equipment. The Contractor shall configure the equipment in accordance with their approved Test Plan and test drawings.

The Contractor shall provide and install all test equipment, video monitors, cables, connectors, equipment racks and other appurtenances necessary to conduct the PDT.

A minimum of one (1) of each proposed equipment component shall be included in the PDT.

The PDT shall include prototypes of the proposed GUI configuration and appearance for all system software.

The PDT shall be conducted with fiber optic cable attenuated to the published maximum link loss budget, or the calculated field link loss (including all splice point and connector losses) whichever is greater, to demonstrate compliance with the functional and performance requirements for the communications equipment. The Contractor shall submit field link loss calculations to the Engineer for review prior to the test.

Prototype Demonstration Test Submittals

The Contractor shall submit:

- Detailed equipment information including type, model number, and serial number of each system component.
- Detailed test configuration block diagrams, depicting the test setup and system configuration for all system equipment and test equipment.
- Wiring diagrams showing the interconnection of all equipment.
- Configuration details (e.g. configurable parameters) for each of the communications system components.
- Detailed test procedures and test report forms.
- Test results recorded on approved test report forms.
- Documentation of all system equipment and configuration changes required to meet functional and performance requirements following test failures.
- Product data for all test equipment to be employed in the PDT.

The Department will review all test submittals, and the Contractor shall modify test equipment, test configurations, and test procedures in accordance with the Department's review comments.

Specific PDT Testing

The PDT shall be sufficient to demonstrate that all equipment Items are compatible, interoperable, and meet the functional and performance requirements specified. In addition, this section identifies specific tests of particular interest to be conducted as part of the PDT. As part of the PDT, the Contractor shall demonstrate the following:

- Full interoperability and compatibility of field devices and central server equipment.
- Quality of video received directly from CCTV Cameras compared to video quality received at the workstations over the fiber attenuated to simulate the manufacturer's published operational loss budget. Video quality at the workstations shall meet the specified performance requirements. Additionally, the PDT shall demonstrate that measured and perceived latency of camera control, tested over the communications link configured for the attenuation limit, is within the specified requirements.
- Control and display of camera feeds to different workstations and monitors using the CCTV Camera Management Software.
- Demonstration of NVR functionality and specifically flagging of video to not be automatically overwritten.
- Control and synchronization of VMS and PA system functionality, including messages generated from the central software, manual control via the TIS Controller, and the readout actuation device.

On-board Equipment Pilot Test (OEPT)

General Requirements

The objectives of the On-board Equipment Pilot Test (OEPT) are to demonstrate to the Department, and/or its designated representative, that the on-board equipment configurations operate in an integrated manner to provide the required functionality and performance, including cellular data exchange with the central system prior to procurement of all equipment quantities for installation.

The test shall be conducted on-board transit vehicles as well as on-board non-revenue vehicles, in combination with observing the central software operation as previously installed for the FAT at the Contractor's facility (using remote connectivity software).

The duration of the test shall not exceed two (2) consecutive work days. The Contractor shall be liable for all travel costs incurred by the Department to witness the OEPT, including for travel costs beyond the expected two (2) day test period due to Contractor's inability to successfully complete the test within the two (2) day period.

OEPT Configuration

After the completion of FAT and Installation Design Documentation for each vehicle type, the OEPT shall be conducted by testing complete on-board equipment configurations installed on a single vehicle of each type in combination with the central system as installed for FAT. To enable this OEPT, the Department will set up a sufficient number of cellular data accounts and the on-board configurations shall include the required cellular modem card.

OEPT Submittals

The Contractor shall submit:

- A detailed schedule for conducting the OEPT, identifying all resources required to conduct the test including Contractor personnel, vehicle operators, test equipment, and communications equipment.
- Detailed equipment information including type, model number, and serial number of each on-board component.
- Detailed test procedures and test report forms.
- Test results recorded on approved test report forms.
- Documentation of all system equipment and configuration changes required to meet functional and performance requirements following test failures.
- Product data for all test equipment to be employed in the OEPT.

The Department will review all test submittals, and the Contractor shall modify test equipment, test configurations, and test procedures in accordance with the Department's review comments.

Specific On-board Equipment Pilot Tests

The OEPT shall be sufficient to demonstrate that all equipment Items are compatible, interoperable, and meet the functional and performance requirements specified. In addition, this section identifies specific tests of particular interest to be conducted as part of the OEPT. As part of the OEPT, the Contractor shall demonstrate the following:

- Ability to login to a run on the on-board computer using the Mobile Data Computer (MDC) on transit vehicles
- Ability for the MDC to send location reports to the central system, tracking the vehicle as it is operated on transit vehicles
- Ability to exchange text messages with the central system using the MDC on transit vehicles
- Ability for the APC equipment to operate accurately and store the counts for each stop in the MDC on transit vehicles
- Ability for the Non-Revenue Vehicle Equipment to send location reports to the central system, tracking the vehicle as it is operated on non-revenue vehicles

System Demonstration Test (SDT)

General Requirements

The objectives of the System Demonstration Test (SDT) are to demonstrate to the Connecticut Department of Transportation and/or its designated representatives that all the proposed ITS and Communications Systems equipment configured by the Contractor will comply with all functional and performance requirements prior to installation.

The test shall be conducted at the Contractor's facility, which shall be within the United States (continental 48 states) or Canada.

The duration of the test shall not exceed five (5) consecutive days. The Contractor shall be liable for all travel costs incurred by the Department to witness the SDT, including for travel costs beyond the expected five (5) day test period due to Contractor's inability to successfully complete the test within the five (5) day period.

System Demonstration Test Configuration

The Contractor shall assemble all ITS and Communications Systems equipment required for the SDT. The Contractor shall configure the equipment in accordance with the accepted Test Plan.

The Contractor shall provide and install all test equipment, video monitors, cables, connectors, equipment racks and other appurtenances necessary to conduct the SDT.

The SDT shall include all quantities of equipment to be installed in the field, at the BOC, at stations, and along the busway. Once configured and tested, this equipment shall not be substituted for other equipment without written authorization by the Engineer.

As part of the SDT, the Contractor shall fully configure the communications system components, including the proper configuration of all network devices and Ethernet switches.

As part of the SDT, the Contractor shall fully configure all software to run on system servers. The Contractor shall establish all connections to system workstations, monitors, and other BOC equipment. The Contractor shall also simulate the automated interface between the CAD/AVL Central Software and CTTRANSIT's existing scheduling software.

The SDT shall be conducted with fiber optic cable attenuated to the published maximum link loss budget, or the calculated field link loss (including all splice point and connector losses) whichever is greater, to demonstrate compliance with functional and performance requirements. The Contractor shall provide field link loss calculations for review prior to the test.

The SDT shall simulate the amount and type of Ethernet traffic across the communication system that will be typical for the system.

System Demonstration Test Submittals

The Contractor shall submit:

- Detailed equipment information including type, model number, and serial number of each system component.
- Detailed test configuration block diagrams, depicting the test setup and system configuration for all system equipment and test equipment.
- Wiring diagrams showing the interconnection of all equipment.
- Equipment rack elevation drawings showing the locations and interconnection of all equipment in the equipment racks.
- Configuration details (e.g. configurable parameters) for each of the communications system components.
- Detailed test procedures and test report forms.
- Test results recorded on approved test report forms.
- Documentation of all communications system equipment and configuration changes required to meet functional and performance requirements following test failures.
- Product data for all test equipment to be employed in the SDT.

The Department will review all test submittals, and the Contractor shall modify test equipment, test configurations, and test procedures in accordance with the Department's review comments.

Specific SDT Testing

The SDT shall be sufficient to demonstrate that all equipment Items are compatible, interoperable, and meet the functional and performance requirements specified. In addition, this section identifies specific tests of particular interest to be conducted as part of the SDT. The Contractor shall repeat all specific testing conducted as part of the PDT for the fully configured system and for each of the equipment units. In addition, as part of the SDT, the Contractor shall demonstrate the following:

- Camera display functionality; specifically the capability to display multiple camera images on different monitors in a variety of display formats.
- Conflict control between multiple workstations for issues such as: manual PTZ control of cameras, manual messaging to station VMS and PA systems, and responding to alerts from the system.
- Measurement of Packet Error Rates for network switches.
- Network resiliency in the face of a node and link breakage.
- Central system backup and recovery.

Installation Tests

General Requirements

The objectives of the Installation Tests are to demonstrate to the Connecticut Department of Transportation and/or its designated representatives that all the proposed ITS and Communications Systems equipment has been properly installed.

No equipment shall be installed without approval of the corresponding Installation Design Documentation. Installation Tests shall be conducted in the field or on-board vehicles for all equipment to be provided as part of this project.

At a minimum, the Installation Test for each unit shall include (as applicable): power-up/power-down tests, log-on/log-off tests, verification of major functions, and verification of operational interfaces to other devices.

The Contractor shall perform Installation Tests for each device first in isolation, prior to integration with other devices, to demonstrate that each installed device meets the required functionality and has been installed in accordance with specified requirements. The Contractor shall integrate the device into the overall ITS and Communications Systems and perform testing necessary to verify operational interfaces with other devices.

Installation Tests shall verify that installation was performed in accordance with manufacturer recommendations, wherever applicable.

Installation Test Submittals

The Contractor shall submit for each unit:

- Detailed equipment information including type, model number, and serial number of each system component.
- Detailed test procedures and test report forms/checklists.
- Test results recorded on approved test report forms.
- Certification that the installation was conducted in accordance with manufacturer recommendations wherever applicable.
- Any additional submittals required by the equipment Item specification.

The Department will review all test submittals, and the Contractor shall modify test equipment, test configurations, and test procedures in accordance with the Department's review comments.

Software Integration

General Requirements

Following Department acceptance of the Contractor's SDT documentation submittals, the Contractor shall install, configure and integrate all software provided as part of this Work as described in the Design Documentation, Interface Control Documents (ICDs), and in all individual software specifications. The Contractor shall successfully integrate all software and demonstrate full functionality and operation of the integrated software to the satisfaction of the Engineer. Integration shall include all automated software interfaces; requiring no manual interventions to accomplish required software functionality.

The Contractor shall configure the software with input from representatives from CTDOT and CTTRANSIT operations staff, to ensure that all software menus, options, data fields, maps, icons, reports, etc. have been configured in accordance with identified owner preferences and in accordance with the approved Design Documentation. The Contractor shall be responsible for configuring all software and software interfaces to allow for full operation of the system as intended, including configuration of all user screens, maps, performance measures, and reports.

All work associated with this Software Integration task shall be to configure and enhance the specified system software functionality. The development of new software functionality shall not be accomplished as part of this Software Integration task.

The Contractor shall demonstrate that the automated interfaces identified in these specifications have been properly implemented and demonstrate proper data exchange, to the satisfaction of the Engineer. In particular, the Contractor shall demonstrate that the CAD/AVL Central Software has been properly interfaced with the existing scheduling software (Trapeze FX – Version 11) at each of the "home" operating agencies, and that reliable communications connections to the software have been properly established.

All costs associated with software configuration and integration work for all software provided as part of this contract, including necessary third party applications, shall be included as part of

the lump sum cost for this specification item. The Contractor shall not include software integration labor costs in its pricing for other software specification items.

Specific Interfaces

Interfaces include the following. The complete list of External and Internal Interfaces are defined in Specification 100 – General Provisions in the Interface Control Documents requirements.

- The CAD/AVL Central Software shall be interfaced with:
    - The Mobile Data Computers (MDC) on busway vehicles via the Cellular and Bulk Data Gateways (Refer to Specification 564 – Mobile Data Computers, Specification 555 – Cellular Data Communications Gateway Software, Specification 552 – Bulk Data Gateway Software),
    - The On-board Processing Devices on non-revenue vehicles via the Cellular and Bulk Data Gateways (Refer to Specification 566 – Non-Revenue Vehicle Equipment),
    - The scheduling software (Trapeze FX – Version 11) at each "home" operating agency,
    - The Automatic Passenger Counter (APC) Management Software (Refer to Specification 551 – APC Management Software),
    - The Traveler Information Software (Refer to Specification 559 – Traveler Information Software), and
    - The Automatic Voice Annunciation (AVA) and Trigger Location Software (Refer to Specification 570 – AVA and Trigger Location Software).
- The CCTV Camera Management Software shall be a separate stand-alone software package and shall interface with CCTV cameras to provide monitoring access to all live video feeds from cameras (see Specifications 511 and 512), and with the NVRs to provide management of all video data stored on the NVR (see Specification 534 – Network Video Recorder). For functional interface details, see Specification 554 CCTV Camera Management Software.
- The ECB Management Software shall be a stand-alone software package and shall interface with the field ECB devices (refer to Specification 513 – Emergency Callbox). For functional interface details, see Specification 556 - Emergency Callbox (ECB) Management Software.
- The Traveler Information Software shall be interfaced with the Traveler Information System (TIS) Controllers at the stations (refer to Specification 518 – TIS Controller).
- The AVA and Trigger Location Management Software shall be interfaced with the AVA Controllers (see Specification 567 – AVA Controller) to send trigger locations and announcement message files and exchange diagnostics. For functional interface details, see Specification 700 - AVA and Trigger Location Management Software.

Integration Test

General Requirements

The objective of the Integration Test is to demonstrate to the Connecticut Department of Transportation that the approved and installed ITS and Communications Systems equipment complies with all functional and performance requirements following installation.

The Integration Test shall be comprehensive and include all equipment provided as part of this contract.

The Department will be responsible for ensuring that the necessary cellular data plans are in place to accommodate data communications with transit vehicles and non-revenue vehicles prior to commencement of the Integration Test.

The test shall be conducted in the field, at the BOC and on-board transit vehicles.

The Contractor shall provide a detailed test schedule identifying when the Integration Test shall be conducted, the required duration, and the schedule for testing at each of the stations, along the busway, and at the BOC, as well as all vehicle testing, in accordance with the Contractor's approved Test Plan, and as approved by the Engineer.

Integration Test Configuration

The Integration Test shall be conducted utilizing all installed ITS and Communications Systems equipment, interconnected in accordance with the equipment requirements and the Drawings.

All aspects of the communications system components shall be fully configured including but not limited to the field and BOC Ethernet switches.

Integration Test Submittals

The Contractor shall submit:

- A detailed schedule for conducting the Integration Test, identifying all resources required to conduct the test including Contractor personnel, vehicle operators, test equipment, and communications equipment.
- Detailed equipment information including type, model number, and serial number of each system component and the location in which the equipment has been installed.
- Detailed test configuration block diagrams, depicting the test setup and system configuration for all system equipment and test equipment.
- Wiring diagrams showing the interconnection of all equipment.
- Equipment rack front elevation drawings showing the locations of all equipment in the equipment racks.

- Configuration details (e.g. configurable parameters) for each of the communications system components.
- Detailed test procedures and test report forms.
- Test results recorded on approved test report forms.
- Documentation of all communications systems equipment and configuration changes required to meet functional and performance requirements following test failures.
- Product data for all test equipment to be employed in the Integration Test.
- Detailed completion of a requirements tracking matrix certifying verification of each individual system requirement in accordance with standard Systems Engineering practices.

The Department will review all test submittals, and the Contractor shall modify test equipment, test configurations, and test procedures in accordance with the Department's review comments.

Specific Integration Testing

The Contractor shall repeat all specific tests conducted in the System Demonstration Test for the fully installed and configured system. In addition, specific testing shall include:

- Tracking and interacting with a transit vehicle along the entire busway using the CAD/AVL central software.
- Tracking a non-revenue vehicle along the entire busway using the CAD/AVL central software.
- Verification of communications to and from all field devices.
- Verification of Emergency Call Box communications with local public safety dispatch and communication of an alert to the BOC.
- Verification of manual control of VMS and PA systems at each station location via the TIS Controller.

Certification of Substantial Completion

Upon completion of all installation, integration, testing, training, and other applicable obligations to the satisfaction of the Department, the Contractor shall provide all necessary documentation, including "as-built" documentation and shall certify to the Department that the CT***fastrak*** ITS and Communications Systems is fully operational. The Department shall confirm that all work under the Contract has been completed, and meets performance standards, prior to issuing a written "Certificate of Substantial Completion". The Department may begin full, unrestricted beneficial use of the system at this time.

Acceptance Test

Final Acceptance

Final Acceptance of the CT***fastrak*** ITS and Communications Systems shall occur after:

- All work is completed under the Contract to the satisfaction of the Department;
- All system documentation, including all testing documentation, "As-built" documentation, and all Operations & Maintenance documentation, has been submitted and approved by the Department;
- All system testing has been completed by the Contractor and approved by the Department, verifying that all system requirements have been met;
- All training, excluding training to occur during the technical support and maintenance period, has been completed by the Contractor to the satisfaction of the Department;
- The Department has issued a written "Certificate of Substantial Completion"; and
- The Acceptance Test (see below), consisting of the ITS and Communications Systems being in full production use with no problems for a period of thirty (30) continuous days (unless otherwise approved by the Engineer), has been completed and approved by the Department.

Upon these preconditions being achieved, the Department shall issue a Notice of Final Acceptance to the Contractor. The official Final Acceptance of the system will mark the end of the system implementation activities and the beginning of the Technical Support and Warranty Services (see Specification 400). Should the Contractor fail to fulfill any system acceptance requirement, the Department will not issue a Notice of Final Acceptance, and the Technical Support and Warranty Services shall not commence, regardless of any beneficial use of the system derived by the Department during or after the system installation and testing process.

General Requirements

The objective of the Acceptance Test is to demonstrate to the Connecticut Department of Transportation that the approved and installed ITS and Communications Systems equipment complies with all functional and performance requirements and provides for stable, failure-free operation in full production use.

The Acceptance Test shall not be scheduled to commence until after the Department has issued a "Certificate of Substantial Completion" for the project. The Department will not issue a "Certificate of Substantial Completion" until all installation, integration, testing, training, and other applicable obligations have been completed to the satisfaction of the Department, and the Contractor has provided all necessary documentation and certifications, including all "As-built" documentation.

Upon issuing the Certificate of Substantial Completion, the Department shall review the work performed by the Contractor and assess the performance of the ITS and Communications

Systems. If the system complies with applicable test requirements and is demonstrating stable, failure-free operation, then the Department shall authorize the commencement of the Acceptance Test. The Department will notify the Contractor in writing regarding commencement date of the Acceptance Test. The Acceptance Test shall consist of thirty (30) continual days of uninterrupted use of the live and complete system, unless otherwise approved by the Engineer.

During the Acceptance Test period, the Contractor shall measure and report system performance and failures, and report the same to the Department on a weekly basis. During the Acceptance Test period, the Contractor shall record any changes to system configuration or operation, report these changes to the Department, and update system documentation as necessary.

For measuring the accuracy of Traveler Information System predictions during Acceptance Testing, the Contractor shall provide the Department with Accuracy Testing Procedures for the Traveler Information Software. For system acceptance, the Contractor shall provide archived raw prediction records (indicating the vehicle, route, direction, stop, time of prediction, and predicted times) and archived data on when vehicles actually arrived at the stops, sufficient to conduct the Accuracy Testing Procedures, and to allow the Department to define periodic excerpts of these data in terms of the range of vehicle, routes, and stops included and the overall number of prediction records.

Failures during the Acceptance Test period shall be defined as follows:

- Type I Failures: A Type I failure is a malfunction resulting from conditions beyond the control of the Contractor, or failures that are minor in nature and can be corrected within twenty-four (24) hours and without software updates.
- Type II Failures: A Type II failure is a malfunction that involves conditions within the control of the Contractor including: a failure related to the system design, installation, or configuration; or a failure that takes longer than twenty-four (24) hours to correct or that requires software updates, or a Type I failure that re-occurs following initial Contractor correction.

For Type I failures:

- Unless otherwise approved by the Department, the Acceptance Test period shall be suspended for the time necessary to make the corrections.
- Time suspension shall begin when the failure is first noticed, and it shall extend only as long as required to correct the failure.
- Once the Contractor has demonstrated that the failure has been corrected, the Department will authorize the Contractor to proceed and the Acceptance Test time period will resume, continuing from the time prior to the suspension.
- If a subsequent Type I failure occurs similar in nature to a previous Type I failure, the Contractor shall provide evidence that the failures were distinct and unrelated or the subsequent failure will be reclassified as Type II.

For Type II failures:

- Unless otherwise approved by the Department, the Acceptance Test period shall be suspended for the time necessary to make the corrections.
- Time suspension shall begin when the failure is first noticed, and it shall extend only as long as required to correct the failure.
- Once the Contractor has demonstrated that the failure has been corrected, the Department will authorize the Contractor to proceed and the Acceptance Test time period will restart, and the 30-day Acceptance Test period will begin again.

During the Acceptance Test period, all failures shall be documented and reported to the Department. A Failure Review Team (FRT) shall be established to review all failures. The FRT shall be comprised of one member from the Department, one member from the Contractor, and potentially, one member of Department's outside consultant team. This team will initially attempt to settle any disputes through mutual agreement. In the event that a dispute cannot be settled by the FRT, the dispute resolution provisions of the Contract shall apply.

Upon commencement of the Acceptance Test, the Contractor shall have one-hundred twenty (120) total days to complete the Acceptance Test, including all testing suspension periods and restart periods. Failure by the Contractor to complete Final Acceptance Testing within 120 days, excluding delays beyond the Contractor's control, may be considered a breach of contract and contract resolution terms, including those related to liquidated damages, shall apply.

Applicable Publications

Publications listed below form a part of these specifications to the extent referenced. The publications are referred to in the text by the basic designation only. For additional relevant publications, refer to individual equipment specifications.

- TIA-455: Fiber Optic Test Procedures.
- EIA/TIA-RS-250-C: Electrical Performance for Television Transmission Systems

Delivery, Storage, and Handling

The Contractor shall deliver, store, handle and install all materials and equipment used in conducting the tests in such a manner as not to degrade quality, serviceability or appearance.

The Contractor shall store materials and equipment in a clean, dry location free from construction dust, precipitation and excess moisture.

All equipment required for the PDT and SDT shall be stored in the original shipping containers until such time as required for testing. Following testing, the Contractor shall remain responsible for delivery, storage, handling and installation of all materials and equipment in such a manner as not to degrade quality, serviceability or appearance.

The Contractor shall replace damaged materials and equipment, as determined by the Engineer, at no additional cost to the Department.

Quality Control

The Contractor shall have a Quality Control Program in place as noted in Specification 108 – Contractor Quality Control Program, and shall maintain documentary evidence of having performed Quality Control reviews on all test submittals.

The Contractor shall provide documentation certifying that all test equipment employed in the conduct of the tests and the demonstration of compliance with specified functional and performance requirements has been properly calibrated.

MATERIALS

The Contractor shall provide all cables, connectors, equipment, equipment racks, power, and other incidental appurtenances, labor, materials and equipment required to configure and conduct Factory Acceptance Tests, the Prototype Demonstration Test, the On-board Equipment Pilot Test, the System Demonstration Test, Installation Tests, Software Integration, the Integration Test, and the Acceptance Test.

METHOD OF MEASUREMENT

Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 207 – Integration Test, and Specification 208 – Acceptance Test

This work shall be measured for payment by the contract price for the successful completion of each Testing line item as determined by the Department issuing approval of each stage of testing. The contract price of this item shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the Work.

Specification 206 – Software Integration

The work for this Item will be measured for payment by the actual number of hours for the Contractor rendering services approved by the Engineer. The Contractor shall submit an estimate of hours required to complete the work to the Engineer for approval a minimum of two (2) weeks prior to planned commencement of work. The Contractor shall not begin Software Integration work without an approved estimate of hours. Following approval of the estimate of hours, if a need for additional hours is identified, the Contractor shall immediately notify the Engineer of the need for additional hours, with justification. Additional hours shall not be measured for payment without written approval by the Engineer. Services shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to

complete the Work. The Software Integration will be measured for payment by the number of hours, measured to the nearest hour.

BASIS OF PAYMENT

Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 207 – Integration Test, and Specification 208 – Acceptance Test

The negotiated contract price for each Testing line item shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the CT***fastrak*** ITS and Communications Systems shall be based on this negotiated total system implementation cost and the milestone completion schedule.

Specification 206 – Software Integration

Payment will include all materials, tools, equipment, and labor incidental to the completion of this Item for the duration of the Project. Software Integration will be paid for at the contract unit price per hour, which price shall include all compensation for the Work. The lump sum price shall not be included in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The lump sum price will be certified for payment as described in "Method of Measurement."

SPECIFICATION 300 – TRAINING

DESCRIPTION

This specification covers requirements for preparation and delivery of Department personnel Training for the ITS and Communications Systems equipment for CT***fastrak***. The Contractor shall develop and deliver a training program sufficient to provide designated Department personnel with a thorough understanding of the operation, administration and maintenance of the ITS and Communications Systems.

Training Requirements

General

All training shall be conducted in English, provided at Connecticut Department of Transportation facilities, and provided for a maximum of fifteen (15) attendees. The Contractor shall coordinate with the Department to schedule the training sessions. Training shall be conducted on the live system following successful completion by the Contractor of Integration Testing. Training must be completed prior to the Department authorizing commencement of Acceptance Testing. Refer to Specification 207 – Integration Test and Specification 208 – Acceptance Test for additional information on requirements for these testing stages.

The Contractor shall provide training to Department personnel on the proper operation, administration and maintenance of the system. The minimum training required is that which is necessary to bring the designated employees to the level of proficiency required for performing their respective duties. Practical training using actual system equipment shall occupy a significant portion of all training classes. The level of competency required to pass any course examinations shall be determined by the Department.

Training Plan

Forty (40) business days prior to the commencement of training, the Contractor shall develop and submit a Training Plan for the Department's review. The Training Plan shall describe the scope, schedule, and objectives of the training program, including identification of specific training focused for different types of recipients. The Training Plan shall also include details on available supplementary training from manufacturers/vendors for specific elements of the system.

The Training Plan shall identify the Contractor personnel proposed to provide training and their qualifications to provide this training. The Contractor shall provide experienced and qualified instructors to conduct all training sessions. These personnel shall have at least two (2) years experience in ITS and communications systems technology and their integration specifically related to the requirements of the Specifications for the CT***fastrak*** ITS and Communications Systems. The Contractor shall not use consultants or manufacturer's representatives to meet

these requirements. The Contractor is responsible for ensuring that the instructors teaching these courses are both familiar with the technical information being imparted and able to utilize proper methods of instruction, training aids, audiovisuals and other materials to provide for effective training.

Training Program

Training shall, at a minimum, be provided for the stated number of days to the following system users (to be designated by the Department):

- At least five (5) full days of "Administrator" training. Training shall include information on system architecture, installation, and configuration; routine central system maintenance and troubleshooting; system interface management; and all system administration and performance monitoring features. At a minimum, all trainees must be able to pass a proficiency test at the completion of training.
- At least two (2) full days of "Dispatcher" training. Training shall include detailed information on the general system and all system features, focusing on the use of system software to manage and monitor activity along the busway, dispatch and manage busway vehicles, and monitor the status of field equipment. Training emphasis shall also be placed on system management and reporting features. At a minimum, all trainees must be able to pass a proficiency test at the completion of training.
- At least three (3) full days of "Operator" training. Training shall include information on how busway vehicle operators will use and interact safely with on-board ITS equipment. At a minimum, all trainees must be able to pass a proficiency test at the completion of training.
- At least four (4) full days of "Field Maintenance" training. Training shall include information on maintaining field devices installed at stations and along the busway. Training shall include troubleshooting, repair, replacement, and configuration of field devices, including communications devices. At a minimum, all trainees must be able to pass a proficiency test at the completion of training.
- At least two (2) full days of "On-Board Equipment Maintenance" training. Training shall include information on maintaining all on-board equipment provided as part of this project. Training shall include troubleshooting, repair, replacement, and configuration of on-board equipment. At a minimum, all trainees must be able to pass a proficiency test at the completion of training.

The Contractor shall develop webinar, PowerPoint presentation, manuals, and other training materials to support Department training of future system users. The Contractor shall make a video recording of all training sessions and provide that video to the Department for its use. The Department reserves the right to retain and reproduce all training materials for internal purposes. The intent is that experienced personnel having the skills covered in the various training courses would be able to train future users without recalling the Contractor for additional training.

The Contractor shall provide as-needed ongoing training for the duration of the Technical Support and Warranty Services (see Specification 400). The Contractor shall be responsible for

providing additional on-site training for any add-on modules, system updates, and system modifications implemented during the Technical Support and Warranty Services. Separate training for each of the different types of system users described above may be required depending on the complexity of the additional training topics.

Training Materials

The Contractor shall submit the proposed training materials for review by the Department. Training Materials shall include the following:

- Materials describing information on all topics to be covered in training sessions
- Video recordings of training sessions in a digital format

Manuals on equipment and software shall be included as part of the Operations and Maintenance Documentation described in Specification 100 – General Provisions.

The training materials shall provide information on all of the topics covered during each of the training sessions and include exercises, equipment diagrams, software screen captures, and other graphical information to clearly convey information to the system user. The training materials shall include full topic descriptions, illustrations as needed to enhance content presentation, common problems together with comprehensive solutions, and space for the users to take notes during the training sessions.

No training shall commence until training materials have been accepted by the Department. Training materials shall be provided to the Department for review a minimum of forty (40) business days prior to the scheduled commencement of training, except for the video recordings of training sessions, which shall be provide to the Department before the commencement of the Acceptance Test.

Once approved by the Department, the Contractor shall provide fifteen (15) hard copies and one (1) electronic copy of all approved training material for reference. Refer to Specification 109 – Document Control Specialist for additional submission requirements.

Additional copies of the training materials shall be provided by the Contractor at the initiation of each training session, in sufficient quantity to provide a copy to each training recipients. Once approved for use, the Department shall retain the unlimited right to reproduce copies for its own purposes.

METHOD OF MEASUREMENT

This work shall be measured for payment by the contract price for the completion of Training. The contract price of this item shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

The negotiated contract price for Training shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the ITS and Communications Systems for CT***fastrak*** shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 400 – TECHNICAL SUPPORT AND WARRANTY SERVICES

SPECIFICATION 401 – TECHNICAL SUPPORT AND WARRANTY SERVICES (YEARS 1 AND 2)

SPECIFICATION 402 –OPTIONAL YEAR 3 EXTENSION OF TECHNICAL SUPPORT AND WARRANTY SERVICES

SPECIFICATION 403 – OPTIONAL YEAR 4 EXTENSION OF TECHNICAL SUPPORT AND WARRANTY SERVICES

DESCRIPTION

This specification covers requirements for the preparation and delivery of Technical Support and Warranty Services for the ITS and Communications Systems for CT***fastrak***. Throughout the duration of the Technical Support and Warranty period (defined below), the Contractor shall provide preventive and corrective technical support and maintenance to the Department for purposes including:

- Answering questions and providing information related to system implementation and performance;
- Assisting the Department in using and configuring the system;
- Coordinating responses to reported problems;
- Remedying and resolving issues with system equipment, software, or other ancillary items being provided as part of this project.

The Contractor shall provide Technical Support and Warranty Services to the Department for all equipment, software, and ancillary items provided as part of the ITS and Communications Systems for CT***fastrak*** for a period of two (2) years (Years 1 and 2) following Final Acceptance by the Department. Upon completion of Years 1 and 2, the Department may, at its sole discretion, choose to extend this contract to include an additional one (1) year of Technical Support and Warranty Services (Year 3). Upon completion of Year 3, the Department may, at its sole discretion, choose to extend this contract to include another additional one (1) year of Technical Support and Warranty Services (Year 4). The initial two-year Technical Support and Warranty period shall not commence until after the Department has issued its written notice of Final Acceptance, regardless of any beneficial use derived by the Department prior to issuance of Final Acceptance.

Technical Support Services

The Contractor shall provide Technical Support services to the Department for all equipment, software, and ancillary items provided as part of this Project for a period of two (2) years (Years 1 and 2) following Final Acceptance of the Project by the Department, with an option of two additional one (1) year extensions for Years 3 and 4. The Contractor shall also provide all software updates, fixes, and patches as required during this time period.

Technical Support shall, at a minimum, provide unlimited telephone and customer service website support 24 hours a day, 7 days a week, 365 days a year plus four (4) on-site staff days of professional services per year to provide system tuning, additional training, and review the Department implementation to identify performance enhancement opportunities.

Technical Support Responsiveness

The following definitions shall apply:

- **"Initial Response Time"** is defined as the time between (a) the Department's call or other communication to the Contractor, and (b) the time at which the Contractor acknowledges receipt of the Department support request.
- **"Follow Up Response Time"** is defined as the time between (a) the Department's call or other communication to the Contractor, and (b) the time at which the Contractor submits a follow up response to the Department which shall indicate a Contractor contact person to whom the issue has been assigned, action items assigned to resolve the issue, estimated time to resolve the issue, and provide the capability to track the issue to its completion.
- **"Issue Resolution Time"** is defined as the time between (a) the Department's call or other communication to the Contractor, and (b) the time at which the Contractor resolves the system failure or responds to the general information request to the satisfaction of the Department.
- **"Failure"** is defined to mean the inability of the ITS and Communications Systems (a) to perform their intended function as defined by the system specifications or (b) to function in accordance with the applicable warranties or performance requirements. The term "Failure" shall include both hardware and equipment failures, as well as software errors.
- **"Software"** shall mean all Software necessary for or provided as part of the ITS and Communications Systems. The term "Software" shall include Contractor-developed software, third party software, and Contractor tools/utilities. The term "Software" also includes, where the context permits, all software, firmware, and any programming contained in ROM, PROM, or other memory which is necessary for or contained in the required components, hardware, and other related equipment.

If the Department submits general requests for information, the Initial Response Time by the Contractor shall be no greater than eight (8) hours from receipt of the question or request. The Follow Up Response Time for general requests for information shall be within twenty-four (24) hours from receipt of the question or request. The Issue Resolution Time for general requests for information shall be no greater than one (1) week, unless otherwise approved by the Department.

For system failures, including equipment failures and software errors, the Initial Response Time by the Contractor shall be no greater than one (1) hour from receipt of the question or request if reported during normal operating hours. Normal operating hours are defined as being between 6:00am to 6:00pm Eastern Time, Monday through Friday, excluding statutory holidays. If a failure is reported outside normal operating hours, the Initial Response Time by the Contractor shall be no greater than four (4) hours from receipt of the question or request. The Follow Up Response Time for a system failure shall be no greater than eight (8) hours from receipt of the question or request. The Failure Resolution Time for failures shall be no greater than twenty-four (24) hours from receipt of the question or request, unless otherwise approved by the Department. In the event a particular Failure cannot be remedied within the 24-hour period, then correction of such Failure shall be completed within a timeframe as agreed between Department and the Contractor within that initial 24-hour period, based on the severity and criticality of the deficiency. In any event, and unless otherwise agreed, the Contractor shall promptly correct all Failures in a manner (a) commensurate with the severity of the Failure and its impact upon system performance, and (b) so as to maintain the performance standards.

Failure to meet Response Times

Failure to meet the Response Times set forth above may be penalized as follows:

- Performance Credits. If the Contractor fails to meet the Response Times, the Department shall be entitled to a Performance Credit for each instance of such failure. For purposes of this Agreement, a "Performance Credit" shall be equal to five percent (5%) of the amount of annual Technical Support and Warranty Service fees allocable to the year during which the Performance Credit arose. The Contractor shall track and periodically report on Performance Credits to the Department, and shall reflect such Credits in applicable invoices.
- Repeated Failures. The Department shall be entitled to treat repeated failures by the Contractor as a material breach of the terms of the Contract Agreement.
- Request/Response Logs: Times for Department requests and Contractor response/resolution times shall be based on emails timestamps as sent and received by the parties.

Technical Support Contact Person

The Contractor shall designate a specific Technical Support contact person (i.e., an account manager) to handle all Department reported issues. This contact person should be the first point of contact for the Department to report all new issues and to follow up on previously reported issues and shall be available during normal operating hours within the Eastern Time Zone as defined above.

Remote System Access

The Contractor may request from the Department temporary remote system access be granted to allow the Contractor to provide technical support and troubleshooting remotely. The Contractor

shall be responsible for identifying a secure method for establishing temporary remote system access that is consistent with the Department's system security requirements. Based on the proposed access method, the Department may decide to allow this access. The Department granting remote access does not absolve the Contractor of any responsibility for meeting its "response time" and "issue resolution time" requirements.

Online Tracking

The Contractor shall provide an online database/log where the Department can log bugs, problems, issues, and requests for enhancements. Each entry will be assigned a unique tracking number when created. The Contractor shall respond with a status, comments, assignment information. The online database/log shall allow the Department to check the status of requests at any time. The Department will be able to create and print reports via the online database/log. The Contractor shall also provide a web-based system of allowing the Department to track information on known bugs and/or technical issues reported by other software users (non-Department users).

Enhancements and New Versions

During the Technical Support and Warranty Services period(s), the Contractor shall notify the Department of the availability of enhancements, releases, and newer versions of the software (including third party software), including all bug fixes, patches, and modifications. The Contractor shall consult with the Department concerning the advisability of incorporating such enhancements and newer versions within the ITS system and shall provide reasonable supporting materials. Within twenty (20) business days from the Department's request, the Contractor shall provide the Department with the enhancement, release, or the new version. In doing so, the Contractor shall (a) provide such enhancements, releases, and new versions to the Department at no charge, (b) perform any integration, installation, configuration, testing and release services necessary, and (c) provide such integration, installation, configuration, testing and release services without charge, except in the case of third-party software, where license fees and other charges of such third-party (without markup) may be imposed. Following installation of the enhancement, new release, or new version, the Contractor shall be responsible for repeating all system testing to demonstrate all required functionality is still provided by the system. Such testing shall be performed at no additional cost to the Department. Should the provision of such a new enhancement, release or version result in any loss of required functionality, at the sole discretion of the Department, the Contractor may be required to revert to the previous fully functional version at no additional cost to the Department. The Contractor shall coordinate the scheduling of the provision and implementation of any new enhancement, release or version with the Department.

Version Control

The Contractor shall monitor and track software versions in operation, to ensure proper version control and hardware compatibility.

Support for Prior Versions

The Contractor shall continue to support earlier versions of the software while providing ongoing technical support and maintenance if the Department, in its sole discretion, decides to remain with the previous version.

Revised Documentation

The Contractor shall provide to the Department at no additional charge all updated system documentation in the form of new revised manuals or changed pages to current manuals (or updated "help screens") consistent with the original system documentation supplied, and reflecting changes embodied in the enhancement, in the new software version, or in the improvement provided herein. The Contractor shall also provide (at no charge) installation instructions, procedures and any installation program required by the installation.

Additional Training

The Contractor shall provide to the Department at no additional charge any additional training required for new add-on modules, enhancements, new versions, system patches, fixes, modifications, etc.

Warranty Services

The Contractor shall provide a System Warranty and Warranty Services to the Department for all equipment, software, and ancillary items provided as part of this Project for a period of two (2) years (Years 1 and 2) following Final Acceptance of the Project by the Department, with an option of two additional one (1) year extensions for Years 3 and 4. This System Warranty shall be in addition to individual manufacturer-provided equipment warranties. Manufacturer-provided equipment warranty requirements are described in greater detail in each Item specification.

The Contractor shall warrant that it has good title to the system and its components and the right to sell to the Department free of any proprietary rights of any manufacturer (if the Contractor is not the manufacturer) or other party, and free of any lien or encumbrance.

The Contractor shall warrant that all installation work and system hardware and software provided by the Contractor, Sub-contractors, or other suppliers or manufacturers, shall be free from defective workmanship for warranty and guarantee periods that are customary and consistent with standard industry and trade practice, all of which shall commence after the date of formal System Acceptance, and shall be effective for not less than two (2) years thereafter, unless otherwise specified in each Item specification. All product warranties shall be registered to the Connecticut Department of Transportation.

The Contractor shall warrant that all installation work and system hardware and software shall perform according to the specifications for the duration of the warranty period(s).

During the warranty period(s), the Contractor shall provide routine and preventive maintenance for all system equipment as proscribed by the Contractor's submitted Operations and Maintenance Manuals (refer to Specification 100 – General Provisions for more information on the Operations and Maintenance Manuals) and in accordance with the manufacturers'

recommendations, and as needed to meet performance standards. This routine and preventive maintenance shall also meet all requirements for maintaining individual Item warranties.

If the original manufacturers' or suppliers' warranties expire before the end of the warranty period(s), the Contractor shall provide extended warranties for all such products or equipment (software, hardware, spare parts) and shall assume full responsibility for replacement or repair for the duration of the warranty period(s), the full cost of which shall included in the Contract Price.

Following the warranty period(s), the Department will operate and maintain the system hardware and software in accordance with the Contractor's specific instructions in order to maintain all warranties that extend beyond the initial warranty period. However, the Contractor shall hold the Department harmless and the Contractor shall be responsible for repairing any damage from the Department's improper operation of any system hardware or software resulting from Contractor's failure to provide adequate or correct training and/or complete operating manuals, software manuals, electrical drawings, complete computer program documentation, and other documents required to be furnished as identified within these specifications.

During the warranty period(s), the Contractor shall maintain detailed repair records and forward this information to the Department on a monthly basis (unless otherwise agreed upon by the Engineer). During the warranty period(s), the Contractor shall also provide monthly performance reports. These performance reports will report on the reliability of field and on-board equipment, as well as the percentage system availability of the central systems and the communications network (excluding any downtime resulting from scheduled preventive maintenance). The performance reports shall also describe the average accuracy of the bus arrival prediction algorithm for the month at each station.

Hardware furnished and installed for this project shall be guaranteed to perform according to the manufacturer's published specifications. Hardware shall be warranted against defects and/or failure in design, materials and workmanship in accordance with the manufacturer's standard warranty. The warranty coverage shall become effective on the date of Final Acceptance of the Item by the Department. The Contractor shall register all manufacturers' normal warranties, licenses and guarantees in the name of the Connecticut Department of Transportation. Defective equipment shall be repaired or replaced during the warranty period(s) at no additional cost to the Department.

During the warranty period(s), defective hardware will be replaced by the Contractor using stock from the spare parts inventory and the defective part will be returned to the equipment supplier. For each defective part, the equipment supplier shall provide the Contractor with a repaired or new replacement unit to replenish the spare parts inventory. The replacement units shall be fully tested and certified to be compliant with the original part. The cost of all transportation and insurance charges for shipping defective and replacement parts to and from the equipment supplier shall not be charged to the Department.

Unsatisfactory Work

If, within the Technical Support and Warranty period(s), the Department finds that warranted Work needs to be re-performed because of workmanship that, in the Department's opinion, is not

in accordance with the terms of the Contract, the Department will so inform the Contractor in writing, and the Contractor shall promptly and without additional expense to the Department place in a satisfactory condition all such warranted Work.

Should the Contractor fail to proceed promptly, the Department may have such Work performed by others and the costs of such Work may be charged to the Contractor, who shall pay these costs to the Department accordingly or deducted from monies due, or to become due, to the Contractor.

The rights and remedies of the Department under these Technical Support and Warranty Services provisions are not intended to be exclusive, and do not preclude the exercise of any other rights or remedies provided by this Contract or by law with respect to unsatisfactory Work performed by the Contractor.

Quality Control

Refer to Specification 108 – Contractor Quality Control Program for any additional Quality Control requirements applicable to Technical Support and Warranty Services.

MATERIALS

The Contractor shall be responsible for providing all equipment, tools, services, and documentation necessary to provide the Technical Support and Warranty Services.

METHOD OF MEASUREMENT

Specification 401 – Technical Support and Warranty Services (Years 1 and 2)

This work shall be measured for payment by the contract price for the completion of Technical Support and Warranty Services. The contract price of this item shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all labor, materials, licenses, tools, equipment, testing, transportation, storage and other incidentals necessary to complete the work.

Specification 402 –Optional Year 3 Extension of Technical Support and Warranty Services

This work shall be measured for payment by the contract price for the completion of Optional Year 3 Extension of Technical Support and Warranty Services. The contract price of this item shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all labor, materials, licenses, tools, equipment, testing, transportation, storage and other incidentals necessary to complete the work.

Specification 403 – Optional Year 4 Extension of Technical Support and Warranty Services

This work shall be measured for payment by the contract price for the completion of Optional Year 4 Extension of Technical Support and Warranty Services. The contract price of this item shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all labor, materials, licenses, tools, equipment, testing, transportation, storage and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Specification 401 – Technical Support and Warranty Services (Years 1 and 2)

The release of payment for all work associated with Technical Support and Warranty services for the ITS and Communications Systems of CT***fastrak*** shall be based on the negotiated Contract Price for the completion of Technical Support and Warranty Services (as defined in Specification 100 – General Provisions), and a quarterly payment schedule. The Contract Price for the initial two-year Technical Support and Warranty Services period shall be equally divided into quarterly payments, payable at the end of each quarter upon satisfactory work by the Contractor.

Specification 402 –Optional Year 3 Extension of Technical Support and Warranty Services

The release of payment for all work associated with Optional Year 3 Extension of Technical Support and Warranty services for the ITS and Communications Systems of CT***fastrak*** shall be based on the negotiated Contract Price for the completion of Optional Year 3 Extension of Technical Support and Warranty Services (as defined in Specification 100 – General Provisions), and a quarterly payment schedule. The Contract Price shall be equally divided into quarterly payments, payable at the end of each quarter upon satisfactory work by the Contractor.

Specification 403 – Optional Year 4 Extension of Technical Support and Warranty Services

The release of payment for all work associated with Optional Year 4 Extension of Technical Support and Warranty services for the ITS and Communications Systems of CT***fastrak*** shall be based on the negotiated Contract Price for the completion of Optional Year 4 Extension of Technical Support and Warranty Services (as defined in Specification 100 – General Provisions), and a quarterly payment schedule. The Contract Price shall be equally divided into quarterly payments, payable at the end of each quarter upon satisfactory work by the Contractor.

SPECIFICATION 501 – CATEGORY 6 (CAT 6) COPPER PATCH CABLE

DESCRIPTION

This item shall consist of furnishing, installing, and testing terminated unshielded twisted pair (UTP) Category 6 Copper Patch Cables (Cat 6 Cabling) required to interconnect Ethernet/IP ready devices on the busway communications system.

The Cat 6 Patch Cable shall consist of

- Solid 23 AWG, 4-pair high-conductivity copper wire, insulated and jacketed
- Unshielded 8P8C/"RJ45" modular connectors terminating both ends of installed cabling
- Plenum rated material for building installations

References and Standards

The following standards shall apply for the following categories:

Electronic Industries Alliance / Telecommunications Industry Association (EIA/TIA):

- ANSI/TIA-1096-A: Shape and dimensions of 8P8C/"RJ45" connectors.
- EIA/TIA-568-B: Commercial Building Telecommunications Wiring Standard.
- EIA/TIA-606: Administration Standard for the Telecommunication Infrastructure.
- EIA/TIA-607: Commercial Building Grounding and Bonding Requirements for Telecommunications.

National Fire Protection Association (NFPA):

- NFPA 70: National Electric Code.
- NFPA 75: Standard for the Protection of Electronic Computer/Data Processing Equipment.

Underwriters Laboratories (UL):

- UL 444: Communications Cables.
- UL 497: Standard for Protectors for Paired-Conductor Communications Circuits.

MATERIALS

General

Cat 6 Cabling shall be comprised of four (4) twisted pairs of copper wire conductors.

Cat 6 Cable wire pairs shall have different twist rates.

Conductors shall be twisted to form pairs with an average mutual capacitance of less than 52 nF/km with a far end crosstalk loss of 69 dB/km.

The conductor pairs wires shall be color coded in compliance with EIA/TIA coloring standards.

The conductor pairs shall be individually insulated with high density poly ethylene (HDPE).

A tight fitting jacket shall be extruded over the conductor pairs.

A non-hygroscopic dielectric tape shall be wrapped around the insulated pairs.

For outdoor installations the cable shall have a sunlight and weather resistant jacket fabricated of HDPE or other material approved by the Engineer that is in compliance with the referenced fire codes.

For indoor installations the jack shall be plenum rated and fabricated of low-smoke polyvinyl chloride (PVC), or a fluorinated ethylene polymer (FEP) or other approved by the Engineer that is in compliance with the referenced fire codes.

Each Cat 6 cable end shall be terminated with 8P8C/"RJ-45" type connectors.

The cable and modular connector materials that are in contact shall not support galvanic action.

The modular connector shall be made of material of a type that does not support galvanic action with the equipment receptacle that it is inserted into.

Manufacturer Requirements

The manufacturer must be regularly engaged in the manufacture and production of Category 6 Copper Patch Cabling for consumer, commercial and industrial applications, meeting internationally accepted quality standards in the manufacture of such cabling.

Environmental Requirements

Criteria	Minimum Conditions to be Met
Operating Temperatures	Indoor: -4^{o}F to 122 ^{o}F (-20^{o}C to 50^{o}C) Outdoor: -40 ^{o}F to 167 ^{o}F (-40^{o}C to 75^{o}C)

Criteria	Minimum Conditions to be Met
Installation Temperatures	Indoor: 32 °F to 122 °F (0°C to 50°C) Outdoor: 13 °F to 167 °F (-25°C to 75°C)
Humidity	0-95% non-condensing
Solid Object and Moisture Protection	IP 53
Water and Solvents	Shall withstand water spray on equipment from cleaning floors and walls, industrial solvents, rain, mud, snow and slush, all of which may contain salt, which may come in contact with equipment.

Electrical Requirements

All installed Cat 6 Cabling shall meet or exceed industry recognized electrical standards.

Warranty Requirements

The Cat 6 Cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The Cat 6 Cabling shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting equipment from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged equipment.

Cat 6 Cabling, 8P8C/"RJ45" modular connectors, associated tools, Velcro™ ties and any other materials required for correct provision of Cat 6 Cabling per this specification shall be stored in a clean, dry, cool indoor environment.

Adequate storage space shall be provided for these materials in order to ensure that no mechanical stress is exerted on the materials.

Materials that have come in contact with water will be replaced by the Contractor, at their own expense. The Department shall not assume any liability for the same.

Installation

Indoor Cat 6 Cabling shall be installed in buildings or interior spaces per the Drawings and shall be rated for indoor use.

Outdoor Cat 6 Cabling shall be installed in outdoor cabinets and conduits per the Drawings and shall be rated for outdoor use.

Cable length shall be sized to minimize excess cable interconnecting equipment, with cables routed and dressed to maintain a neat appearance.

An installed cable shall not exceed 100m in length. For installations that require longer than 100m of Cat 6 cable, the Engineer and the Department must approve cable and deployment prior to installation. The Contractor may propose using Ethernet over copper transmission extending equipment, with justification, for the Engineer to review. The Department may decide to approve such equipment at its sole discretion.

Sufficient slack shall be provided on installation to avoid sharp bends in the cable that may degrade performance.

For both indoor and outdoor cable, the minimum bend radius of cable during installation shall comply with the manufacturer's recommendation. Installed cables with bends must meet the Cat 6 installation and performance requirements.

Cables shall be neatly routed using approved cable management hardware, and with removable (e.g. Velcro™) tie wraps as necessary.

At minimum, each cable shall be labeled appropriately on each end. A labeling scheme for all Cat 6 cabling shall be submitted for Engineer's approval.

Outdoor cables shall be installed with weatherproof labels at each modular connector on both ends of the cable.

Indoor cables shall be installed with labels at each modular connector on both ends of the cable.

Cable termination shall be performed in a clean, dry environment.

Cable jacketing shall be removed to expose wires using a stripping tool specifically designed for stripping Cat 6 cable. If wires are scratched, cut, or otherwise damaged in jacket stripping, the Contractor shall discard that section of cable and re-strip the jacket.

A maximum of ½" (one-half inch) of unjacketed wire shall be left at the end of a cable for insertion into the 8P8C/"RJ45" modular connector.

Unfurled wires shall be threaded into a modular plug that shall be supplied as part of the 8P8C/"RJ45" modular connector. The modular plug – cable assembly shall then be inserted into the modular connector for crimping.

A crimping tool specifically designed for terminating Cat 6 cable into 8P8C/"RJ45" connectors shall be used.

A dedicated boot made of Ethylene Propylene Terpolymer Rubber (EPTR) or equivalent approved by the Engineer shall be placed over each modular connector.

Documentation and Training

The Contractor shall provide certificate of compliance with Cat 6 specifications for each terminated cable provided.

The Cat 6 Cabling, and all associated equipment and cabling shall conform to the documentation and training requirements stated in Specification 100 – General Provisions and Specification 300 – Training.

Testing

Cat 6 Cabling, and all associated equipment and cabling shall conform to the testing requirements stated in Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 203 – On-board Equipment Pilot Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

All Cat 6 cables shall be tested prior to installation.

The Contractor shall be responsible for all testing that may be required to establish approval and acceptance of the Cat 6 Cabling.

The Contractor shall employ industry-standard methods and tools to demonstrate that the cable is compliant with Cat 6 requirements, monitor Cat 6 Cabling performance and compliance with availability requirements throughout the term of the Contract, including all ongoing technical support and maintenance periods.

METHOD OF MEASUREMENT

This work shall be measured for payment by the number of feet of Category 6 Copper Patch Cables of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each foot of Category 6 Copper Patch Cables shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the CT***fastrak*** ITS and Communications Systems shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 502 – GIGABIT ETHERNET SWITCH (TYPE A)

SPECIFICATION 503 – GIGABIT ETHERNET SWITCH (TYPE B)

DESCRIPTION

This item shall consist of furnishing, installing, integrating, and testing Gigabit Ethernet Switches, all needed components and accessories required for a full and complete installation, including all associated equipment and cabling, as described herein.

The Gigabit Ethernet Switch shall be capable of:

- networking and routing Ethernet ready ITS equipment traffic; and
- converting Ethernet (electrical, over twisted-pair copper) to optical Ethernet on Fiber.

The Gigabit Ethernet Switches shall be installed in designated enclosures along the busway, at busway stations, and in the Busway Operations Center (BOC) as shown on the Drawings. There shall be two (2) types of Gigabit Ethernet Switches:

- Type A – more than 8-port, consisting of eight (8) or more RJ45 copper ports and four (4) or more Optical Fiber ports.
- Type B – more than 24-port, consisting of 24 or more RJ45 copper ports and four (4) or more Optical Fiber ports.

Gigabit Ethernet Switches shall transmit and receive 10/100/1000 Mbps (mega-bits-per-second) data over single mode Fiber.

At existing station communications cabinets, a minimum of two (2) Gigabit Ethernet Switches shall be installed in order to accommodate separate communications networks for video and data as shown in the Drawings. Additional Gigabit Ethernet Switches may need to be installed at specific stations depending on the quantity of devices at each station. At existing Traffic Management System Cabinets along the busway, and at secondary cabinets at the stations, a single Gigabit Ethernet Switch may be installed as shown in Drawings. The Contractor shall confirm that the quantity of Gigabit Ethernet Switches and the total number of ports proposed for these switches at each location is sufficient to support connection to the proposed quantities of field devices, with spare capacity for potential future expansion.

At cabinet locations where more than two (2) devices shall be connected to a Gigabit Ethernet Switch, the Contractor shall also provide a Cat 6 Patch Panel. For Type A Gigabit Ethernet Switches, the Contractor shall provide a 12-port Cat 6 Patch Panel. For Type B Gigabit Ethernet Switches, the Contractor shall provide a 24-port or 48-port Cat 6 Patch Panel.

References

The following standards shall apply for the following categories:

IEEE

- 802.3-2008-Gigabit Ethernet standard
- 802.1p-Quality of Service
- 802.1Q-VLAN Tagging
- 802.3x-Flow Control
- 802.1d-Spanning Tree Protocol
- 802.1p-Class of Service
- 802.1w-Rapid Spanning Tree Protocol
- 802.17-Resilient Packet Ring

Other

- UL Listing
- NEC CM/MP

MATERIALS

General

The Gigabit Ethernet Switches shall have copper ports complying with IEEE 1000BASE-T or higher standards.

The Gigabit Ethernet Switches shall have fiber ports complying with IEEE 1000BASE-FX or higher standards.

The Gigabit Ethernet Switches shall have power over Ethernet (POE) ports.

Gigabit Ethernet Switches installed in designated field locations or Communications Cabinets shall aggregate and disseminate data from all connected ITS components. As shown on the Drawings, Gigabit Ethernet Switches installed at each of the stations and other designated locations shall be interconnected over the Optical Fiber Distribution and Drop Cables.

The Cat 6 Patch Panels shall meet or exceed the relevant requirements identified for Cat 6 cabling in Specification 501 – Category 6 (Cat 6) Copper Patch Cable.

The Cat 6 Patch Panels shall meet or exceed the requirements for Category 6 described in TIA-568-C.2 as well as the Class E requirements described in ISO/IEC 11801-B.

The Cat 6 Patch Panels shall feature mounting standoffs for cable management bars, color-coded labeling, and a termination standoff for patch panel earthing/grounding.

The Cat 6 Patch Panels shall be made of corrosion-resistant steel construction. The plastic elements shall be fire-retardant with a UL flammability rating of 94V-0.

The Gigabit Ethernet Switches, the Cat 6 Patch Panels, and all associated equipment and cabling shall comply with the Materials requirements stated in Specification 100 – General Provisions. If conflicts exist, this Item specification shall govern.

Functional Requirements

General

The Gigabit Ethernet Switch shall provide electrical Ethernet ports for connection to ITS equipment and shall provide optical Ethernet ports for connection to Optical Fiber. The optical Ethernet ports shall serve as "trunk" ports for transmission of aggregated data from the ITS equipment connected to that switch.

Gigabit Ethernet Switches shall be assigned IP addresses in accordance with the Contractor-developed IP Address Coordination Plan and as approved by the Engineer and shall be configurable remotely.

The Gigabit Ethernet Switches shall provide 10/100/1000Base-T with speed auto negotiation. The Gigabit Ethernet Switch shall store and forward with IEEE802.3x full duplex, non-blocking flow control.

The Gigabit Ethernet Switches shall support Resilient Packet Ring standards.

The Gigabit Ethernet Switch shall support the following features and function:

- 8192 MAC address
- IEEE 802.1p (Quality of Service) for 4-level transmission priorities
- IP Multicast Filtering through IGMP Snooping (v2)
- SNMPv2, Web-based (http) management, and Telnet.
- Port Mirroring
- Port Based Network Access Control (IEEE 802.1x).
- Broadcast Storm Filtering
- Loss of Link Management
- Port Statistics and Remote Monitoring
- Individual Port Configuration and Status
  - Speed
  - Auto-negotiation
  - Flow Control
- Event Logging and Alarms

The Gigabit Ethernet Switch shall support the following properties:

- Switch Method: Store and Forward
- Switch Latency: 7us (100 Mbps)
- Switch Bandwidth: 1.6 Gbps
- Priority Queues: 2
- Frame Buffer: 160 Packet Buffers (1536 bytes each)
- VLANs: 1000
- IGMP Multicast Groups: 256

Performance Specifications

Gigabit Ethernet Switch optical interfaces shall be compatible with the Distribution and Drop Cables (refer to Specification 505 – Optical Fiber Cable (12 Strand) and Specification 506 – Optical Fiber Cable (48 Strand)) and OFTPP (refer to Specification 508 – Optical Fiber Termination Patch Panel (48-port) and Specification 509 - Optical Fiber Termination Patch Panel (12-port)) requirements.

The devices shall have an optical link budget to facilitate communication as required by the Drawings. Pluggable optical transceiver modules shall be available from the manufacturer of the switch to support minimum link budgets of 40 km over 9μ/125 single-mode fiber at 1310 nm, and 60 km over 9μ/125 single-mode fiber at 1550 nm. These modules shall also have optical monitoring capabilities.

The Ethernet switches' optical receivers shall not experience optical saturation from the transmitting devices when on links 100 m apart or greater. If optical saturation occurs on links less than 100 m apart, the Contractor shall supply optical attenuators to prevent saturation.

Multicasting traffic shall experience no packet loss.

The mean time between failures (MTBF) for the Gigabit Ethernet Switches shall be > 70,000 hours.

Manufacturer Requirements

The manufacturer of the Gigabit Ethernet Switches and Cat 6 Patch Panels shall be regularly engaged in the manufacture and production of high performance and rugged Ethernet switching equipment for use in communications systems for at least ten (10) years.

Physical Requirements

The Gigabit Ethernet Switch and Cat 6 Patch Panel dimensions shall be suitable for installation at Communication Cabinets as specified in the Drawings.

Environmental Requirements

Gigabit Ethernet Switches and Cat 6 Patch Panels installed shall comply with the following environmental conditions:

Criteria	Minimum Conditions to be Met
Operating Temperatures	Indoor: 32°F to 122°F (0°C to 50°C) Outdoor: -40° F to 167° F (-40°C to 75°C)
Storage Temperatures	Indoor: 32°F to 122°F (0°C to 50°C) Outdoor: -40° F to 185° F (-40°C to 85°C)
Humidity	5-95% non-condensing
Solid Object and Moisture Protection	Indoor: IP 52 Outdoor: IP 56

Note: The manufacturer shall verify maximum continuous operating temperatures using a minimum of 16 hours of continuous use in accordance with applicable industry standards.

Electrical Requirements

Item	Requirement
Operating Voltage	115 VAC ± 5%, 60 Hz or a 24VDC ±2%.
Input Current	<25 Amperes
Maximum Power Dissipation	3000 Watts

The Gigabit Ethernet Switch's power supply shall have no exposed power connectors.

The Gigabit Ethernet Switches shall support POE.

All Gigabit Ethernet Switches to be installed in outdoor equipment cabinets shall have conformal coating.

Warranty Requirements

The Gigabit Ethernet Switches, the Cat 6 Patch Panels, and all associated equipment and cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The Gigabit Ethernet Switches, the Cat 6 Patch Panels, and all associated equipment and cabling shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting equipment from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged equipment, as may be determined by the Engineer.

Installation

At the stations along the busway, the Contractor shall install the Gigabit Ethernet Switches, Cat 6 Patch Panels, and all associated equipment and cabling in standard EIA-19-inch equipment racks in the Communications Cabinets, and inside smaller secondary cabinets as shown on the Drawings. Gigabit Ethernet Switches, Cat 6 Patch Panels, and all associated equipment and cabling shall also be installed at existing Traffic Management System Cabinets at points the busway as shown on the Drawings. Gigabit Ethernet Switches, Cat 6 Patch Panels, and all associated equipment and cabling shall also be installed at the BOC as shown on the Drawings.

The Contractor shall connect the Gigabit Ethernet Switch to a protected power source, either an Uninterruptible Power Supply, or the protected side of a transient voltage surge suppressor installed in the cabinet. The Contractor shall connect the equipment to low-resistance protective ground.

The Contractor shall furnish and install Cat 6 Patch Cables (specified elsewhere) and connectors from the proposed Ethernet equipment in the Communications Cabinets, the secondary cabinets, the Traffic Management System Cabinets, and the BOC communications racks. The Contractor shall provide the necessary Patch Cable lengths based on the distance and Cable path between the patch panel and the communications equipment in the communications rack. Patch Cables shall be neatly routed through cable management.

The Contractor shall provide and install all interconnecting Optical Fiber Cable between the Gigabit Ethernet Switch and the OFTPP in the Communications Cabinet.

Documentation and Training

The Gigabit Ethernet Switches, and all associated equipment and cabling shall conform to the documentation and training requirements stated in Specification 100 – General Provisions and Specification 300 – Training.

Testing

The Gigabit Ethernet Switch, and all associated equipment and cabling shall conform to the testing requirements stated in the Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The Contractor shall be responsible for all testing that may be required to establish approval and acceptance of the Gigabit Ethernet Switch.

The Contractor shall test and verify the cabling for the electrical (Cat 6) and Optical Ethernet connections for each data link prior to the connection to the Gigabit Ethernet Switch.

The Contractor shall configure the Gigabit Ethernet Switches according to manufacturer's instructions and shall demonstrate shall demonstrate complete operability with connected equipment and system.

METHOD OF MEASUREMENT

Specification 502 – Gigabit Ethernet Switch (Type A)

This work shall be measured for payment by the number of units of Gigabit Ethernet Switch (Type A) of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each Gigabit Ethernet Switch (Type A) shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

Specification 503 – Gigabit Ethernet Switch (Type B)

This work shall be measured for payment by the number of units of Gigabit Ethernet Switch (Type B)s of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each Gigabit Ethernet Switch (Type B) shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the ITS and Communications Systems for CT***fastrak*** shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 504 – FIELD-HARDENED MEDIA CONVERTER

DESCRIPTION

This item shall consist of furnishing and installing outdoor, Field-hardened Media Converters with Enclosure (also referred to as the "Media Converter Cabinet") at locations as shown on the Drawings.

The Field-hardened Media Converters shall be capable of converting optical signals from optical fiber cable to electrical signals over twisted-pair copper, and vice versa.

The Field-hardened Media Converters shall be capable of transmitting and receiving 10/100/1000 Mbps (mega-bits-per-second) data over single mode fiber cable, and transmitting and receiving 10/100 Mbps data over Cat-6 copper cable.

References and Standards

ASTM International

- ASTM F967-95: Standard Practice for Security Engineering Symbols

Electronic Industries Alliance / Telecommunications Industry Association (EIA/TIA)

- EIA-310-C Racks, Panels, and Associated Equipment.
- EIA-TIA-455-A Standard Test Procedures for Fiber Optic Fibers, Cable Transducer Sensors, Connecting and Terminating Devices and Other Fiber Optic Components.
- EIA-455-6B Cable Retention Test Procedure for Fiber Optic Cable Interconnecting Devices.
- EIA-485 Standard for Electrical Characteristics of Generators and Receivers for use in Balanced Digital Multipoint Systems.
- TIA/EIA-598-A Optical Fiber Cable Color Coding.
- FOTP References

IEEE

- 802.3-2008-Gigabit Ethernet standard
- 802.3x-Flow Control

National Fire Protection Association (NFPA)

- NFPA 70: National Electric Code.

Underwriter's Laboratories (UL)

- UL 444: Communications Cables.
- UL 497: Standard for Protectors for Paired-Conductor Communications Circuits.

MATERIALS

General

The Field-hardened Media Converters shall have copper ports complying with IEEE 100BASE-T or higher standards.

The Field-hardened Media Converters shall have fiber ports complying with IEEE 1000BASE-FX or higher standards.

Field-hardened Media Converters with Enclosures shall be installed in designated field locations on existing poles as shown in Drawings.

The Field-hardened Media Converters shall be connected to CCTV Camera Assembly (Busway) using Cat-6 Copper Patch Cable, and shall be connected to the Optical Fiber Termination Patch Panel using Optical Fiber Drop Cables. (Refer to Specification 501 – Cat 6 Copper Patch Cable, Specification 505 – Optical Fiber (12 Strand), Specification 508 – Optical Fiber Termination Patch Panel (48-port), and Specification 511 – CCTV Camera Assembly (Busway))

The Field-hardened Media Converters shall comply with the Materials requirements stated in Specification 100 - General Provisions. If conflicts exist, this Item specification shall govern.

Manufacturer Requirements

The manufacturer of the Field-hardened Media Converters shall be regularly engaged in the manufacture of products specified for a period of no less than ten years with satisfactory performance in similar applications. The manufacturer shall be ISO 9001 certified.

Physical Requirements

General

The Field-hardened Media Converters' copper interfaces shall include at least one (1) RJ-45 port complying with IEEE 100BASE-T or higher standards and the media converters' optical

interfaces shall include at least two (2) fiber ports complying with IEEE 1000BASE-FX or higher standards (with SC connectors).

Enclosure

The Contractor shall provide an Enclosure to protect the Field-hardened Media Converters from the environment. The Enclosure shall be made of rugged aluminum alloy, 16 gauge steel, or approved similar material and shall be designed to enclose electrical and electronic equipment, and allow for entry and exit of power cabling, Drop Fiber Cabling and Copper Patch Cabling. It shall also provide a hinged door for opening and closing. The Enclosure shall comply with the environmental requirements. The maximum size of the Enclosure shall not exceed 12”(W) x 12”(H) x 6”(D).

Environmental Requirements

The Field-hardened Media Converters, including Enclosures, other mounting hardware, connections with power supply and data cabling etc., shall be suitable for an outdoor pole-mounted installation and provide adequate environmental protection for year-round operation.

The Field-hardened Media Converters, including Enclosures, other mounting hardware, connections with power supply and data cabling etc., shall comply with the environmental requirements listed in the table below:

Criteria	**Minimum Conditions to be Met**
Operating Temperatures	Between - 40ºF to +167ºF (- 40ºC to +75ºC)
Operating Humidity	5-95% relative humidity, non-condensing
Solid Object and Moisture Protection	IEC IP66 or NEMA 4/4X
Water and Solvents	Shall withstand water spray on equipment from cleaning floors and walls, industrial solvents, rain, mud, snow and slush, all of which may contain salt, which may come in contact with equipment.

The Field-hardened Media Converters, including Enclosures, other mounting hardware, connections with power supply and data cabling etc., shall be suitably protected against external EMI / ESI Interference through shielding / grounding.

Electrical Requirements

All Field-hardened Media Converters shall operate from a 115VAC +/- 10%, 60 Hz power source. The Contractor shall be responsible for providing any accessories (such as power adapters) required to power the devices from the power source.

Functional Requirements

The Field-hardened Media Converters shall be plug-and-play for easy installation, featuring auto-negotiation and auto-MDI and MDI-X detection.

The Field-hardened Media Converters shall have external LED indicators for power, fault, 10/100, and collision.

The Field-hardened Media Converters shall allow for selectable link speed in duplex communications.

Performance Specifications

Field-hardened Media Converter optical interfaces shall be compatible with the Distribution Cables (refer to Specification 505 – Optical Fiber Cable (12 Strand)) and OFTPP (refer to Specification 508 – Optical Fiber Termination Patch Panel (48-port)) requirements.

The devices shall have an optical link budget to facilitate communication as required by the Drawings. Pluggable optical transceiver modules shall be available from the manufacturer of the switch to support minimum link budgets of 2 km over 9µ/125 single-mode fiber at 1310 nm, and 20 km over 9µ/125 single-mode fiber at 1550 nm.

The Field-hardened Media Converter optical receivers shall not experience optical saturation from the transmitting devices when on links 100 m apart or greater. If optical saturation occurs on links less than 100 m apart, the Contractor shall supply optical attenuators to prevent saturation.

The mean time between failures (MTBF) for the Field-hardened Media Converters shall be > 100,000 hours.

Warranty Requirements

The Field-hardened Media Converter, and all associated equipment and cabling shall comply with the warranty requirements stated in the Specification 400 – Technical Support and Warranty Services.

The Field-hardened Media Converter and all associated equipment and cabling shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting equipment from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged equipment, as may be determined by the Engineer.

Installation

The Field-hardened Media Converters shall be installed in the Enclosures at locations as shown on the Drawings.

The Contractor shall furnish all mounting hardware (i.e., enclosures, brackets, machine screws, nuts, locking washers) to install the Field-hardened Media Converter.

The Contractor shall connect the Field-hardened Media Converter to a protected power source, either an Uninterruptible Power Supply, or the protected side of a transient voltage surge suppressor installed in the communications cabinet. The Contractor shall connect the equipment to low-resistance protective ground.

The Contractor shall furnish and install Cat 6 Patch Cables (specified elsewhere) and connectors from the Field-hardened Media Converter to the CCTV Camera Assembly (Busway). Patch Cables shall be neatly routed through cable management and through the Enclosure.

The Contractor shall provide and install all interconnecting Optical Fiber Cable between the Field-Hardened Media Converter and the OFTPP.

The Contractor shall be responsible for weatherproofing the Field-hardened Media Converters' connections with electrical and data cabling to comply with the environmental requirements.

All wiring shall be neat and firm and in conformance with the current National Electrical Code.

Communications, power and all other cabling required to connect to the Field-hardened Media Converter shall be installed in accordance with manufacturer's recommendations.

Security/Maintenance

All internal and external components, including all installed modules, shall be removable and replaceable by a single technician with basic hand tools.

Documentation and Training

The Field-hardened Media Converter, and all associated hardware shall comply with the documentation and training requirements stated in Specification 100 – General Provisions and Specification 300 – Training.

Testing

The Gigabit Ethernet Switch, and all associated equipment and cabling shall conform to the testing requirements stated in the Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

In addition to the testing required elsewhere in these specifications, the Contractor shall be required to do additional testing on this Item. The testing and test procedures shall include, but not be limited to the following:

- The Contractor shall conduct tests to verify compliance with the specifications, plans, and all requirements.
- The Contractor shall verify that the Field-hardened Media Converters are compatible with other System equipment, including the CCTV Camera Assembly (Busway).
- The Contractor shall perform Visual and Mechanical tests, which include the following:
    - Inspect for physical damage
    - Check for proper labeling
    - Compare equipment nameplate information and connections with the drawings and report any discrepancies
    - Check tightness and weatherproofing of connections
    - Verify that the proper components have been installed
- All Field-hardened Media Converters furnished by the Contractor shall be tested and subjected to a nominal 72-hour burn-in period at the factory. The factory tests shall be in accordance with the manufacturer's standard procedures and quality assurance program.
- The Contractor shall provide the Department with a copy of the manufacturer's test procedures and quality assurance procedures for information. If the Department determines that these procedures are not adequate, the Department may require that the Contractor conduct additional tests prior to installation. The Contractor shall provide documentation certifying and showing that each item supplied has passed factory inspection, burn-in and testing.

METHOD OF MEASUREMENT

This work shall be measured for payment by the number of Field-hardened Media Converter units of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each Field-hardened Media Converter shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 - General Provisions.

SPECIFICATION 505 – OPTICAL FIBER CABLE (12 STRAND)

SPECIFICATION 506 – OPTICAL FIBER CABLE (48 STRAND)

DESCRIPTION

This item shall consist of furnishing, installing, splicing, testing and connecting single-mode Optical Fiber Cables (Fiber). Optical Fiber Cabling shall provide high-bandwidth communication networking capability to the ITS equipment in the busway system.

The single mode Optical Fiber Cables discussed in this item shall consist of:

- The Optical Fiber Cable (48 Strand), which shall be used as Distribution Cable installed along the busway, interconnecting the stations and the Busway Operations Center (BOC). It shall form the fiber backbone for the Busway network.
- The Optical Fiber Cable (12 Strand), which shall be used as Drop Cable installed from the distribution cable to specific equipment locations along the busway.
- SC Fiber Optic Connectors (Connectors)

References and Standards

All fiber optic system hardware shall be compliant with the following specifications:

Electronics Industries Association (EIA):

- EIA-310-C Racks, Panels, and Associated Equipment.
- EIA-359-A Colors for Color Identification and Coding.
- EIA-422-A Electrical Characteristics of Balanced Voltage Digital Interface Circuits.
- EIA-TIA-455-A Standard Test Procedures for Fiber Optic Fibers, Cable Transducer Sensors, Connecting and Terminating Devices and Other Fiber Optic Components.
- EIA-455-6B Cable Retention Test Procedure for Fiber Optic Cable Interconnecting Devices.
- EIA-485 Standard for Electrical Characteristics of Generators and Receivers for use in Balanced Digital Multipoint Systems.
- TIA/EIA-598-A Optical Fiber Cable Color Coding.
- FOTP References

Other

- USDA Rural Utilities Service (RUS) 7 CFR 1755.900.
- ANSI/ICEA Standard for Fiber Optic Outside Plant Communications Cable, ANSI/ICEA S-87-640-1992
- Underwriters Laboratories-listed OFNR,
- Candian Standards Authority-listed FT-4
- National Electrical Safety Code Section 350G

MATERIALS

General

All materials shall be new, conforming to UL and RoHS standards, meeting the requirement od all enforcing authorities having jurisdiction, and be approved by the Engineer. All equipment shall be the latest revision or product version under production by the equipment supplier. Obsolete, no-longer-supported, or no-longer-produced equipment will not be acceptable. Like itesm shall be all the same manufacturer and type and/or approved by the Engineer.

Manufacturer Requirements

The manufacturer of the Optical Fiber Cable shall be regularly engaged in the manufacture and production of high quality fiber cable for use in communications networks. The manufacturer shall have a minimum of ten (10) years experience in the design, manufacture, and testing of Optical Fiber Cable and Connectors. The manufacturer shall be ISO 9001 certified.

Physical Requirements

All Optical Fiber Cables, coatings, tubes, metals and jackets shall be free of roughness, porosity, blisters, splits and voids in accordance with good manufacturing practice.

The nominal outer diamater shall be 10.5mm.

Minimum bend radius during installation shall be 6.2 in and 4.1 in during operation.

The buffer tubes shall contain 12 fibers and be resistant to external forces, kinking and shall meet the buffer tube cold bend and shrinkback requirements of 7 CFR 1755.900.

Each buffer tube shall contain a water blocking element for water-blocking protection. The water-swellable element shall be non-nutritive to fungus, electrically non-conductive, and

homogenous. It shall also be free from dirt and foreign matter. This element will preclude the need for other water-blocking material; the buffer tubes shall be gel-free.

Buffer tubes shall be stranded around the dielectric central member using the reverse oscillation, or "S-Z", stranding process. Water blocking yarn(s) shall be applied longitudinally along the central member during stranding.

Each fiber and buffer tube shall be distinguishable by means of color coding in accordance with TIA/EIA-598, "Optical Fiber Cable Color Coding."

Filler rods may be included in the cable core to lend symmetry to the cable cross-section where needed. Fillers shall be placed so that they do not interrupt the consecutive positioning of the buffer tubes.

The central member shall consist of a dielectric, glass reinforced plastic (GRP) rod. The purpose of the central member is to provide tensile strength and prevent buckling of the cable. The GRP rod shall be overcoated with a thermoplastic, when required, to achieve dimensional sizing to accommodate buffer tubes/fillers.

A water blocking tape shall be applied longitudinally around the outside of the stranded tubes/fillers. The tape shall be held in place by a single polyester binder yarn. The water blocking tape shall be non-nutritive to fungus and electrically non-conductive.

Two polyester yarn binders shall be applied contra-helically with sufficient tension to secure each buffer tube layer to the dielectric central member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking and dielectric with low shrinkage.

The fiber cable shall be able to withstand a maximum pulling tension of 2700 N during installation and 810 N (180 lbf) long term installed without any resulting damage. Tensile strength shall be provided by dielectric yarns. The high tensile strength dielectric yarns shall be helically stranded evenly around the cable core.

The outer jacket of the fiber cables hall be constructed of medium or high density polyethylene. The minimum nominal jacket thickness shall be 1.4 mm. Jacketing material shall be applied directly over the tensile strength members and water blocking tape. The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus. HDPE/MDPE jacket material shall be as defined by ASTM D1248, Type II, Class C and Grades J4, E7 and E8.

The jacket shall be continuous, free from pinholes, splits, blisters, or other imperfections. The jacket shall have a consistent, uniform thickness; jackets extruded under high pressure are not acceptable. The jacket shall be smooth, as is consistent with the best commercial practice. The jacket shall provide the cable with a tough, flexible, protective coating, able to withstand the stresses expected in normal installation and service.

All jacketed Optical Fiber Cables shall contain at least one ripcord under the sheath (outer jacket) for easy sheath removal.

The Optical Fiber Cable jacket shall be marked with manufacturer's name, sequential meter or foot markings, month, year or quarter year of manufacture, and a telecommunications handset symbol, as required by Section 350G of the National Electrical Safety Code. The actual length of the cable shall be within 1% of the length markings.

If the initial marking fails to meet the specified requirements (i.e., improper text statement, color, legibility, or print interval) the cable may be remarked using a contrasting alternate color. The numbering sequence will differ from the previous numbering sequence, and a tag will be attached to both the outside end of the cable and to the reel to indicate the sequence of remarking. The preferred remarking color will be yellow; the secondary choice will be blue.

Materials used in the cable shall not produce hydrogen in a concentration large enough to cause any degradation in the transmission performance of the Optical Fiber Cables.

The color coding and position of Fibers/buffer tubes within the cable shall be in accordance with TIA/EIA–598-A "Optical Fiber Cable Color Coding". Fibers shall be colored with ultraviolet curable ink. In buffer tubes containing multiple Fibers, the colors shall be stable across the specified storage and operating temperature range and not subject to fading or smearing onto adjacent Fibers or into the gel filing material. Color materials shall not cause Fibers to stick together.

The fiber shall consist of a doped silica core surrounded by a concentric silica cladding. The fiber shall be matched clad design.

The tensile strength shall be provided by the central member, and additional dielectric yarns as required. The dielectric yarns shall be helically stranded evenly around the cable core.

The dispersion un-shifted or dispersion flattened fiber shall comply with the following specifications:

- The Fiber core shall have a diameter of between 8.2 to 9 μm inclusive with a tolerance of ± 1.3 μm.
- The cladding shall have an outer diameter of 125 μm with a tolerance of ±1.0 μm.
- The core-to-cladding offset shall not be greater than 0.6 μm.
- The cladding Non-Circularity shall not be greater than 1.0%. The cladding Non-Circularity is defined as,

  (1 - (Minimum Cladding Diameter/Maximum Cladding Diameter)) x 100

The fiber shall be coated with a protective polymer to preserve its strength. The coating shall be removable by mechanical or chemical means. The coating shall retain its color when subject to the manufacturer's recommended Fiber cleaning and splicing preparation methods.

Fiber Optic Connectors

The Connectors shall have a ceramic ferrule with a square front profile and moulded plastic body.

The Connectors shall be of the SC type and fully compatible with the fiber optic cable utilized and the mating jacks to which they will be attached.

The Connector shall be compatible with a physical contact (PC) finish.

Index matching fluids or gels shall not be used.

Connectors shall be protected by a suitably installed waterproof protection cap.

Attenuation shall not exceed 0.3dB for each connector.

The Connector mean loss shall not be greater than 0.2 dB with a standard deviation of not greater than 0.1 dB.

The Connector loss shall not vary more than 0.1 dB after 500 repeated matings.

The Connector shall withstand an axial load of 135 N.

The Connectors shall be attached in accordance with the manufacturer's recommended materials, equipment and practices.

The Connector loss shall not vary more than 0.2 dB over the operating temperature range.

Pull Tape

Pull Tape shall consist of polyethylene or PVC jacket woven into the polyester tape. The pull tape shall not “burn in” to the innerducts under normal pulling conditions or as specified herein.

The pull tape shall have the following properties:

- 1250lb tensile strength
- Flat, not round construction
- Printed foot markings
- Pre-lubricated

- Moisture resistant

Environmental Requirements

Criteria	Minimum Conditions to be Met
Operating Temperatures	-40°F to 167°F (-40°C to 80°C)
Installation Temperatures	14°F to 185°F (-10°C to 85°C)
Water and Solvents	Shall withstand water spray on equipment from cleaning floors and walls, industrial solvents, rain, mud, snow and slush, all of which may contain salt, which may come in contact with equipment.

The Optical Fiber Cable shall be suitable for installation and operation in outdoor ducts.

Performance Specifications

The change in attenuation at extreme operational temperatures (-40°F to 167°F) shall not exceed 0.3 dB/km at 1550 nm for Fiber and 0.4 db at 1310 nm wavelengths.

The storage temperature range for the cable on the original shipping reel shall be -40°F to 167°F. The installation temperature range for the cable shall be -10°F to 176°F. The operating temperature range for the cable shall be -40°F to 167°F. Testing shall be in accordance with FOTP-3.

When tested in accordance with FOTP-33, "Fiber Optic Cable Tensile Loading and Bending Test," and FOTP-38, “Measurement of Fiber Strain in Cables Under Tensile Load,” a length of cable shall be tested to the rated tensile load. The rated tensile load shall be 2670 N (600 lbf). While under the rated tensile load, the fiber shall not experience a measured fiber strain greater than 60% of the fiber proof test level. After being held at the residual load (30% of the rated tensile load) the fiber shall not experience a measured fiber strain greater than 20% of the fiber proof test level nor an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode). After the tensile load is removed, the fibers shall not experience an attenuation change greater than 0.40 dB at 1550 nm (singlemode) or greater than 0.60 dB at 1300 nm (multimode).

When tested in accordance with FOTP-41, "Compressive Loading Resistance of Fiber Optic Cables," the cable shall withstand a minimum compressive load of 220 N/cm (125 lbf/in) applied uniformly over the length of the sample. The 220 N/cm (125 lbf/in) load shall be applied at a rate of 2.5 mm (0.1 in) per minute. The load shall be maintained for a period of 1 minute. The load shall then be decreased to 110 N/cm (63 lbf/in). Alternatively, it is acceptable to remove the 220

N/cm (125 lbf/in) load entirely and apply the 110 N/cm (63 lbf/in) load within five minutes at a rate of 2.5 mm (0.1 in) per minute. The 110 N/cm (63 lbf/in) load shall be maintained for a period of 10 minutes. Attenuation measurements shall be performed before release of the 110 N/cm (63 lbf/in) load. The change in attenuation shall not exceed 0.40 dB at 1550 nm for single-mode fibers.

When tested in accordance with FOTP-104, "Fiber Optic Cable Cyclic Flexing Test," the cable shall withstand 25 mechanical flexing cycles at a rate of 30 ± 1 cycles per minute. The fiber shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode). No cracks, splits, tears or other opening shall be present on the inner or outer surface of the jacket. No visible cracks greater than 5 mm in the armor, if present, shall be present.

When tested in accordance with FOTP-85, "Fiber Optic Cable Twist Test," a length of cable no greater than 2 meters will withstand 10 cycles of mechanical twisting. The fiber shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode). No cracks or splits in the jacket shall be present when inspected under 5X magnification.

When tested in accordance with FOTP-37, "Fiber Optic Cable Bend Test, Low and High Temperature," the cable shall withstand four full turns around a mandrel at test temperatures of -50°F and 140°F. The fibers shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode).

When tested in accordance with FOTP-37, "Fiber Optic Cable Bend Test, Low and High Temperature," the cable shall withstand four full turns around a mandrel at test temperatures of -50°F and 140°F. The fibers shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode).

When tested in accordance with FOTP-3, "Procedure to Measure Temperature Cycling Effects on Optical Fiber, Optical Cable, and Other Passive Fiber Optic Components," the change in attenuation after 2 cycles at extreme operational temperatures (-40°F to 158°F) shall not exceed 0.40 dB/km at 1550 nm (single-mode) or 0.60 dB/km at 1300 nm (multimode). The change in attenuation is measured with respect to the baseline values measured at room temperature before temperature cycling after the last low and last high temperature.

When tested in accordance with FOTP-82, “Fluid Penetration Test for Fluid-Blocked Fiber Optic Cable”, a one meter length of unaged cable shall withstand a one meter static head or equivalent continuous pressure of water for one hour without leakage through the open cable end.

When tested in accordance with FOTP-25, "Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies," the cable shall withstand a minimum of 2 impact cycles at 3 locations separated by at least 150 mm. The impact energy shall be 2.9 N•m. The cable shall be conditioned for at least 4 hours at the minimum installation temperature (14°F). The presence of visible cracks on either the inner or outer surface of the jacket constitutes a failure. No optical

measurements are required.

A one meter length of undamaged Optical Fiber Cable shall withstand a one meter static head or equivalent continuous pressure of water for cable end.

The Optical Fiber Cable shall exhibit no flow (drip or leak) of filling and/or flooding material at 149°F.

The Optical Fiber Cable shall withstand 25 mechanical flexing cycles around a sheave diameter not greater than 20 times the cable diameter. The change in attenuation shall not exceed 0.1 dB at 1550 nm for Fiber.

The Optical Cable shall withstand 25 impact cycles. The change in attenuation shall not exceed 0.2 dB at 1550 nm for Fiber.

Using a maximum mandrel and sheave diameter of 560 mm, the Distribution Cable shall withstand a tensile load of 2700 N (608 lbf). The change in attenuation shall not exceed 0.2 dB during loading and 0.1 dB after loading at 1550 nm for single-mode fiber.

A length of Optical Fiber Cable no greater than 4 meters shall withstand 10 cycles of mechanical twisting. The change in attenuation shall not exceed 0.1 dB at 1550 nm for single-mode fiber.

The Optical Fiber Cable shall withstand a simulated lightning strike with a peak value of the current pulse equal to 105 kA without loss of fiber continuity. A damped oscillatory test current shall be used with a maximum time-to-peak value of 15 μs (which corresponds to a minimum frequency of 16.7 kHz) and a maximum frequency of 30 kHz. The time to half-value of the waveform envelope shall be from 40 - 70 μs.

The Optical Fiber Cable shall withstand four full turns around a mandrel of ≤ 10 times the cable diameter for non-armored cables and ≤ 20 times the cable diameter for armored cables after conditioning for four hours at test temperatures of -22°F and 140°F. Neither the inner or outer surfaces of the jacket shall exhibit visible cracks, splits, tears or other openings. Optical continuity shall be maintained throughout the test.

The mean optical attenuation at 1310 nm shall not be greater than 0.4 dB/km with a standard deviation not greater than 0.05 dB/km. The maximum attenuation of any continuous length of Fiber at 1310 nm shall not exceed 0.45 dB/km.

The mean optical attenuation at 1550 nm shall not be greater than 0.3 dB/km with a standard deviation not greater than 0.06 dB/km. The maximum attenuation of any continuous length of Fiber shall not exceed 0.36 dB/km.

The Fiber attenuation shall not vary more than 0.2 dB/km over the specified cable operational temperature range.

The maximum dispersion at 1550 nm shall not exceed 18 ps / (nm-km).

Warranty Requirements

The Optical Fiber Cable shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The Optical Fiber Cable shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting equipment from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged equipment, as directed by the Engineer or a designated Department representative.

Optical Fiber Cable, Connectors, associated tools, ties and any other materials required for correct provision of Optical Fiber Cabling per this specification shall be stored in a clean, dry, cool indoor environment.

Adequate storage space shall be provided for these materials in order to ensure that no mechanical stress is exerted on the materials.

Materials that have come in contact with water will be replaced at cost to the Contractor.

Care shall be taken at all times to avoid scraping, denting, or otherwise damaging Optical Fiber Cable before, during or after installation. Damaged Optical Fiber Cable shall be replaced by the Contractor without additional compensation.

Packing and Shipment

The Optical Fiber Cable shall be supplied on reels. Top and bottom end of the cable shall be available for testing. Both ends of the cable shall be sealed to prevent ingress of moisture.

The Optical Fiber Cable shall be in one continuous length per reel with no factory splices in the fiber. Each reel shall be marked to indicate the direction the reel should be rolled to prevent loosening of the cable. Installation procedures and technical support shall be furnished upon request.

Each reel shall have the following information clearly labeled on it:

- Customer
- Customer order number

- Reel number
- Destination
- Ship date
- Manufactured date
- Manufacturer's name
- Cable code
- Length of cable

Installation

Prior to ordering the Optical Fiber Cabling, the Contractor shall submit a detailed cable layout plan showing the proposed reel lengths and splice points.

Optical Fiber Distribution Cable

Optical Fiber Distribution Cable shall be installed in conduit or inner-duct as shown on the Drawings by the Methods defined in this Specification. Distribution Cable shall be installed in the lowest available innerduct in the conduit, as specified below.

The Contractor shall provide Distribution Cable that shall be suitable for placement in an underground environment as shown in the Drawings.

Optical Fiber Drop Cable

Drop Cables shall be of length suitably long to be connected from the Communications Cabinet to the Distribution Cable. Sufficient slack shall be left at each end to allow removal of the Splice Closure and tray, and relocation of the equipment anywhere within the cabinet.

Drop Cable shall be used to connect the Distribution Cable to optical equipment located along the Busway or at the Stations via the fiber termination patch panel (refer to Specification 508 – Optical Fiber Termination Patch Panel) or Splice Enclosure (refer to Specification 507 – Optical Fiber Cable Splice Enclosure).

Drop Cable in the Communications Cabinet shall be spliced to pig-tails in a rack-mounted splice closure. Splicing shall be in accordance with the requirements specified elsewhere in these Specifications and as shown on the Drawings. All unused Fibers shall be properly terminated in accordance with manufacturer recommendations.

The attenuation of Drop Cables after installation, not including the connector loss, shall not exceed 0.1 dB measured at 1310 nm and 1550 nm.

Installation in Ducts and Cable Tray or Ladder Rack

Each fiber optic cable shall be suitable for placement in an underground duct or aerial installation.

Physical installation shall be in accordance with manufacturers' instructions.

Cable shall be installed in innerduct, duct or conduit in the field in locations in accordance with the Drawings.

The Contractor shall install pull tape in the existing innerducts as necessary to install the fiber optic cable. A 2.0 m length of pull tape shall be left coiled, tied, and accessible in each cabinet, vault, maintenance hole and junction box. The pull tape shall be installed according to manufacturer recommendations and shall be "free" and NOT helical about communications cables.

The Contractor shall install cables in innerducts consistently throughout the project; crossover of a cable from one innerduct to another is not allowed.

Duct ends shall have all rough ends smoothed to prevent scraping the cable.

Where Fiber will be installed directly in conduit with no innerduct, a stiff bristle brush shall be pulled through each section of duct before pulling Fiber.

The Contractor shall not exceed the manufacturer's recommended safe pulling tension and minimum bending radius during delivery and installation.

A manufacturer's recommended lubricant shall be applied to the Fiber to reduce friction between the Fiber and the duct.

A cable grip shall be attached to the Fibers so that no direct force is applied to the Fibers. The cable grip shall have a ball bearing swivel to prevent the Fibers from twisting during pulling.

Cable rollers and feeders and winch cable blocks shall be used to guide the Fibers freely into the duct and at maintenance hole locations.

Mechanical aids and pulling cable or ropes shall be used as required.

The Contractor shall employ personnel at as many pull points as need be to achieve the longest continuous Fiber segment as possible to reduce the need for excessive main-line splices.

Personnel equipped with two-way radios shall be stationed at each maintenance hole, cabinet and communications vault at which the Fiber is to be pulled to observe and lubricate the Fiber.

Where mechanical pulling is required (i.e. all runs greater than 50 m), a dynamometer shall be used to record installation tension and a tension limiting device shall be used to prevent exceeding the maximum pulling tension as defined by the Fiber manufacturer. The maximum pulling tension shall be recorded for each run of cable. The cable shall be taken up at intermediate pulling points with an intermediate Fiber take-up device as approved by the Engineer to prevent over tension on the cable. Cable pulls shall be continuous and steady between pull points and shall not be interrupted until the entire run of cable has been pulled.

Distribution Cable segment lengths shall be the maximum tolerable length within the maximum pulling tension defined by the manufacturer. The number of Distribution Cable reel-end splices shall be minimized. The Contractor shall provide a plan to the Engineer showing the reel-end splice point locations following a field investigation of the conduit and shall not install Fiber until receiving the Engineer's approval of the reel-end splice location plan. The Contractor shall obtain the Engineer's approval for all required changes to the reel-end splice point location plans. Fiber segments installed with reel-end splices not approved by the Engineer will be replaced by the Contractor at no additional cost to the Department.

The Contractor shall be responsible for ensuring the Fiber length is sufficient to allow for connection between the communication equipment and the Splice Enclosures, and including provision for slack, vertical runs, cable necessary for splicing, wastage and Fiber to allow for the removal of the splice enclosure for future splicing.

All Connectors shall be protected from moisture ingress by using properly sealed caps.

Following installation of the Fiber in the ducts, all duct entrances at pedestals and cabinets shall be sealed with duct sealing compound to prevent the ingress of moisture, foreign materials, and rodents.

6 m of cable going to and coming from each Splice Enclosure shall be coiled in the first pull box on each side of each closure. In addition, 15 m of cable shall be left coiled in the first pull box on each side of all surface mounted conduit systems.

Where Distribution Cable terminations are left "dead ended", 25 m of cable shall be left coiled.

All coiled Distribution Cable shall be securely fastened in place with a minimum of four galvanized steel conduit straps.

Fish line shall be installed in all communications ducts or conduits along with Fiber. A 2.0 m length of fish line shall be left coiled, tied and accessible in each cabinet, vault, maintenance hole and junction box. The fish line shall be installed according to manufacturer specifications and shall be "free" and NOT helical about communications cables.

At intermediate pulling points, to prevent over tension on the Fiber, the Fiber shall be either taken up with an intermediate Fiber take up device as approved by the Engineer, or all excess

Fiber shall be laid out on the ground in a figure eight configuration before subsequent installation.

Following installation in duct, a label shall be affixed to each Fiber end in a pull box or cable vault and the label shall contain the following information:

- Customer order number
- Reel number
- Ship date
- Manufactured date
- Manufacturer's name
- Cable designation as shown on the Drawings
- Length of cable to next reel-end splice point
- Location of other end of cable (reel-end splice point)
- Cable test data

The Contractor shall support the installation of Fiber to an existing conduit system using cable ties at the locations shown on the plans.

Splicing

Splicing of the cable shall only be permitted at a Splice Enclosure or OFTPP location as indicated in the Drawings, unless authorized by the Engineer.

The Contractor shall splice the designated Fiber of the Distribution Cable to the Drop Cables connecting the communications equipment located in the Communications Cabinet. Sufficient cable shall be coiled in the pullbox/vault/Communications Cabinet to allow for consumption during the splicing and to permit the splice to be removed from the pullbox/vault/Communications Cabinet for future splicing.

At least 1.0m of each Fiber shall be stored in the splice trays. The Contractor shall further splice all additional Fibers provided in order to meet the Fiber requirements specified in the Contract and including any Fibers provided which are additional to the Contract requirements.

In order to reduce the overall number of splices required, Fiber shall be installed in the maximum continuous reel length provided by the manufacturer, or as shown on the plans, or as approved by the Engineer. Factory splices shall not be permitted.

Documentation and Training

The Contractor shall verify the compliance of the Optical Fiber Cable with with performance specification requirements.

The Optical Fiber Cable, and all associated equipment and cabling shall comply with the documentation and training requirements stated in Specification 100 – General Provisions and Specification 300 – Training.

Testing

The Optical Fiber Cable, and all associated equipment and cabling shall comply with the testing requirements stated in Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The Contractor shall employ industry-standard methods and tools to demonstrate that the cable is compliant with Optical Fiber Cable requirements, monitor Optical Fiber Cable performance and compliance with availability requirements throughout the term of the Contract, including all ongoing technical support and maintenance periods.

Pre-Installation Testing

The Contractor shall conduct OTDR tests on each fiber strand in accordance to the specifications below.

Reels of Fiber shall be tested for attenuation prior to installation in ducts. The Contractor shall measure and record the attenuation of 100% of the Fibers on each reel using OTDR testing. Attenuation shall meet or exceed the specified performance requirements in accordance with the Contract.

The Contractor shall ensure that specifications for the Fiber are met prior to installation.

Post-Installation Testing

The Contractor shall measure the attenuation per kilometre of Fiber in each length of Fiber after installation usting OTDR testing.

All (100%) of Fibers assigned to be spare or reserved shall be individually tested for optical attenuation.

The Contractor shall sequence the Fibers which are to be measured after each pull, such that the same Fibers are not measured on consecutive lengths.

The Contractor shall record the reel number from which the Fiber came, the identification of the Fibers measured and the attenuation in dB/km of the Fibers measured.

The Contractor shall measure and record the splice quality of each fusion splice performed. The Engineer shall be provided with access to interim results.

Optical Time Domain Reflectometer (OTDR) Testing

The Contractor shall provide the Engineer with information regarding OTDR test equipment make and model with the equipment calibration procedures and certification dates prior to conducting the test routine.

An OTDR shall be used for backscattered light measurements. The OTDR shall operate at a nominal wavelength of 1310 nm and 1550 nm and shall include all necessary hardware required to couple it with Fiber.

The backscatter light measurement of each Fiber link shall be measured in both directions and at both 1310 nm and 1550 nm wavelengths.

The Contractor shall maintain a test result record of each Fiber link by means of printer copy of the OTDR measured cable attenuation profile. Fiber shall be identified in the test results by identifying the Fiber under test and by identifying the cabinet site or HOC Cabinet at which the OTDR was connected.

The test results shall include the following measurements:

- Total length of the Fiber link
- Total attenuation of the Fiber link
- Attenuation of each splice in the Fiber link under test
- Attenuation per kilometer of each interconnected Fiber in the link under test

Attenuation shall be measured in decibels referencing optical power.

Each Fiber and splice tested shall be tested to meet the performance requirements in accordance with the Contract. Fiber strands failing this test shall be re-terminated and re-tested.
The Contractor shall supply Optical Time Domain Reflectometer (OTDR) certification for each reel of Fiber listing each specification compliant Fiber by Fiber color code and group color code.

METHOD OF MEASUREMENT

Specification 505 – Optical Fiber Cable (12 Strand)

This work shall be measured for payment by the number of feet of Optical Fiber Cable (12 Strand) of the type specified, installed, integrated, completed, tested and accepted in-place. The

unit price for each foot of Optical Fiber Cable (12 Strand) shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

Specification 506 – Optical Fiber Cable (48 Strand)

This work shall be measured for payment by the number of feet of Optical Fiber Cable (48 Strand) of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each foot of Optical Fiber Cable (48 Strand) shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100- General Provisions. The release of payment for all work associated with the implementation of the CT***fastrak*** ITS and Communications Systems shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 507 – OPTICAL FIBER CABLE SPLICE ENCLOSURE

DESCRIPTION

This Item shall consist of furnishing, installing, and testing Optical Fiber Cable Splice Enclosures (Splice Enclosures) to interconnect Optical Fiber Cabling (Fiber – refer to Specification 506 – Optical Fiber Cable (48 Strand) and Specification 505 – Optical Fiber Cable (12 Strand)) segments.

The Optical Fiber Cable Splice Enclosure shall consist of

- Waterproof, environmentally hardened enclosure suitable for total immersion in water
- Stackable splice trays
- Rigid plastic splice tray construction
- Non-metallic housing
- Support a minimum of 72 fiber splices

The Optical Fiber Cable Splice Enclosure shall be installed in existing communications vaults and pullboxes along the busway, as shown on the Drawings.

References and Standards

All Optical Fiber Splice Enclosure hardware shall be compliant with the following standards:

Telecommunications Industry Association (TIA), Electronics Industries Association (EIA):

- TIA/EIA-526.3 Fiber Optic Terminal Equipment Receiver Sensitivity and Maximum Receiver Input
- TIA/EIA -455-32A Fiber Optic Circuit Discontinuities
- EIA-310-E Racks, Panels, and Associated Equipment
- EIA-359-A Colors for Color Identification and Coding
- TIA/EIA-455-B Standard Test Procedure for Fiber Optic Fibers, Cables Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components
- TIA/EIA-455-6B Cable Retention Test Procedure for Fiber Optic Cable Interconnecting Devices
- TIA/EIA-598-C Optical Fiber Cable Color Coding
- TIA/EIA-609000

MATERIALS

General

The Optical Fiber Cable Splice Enclosure shall be connected to the Optical Fiber Distribution and Optical Fiber Drop Cable (refer to Specification 506 – Optical Fiber Cable (48 Strand) and Specification 505 – Optical Fiber Cable (12 Strand)).

The Optical Fiber Cable Splice Enclosure, and all associated equipment and cabling shall comply with the Materials requirements stated in Specification 100 – General Provisions. If conflicts exist, this Item specification shall govern.

Manufacturer Requirements

The manufacturer of the Splice Enclosures shall be regularly engaged in the manufacture and production of high quality splice enclosures and related optical fiber equipment for use in communications networks for at least ten (10) years.

Physical Requirements

The Splice Enclosures shall accommodate a minimum of at least 72 Fiber splices. Each Splice Enclosure shall have a splice tray organizer capable of holding 6 to 12 splice trays. The organizer shall provide access to and removal of individual splice trays and permit selective splicing to allow one or more Fibers to be cut and spliced to branch Fiber(s) without disrupting other Fibers.

The Contractor shall install Splice Enclosures with spare capacity to allow splicing of 24 Fibers more than the current Fiber count at any given splice location as shown on the Drawings.

Each splice tray shall be able to accommodate a minimum of 12 fusion splices for the single mode fiber cable of the type selected. The splice trays shall be compatible with the splice enclosure, and shall be constructed of rigid plastic.

Environmental Requirements

The Splice Enclosure shall be capable of performing in a cable vault or pullbox, where total and continuous immersion in water is to be expected.

All materials in the enclosures shall be non-reactive and shall not support galvanic cell action.

All environmentally exposed components of the Splice Enclosure shall be UV light resistant.

Functional Requirements

The Splice Enclosure shall fit within the space allocated for it as shown on the Drawings and shall be rated to operate within the environment in which it is to be installed.

The outer enclosure shall be compatible with the other enclosure components, splice trays, and fibers. The end plate shall consist of two sections and shall have the capacity for a minimum of five (5) fiber entries.

All Splice Enclosures shall employ re-usable sealing materials allowing multiple re-entrances without replacing any component. Access to the Splice Enclosures shall be accomplished without the use of special tools or devices. The Splice Enclosure shall employ a latching mechanism for entrance to the internal components of the enclosure.

All splice trays shall be lined to provide a contrasting background for splicing colored fibers. The splice trays shall include clear snap-on covers and tie wraps to secure the buffer or transport tubes to the tray. The splice trays shall be of adequate size to prevent induced attenuation due to fiber bending.

The splice tray shall have features that retain the fiber loops and control the bend radius. The splice tray cover shall be clear plastic to allow for inspection of the fiber without opening the tray.

Vinyl markers shall be supplied to identify each fiber to be spliced within the enclosure. Each splice shall be individually mounted and mechanically protected on the splice tray.

The splice closure housing shall be non-metallic. It shall be resistant to solvents, stress cracking, and creep. The housing materials shall also be compatible with chemicals and other materials to which they might be exposed in specified environment.

Warranty Requirements

The Splice Enclosure shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The Splice Enclosure shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting equipment from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged equipment, as may be determined by the Engineer or a designated Department representative.

Installation

Splice Enclosures shall be installed at locations as shown in the Drawings. Unless otherwise specified, Splice Enclosures shall be installed within existing communications vaults and pullboxes and at fiber reel-end splice locations as shown on the Drawings. The Contractor shall confirm locations with the Engineer or a designated Department representative.

The installations shall include all required components including sealing kits, fiber racking hardware and mounting hardware to achieve an environmentally secure permanent installation.

The Contractor shall supply all materials, tools, equipment and labor, including but not limited to, trays, and any other incidentals necessary to complete the installation of the Fiber Splice Enclosure.

The Splice Enclosure shall be secured to the interior of the cavity of the communications vault or pullbox using materials and methods approved by the Engineer.

The Splice Enclosure shall be mounted in such position to allow the fiber to enter and exit the enclosure without exceeding the cables' minimum bending radius.

Sufficient cable shall be coiled in the vault to allow the Splice Enclosure to be removed from the vault for current and future splicing and fiber repairs, as specified in Specification 506 – Optical Fiber Cable (48 Strand) and Specification 505 – Optical Fiber Cable (12 Strand).

In no cases shall the Splice Enclosure be allowed to rest on the bottom of the pullbox or vault.

After the splice trays are placed inside the Splice Enclosure, the Splice Enclosure shall be sealed using a procedure recommended by the manufacturer that will provide a waterproof environment for the splices. The individual fiber shall be looped at least one full turn within the Splice Enclosure to avoid micro bending.

Care shall be taken at the fiber entry points to ensure a waterproof seal is made which will not leak with aging.

All splices shall be protected with a thermal shrink sleeve and shall be labeled in the splice tray with permanent vinyl markers. Butt ends shall also be labeled to identify the destination of the fiber.

The splices shall be fabricated using modern, high quality fusion type splicing equipment. All splicing equipment shall be in good working order, properly calibrated, and meeting all industry standards and safety regulations. Optical Fiber Cable preparation, Enclosure installation, and splicing shall be accomplished in accordance with accepted and approved industry standards.

Fiber shall be spliced as noted on the plans using the fusion type, and the maximum splice loss shall not exceed the loss per splice in each direction as specified elsewhere.

All splices shall be arranged neatly in splice trays, supported and protected with a suitable splice protector.

Only the fibers required to be spliced to Drop Cables shall be severed and spliced. Where required, the buffer tube splitting tool recommended by the manufacturer shall be used to open the correct buffer tube. Unsevered fibers in an open buffer tube shall be coiled in the splice tray. When buffer tubes do not need to be opened, at least 1.0 m of unopened buffer tubes shall be coiled in the Splice Enclosure.

Fiber identification shall be in accordance with the tables and schedules provided in the Contract Drawings.

Upon completion of the splicing operation, all waste material shall be deposited in suitable containers, removed from the job site, and disposed of in an environmentally acceptable manner.

Security/Maintenance

All internal components, including all installed modules, shall be removable and replaceable by a single technician with basic hand tools.

Testing

The Contractor shall provide a certification that the equipment complies with the following test results.

The closure central member clamp shall prevent movement (e.g. bowing, pistoning, or breaking) of the cable central member (CM) when the CM exerts a force of 100 lbf on the clamp.

The closure shall be capable of safe and proper assembly at temperatures of 0 °C ± 2 °C (32 °F ± 3.6 °F) and 40 °C ± 2 °C (104 °F ± 3.6 °F) using materials and procedures specified by the manufacturer.

The cable clamping and sealing hardware used to terminate optical fiber cable shall not cause an attenuation change greater than ± 0.05 dB per fiber, when tested with a source operating at 1550 nm ± 20 nm.

Sealing components (gaskets, grommets, O-rings) used in a closure, shall not permit the entry of water into the closure after thermal aging at 90 °C ± 1 °C (194 °F ± 1.8 °F) for 720 hours (30 days).

An axial load of 100 lbf, individually applied to each cable, shall not cause mechanical damage to the cable or clamping hardware. The load to the optical fiber cable shall not cause an attenuation change greater than ± 0.05 dB per fiber, when tested with a source operating at 1550 ± 20 nm.

Subjecting the closure/cable interface to 90° flexing for 8 cycles at ambient temperatures of –18 °C ± 2 °C (0 °F ± 3.6 °F) and 40 °C ± 2 °C (104 °F ± 3.6 °F) shall not cause any mechanical damage to the cable or clamping hardware. In addition, flexing of the optical fiber cable shall not cause an attenuation change greater than ± 0.05 dB per fiber, when tested with a source operating at 1550 ± 20 nm.

Subjecting the closure/cable interface to 10 cycles of torsional loading at ambient temperatures of –18 °C ± 2 °C (0 °F ± 3.6 °F) and 40 °C ± 2 °C (104 °F ± 3.6 °F) shall not cause any mechanical damage to the cable or clamping hardware. In addition, torsional loading of the optical fiber cable shall not cause an attenuation change greater than ± 0.05 dB per fiber, when tested with a source operating at 1550 ± 20 nm.

The closure shall not exhibit any mechanical damage after being subjected to mechanical impact of 100 lbf (136 Nm) at temperatures of –18 °C ± 2 °C (0 °F ± 3.6 °F) and 40 °C ± 2 °C (104 °F ± 3.6 °F).

The closure shall not exhibit any mechanical damage or corrosion following 30 days of severe temperature and humidity cycling from 65 °C ± 2 °C (150 °F ± 3.6°F) and 95% relative humidity to –40 °C ± 2 °C (-40 °F ± 3.6 °F) and uncontrolled humidity. Additionally, at the midpoint of the temperature cycle, re-entry and re-assembly of the closure shall be done. If the closure has a hinged cover, it shall be flexed 25 times.

The closure shall show no evidence of water intrusion into the compartment containing fiber splices after it is immersed in water and subjected to 10 freeze/thaw cycles.

The closure shall show no change in sealing ability after immersion in a specified chemical test fluid for 7 days. The mechanical integrity of the closure shall be confirmed by performing the compression and impact tests. The closure seal shall also be checked by performing the water immersion test. Additionally, samples of external, non-metallic closure materials shall neither experience a change in weight greater than 10%, nor experience a reduction in tensile strength or elongation properties greater that 20%, after immersion in the chemical test fluid.

Samples of external, non-metallic closure materials shall not have a reduction in tensile strength or elongation properties greater than 20% of their original value, after being exposed to a UV-B type ultraviolet light source with a peak emission at 313 nm for 2,160 hours (90 days).

Samples of polymeric closure materials shall not support fungus growth when tested per ASTM G 21. A rating of 0 is required.

A closure shall show no evidence of corrosion following exposure to acidified saltwater for a period of 90 days.

All fiber optic cables, splices, and terminations shall be tested using an Optical Time Domain Reflectometer (OTDR). OTDR testing shall occur after completion of the installation, splice, or termination.

Acceptable loss per each fiber, per direction, shall be the sum of the cable length times the specified loss as indicated above. An allowance of 0.05 dB per fusion splice will be granted. Any cable, termination, or splice, installed under this contract, with losses in excess of the acceptable limit shall be repaired, or replaced by the Contractor at the Contractor’s sole expense.

Where OTDR results indicate excessive loss, or other problems, in existing fibers, terminations, or splices, the Contractor shall be responsible for correcting faults at no cost to the client.

The Contractor shall test all splices for signal loss.

METHOD OF MEASUREMENT

This work shall be measured for payment by the number of units of Optical Fiber Cable Splice Enclosures of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each Optical Fiber Cable Splice Enclosure shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the CT***fastrak*** ITS and Communications Systems shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 508 – OPTICAL FIBER TERMINATION PATCH PANEL (48-PORT)

DESCRIPTION

This item shall consist of furnishing, installing, and testing an Optical Fiber Termination Patch Panel (OFTPP) (48-port) for termination, splicing and inter-connection of Optical Fiber Cable (Fiber) (refer to Specification 506 – Optical Fiber Cable (48 Strand) and Specification 505 – Optical Fiber Cable (12 Strand)) between the Optical Fiber Drop Cable and Optical Cabling from the Gigabit Ethernet Switches (refer to Specification 502 – Gigabit Ethernet Switch (Type A), and Specification 503 – Gigabit Ethernet Switch (Type B)) at the busway stations and Busway Operations Center (BOC), and at other locations shown on the Drawings.

The OFTPP shall include:

- Fiber strain- relief
- Splice trays
- Fiber optic pigtails
- Splices
- All necessary equipment

This Item shall also include all labor necessary to complete this Item as described in this specification.

References and Standards

Electronic Industries Alliance / Telecommunications Industry Association (EIA/TIA):

- ANSI/EIA/TIA-455-34: Fibre Optics-Interconnection Device Insertion Loss Test (factory testing)
- ANSI/EIA/TIA-455-59: Fibre Optics-Interconnection Device Insertion Loss Test (field testing)
- TIA/EIA-455-B Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and other Fiber Optic Components
- TIA/EIA-526 Standard Test Procedures for Fiber Optic Systems

MATERIALS

General

Each OFTPP shall consist of the following components:

- Constructed of high-grade steel material
- Steel cover shall be removable for cabling and connections access
- Side and rear cable entry
- Rack-mountable

The OFTPP, and all associated equipment and cabling shall comply with the Materials requirements stated in Specification 100 – General Provisions. If conflicts exist, this Item specification shall govern.

Manufacturer Requirements

The manufacturer of the OFTPP shall be regularly engaged in the manufacture and production of high quality fiber patch panels and related optical fiber equipment for use in communications networks for at least ten (10) years.

Physical Requirements

The OFTPP shall be rack mountable and have the capacity to terminate a minimum of forty-eight (48) fibers into SC type connectors.

The OFTPP shall have a splice tray organizer capable of holding a minimum of 8 splice trays. The organizer shall provide access to and removal of individual splice trays and permit selective splicing to allow one or more fibers to be cut and splice to branch cable without disrupting other fibers.

The OFTPP shall include splice trays to interconnect fused fibers.

Polyethylene tubes shall be supplied to protect exposed individual fiber splices within the closure.

Vinyl markers shall be supplied to identify each fiber to be spliced within the closure.

Each splice tray shall be capable of accommodating a minimum of 6 fusion splices for the single mode fiber (refer to Specification 505 Optical Fiber Cable (12 Strand) and Specification 506 Optical Fiber Cable (48 Strand)). The splice trays shall be compatible with the splice closure and shall be constructed of rigid plastic.

All fiber connection shall be identified on a label permanently affixed to the Communications Cabinet door. The label shall show the connector position and the designated Optical Fiber transmission equipment.

The OFTPP shall protect the fiber splices from mechanical damage, shall provide strain relief for the fiber, and shall be manufactured of non-corroding materials.

All splice trays shall have a contrasting background for splicing colored fibers. The splice trays shall include clear snap-on covers, and tie-wraps to secure the buffer or transport tubes to the tray. The splice trays shall be of adequate size to prevent induced attenuation due to fiber bending.

The splice tray shall have features that retain the fiber loops and control the bend radius. The splice tray cover shall be clear plastic to allow for inspection of the fibers without opening the tray.

Warranty Requirements

The OFTPP shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The OFTPP shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting equipment from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged equipment, as may be determined by the Engineer or a designated Department representative.

OFTPPs, associated tools, and any other materials required for correct provision of OFTPPs per this specification shall be stored in a clean, dry, cool indoor environment.

Adequate storage space shall be provided for these materials in order to ensure that no mechanical stress is exerted on the materials.

Materials that have come in contact with water will be replaced at cost to the Contractor.

Installation

The OFTPP shall be mounted in the Communications Cabinets at busway stations, at the BOC, and at other locations as shown on the Drawings.

The Contractor shall install the OFTPP at the locations shown on the Drawings and shall provide and install all fiber patch cords between the optical equipment and the OFTPP as shown on the Drawings.

All fiber splicing shall use modern, high quality fusion type splicing equipment.

All splices shall be arranged neatly in splice trays, supported and protected with a suitable splice protector.

The Contractor shall neatly train all fiber and pigtails together when routing them along the same path and shall neatly train them along the support rails equipment cabinet.

No fibers shall be installed with a bend radius less than the manufacturer's minimum recommended bending radius.

The Contractor shall install and provide all splicing and termination required to connect Optical Fiber Distribution Cable (refer to Specification 506 – Optical Fiber Cable (48 Strand) and Specification 505 – Optical Fiber Cable (12 Strand) to the equipment shown on the Drawings and specified elsewhere in this project.

Security/Maintenance

All internal components, including all installed modules, shall be removable and replaceable by a single technician with basic hand tools.

Documentation and Training

The OFTPP and all associated equipment and cabling shall conform to the documentation and training requirements stated in Specification 100 – General Provisions and Specification 300 – Training.

Testing

The OFTPP and all associated equipment and cabling shall conform to the testing requirements stated in the Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The fiber path shall be tested and verified in accordance with this Contract prior to the connection to the equipment.

The Contractor shall be responsible for all testing that may be required to establish approval and acceptance of the OFTPP.

METHOD OF MEASUREMENT

This work shall be measured for payment by the number of units of Optical Fiber Termination Patch Panels (48-port) of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each Optical Fiber Termination Patch Panel (48-port) shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the CT***fastrak*** ITS and Communications Systems shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 509 – OPTICAL FIBER TERMINATION PATCH PANEL (12-PORT)

DESCRIPTION

This item shall consist of furnishing, installing, and testing a Optical Fiber Termination Patch Panel (OFTPP) for termination, splicing and inter-connection of Optical Fiber Cable (Fiber) (refer to Specification 505 – Optical Fiber Cable (12 Strand)) between the Optical Fiber Drop Cable and Optical Cabling from the Gigabit Ethernet Switches (refer to Specification 502 – Gigabit Ethernet Switch (Type A), and Specification 503 – Gigabit Ethernet Switch (Type B)) at the existing secondary field cabinets at the locations shown on the Drawings.

The OFTPP shall include:

- Fiber strain- relief
- Splice trays
- Fiber optic pigtails
- Splices
- All necessary equipment

This Item shall also include all labor necessary to complete this Item as described in this specification.

REFERENCES AND STANDARDS

Electronic Industries Alliance / Telecommunications Industry Association (EIA/TIA):

- ANSI/EIA/TIA-455-34: Fibre Optics-Interconnection Device Insertion Loss Test (factory testing)
- ANSI/EIA/TIA-455-59: Fibre Optics-Interconnection Device Insertion Loss Test (field testing)
- TIA/EIA-455-B Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and other Fiber Optic Components
- TIA/EIA-526 Standard Test Procedures for Fiber Optic Systems

MATERIALS

General

Each OFTPP shall include the following:

- Removable cover or mid-span access for cabling and connections access
- Corrosion-resistant metal construction

The OFTPP, and all associated equipment and cabling shall comply with the Materials requirements stated in Specification 100 – General Provisions. If conflicts exist, this Item specification shall govern.

Manufacturer Requirements

The manufacturer of the OFTPP shall be regularly engaged in the manufacture and production of high quality fiber patch panels and related optical fiber equipment for use in communications networks for at least ten (10) years.

Physical Requirements

The OFTPP shall be rated for outdoor use.

The OFTPP shall have the capacity to terminate a minimum of twelve (12) fibers into SC type connectors.

The OFTPP shall have a splice tray organizer capable of holding a single splice tray. The organizer shall provide access to and removal of the individual splice tray and permit selective splicing to allow one or more fibers to be cut and splice to branch cable without disrupting other fibers.

The OFTPP shall include a splice tray to interconnect fused fibers.

Polyethylene tubes shall be supplied to protect exposed individual fiber splices within the closure.

Vinyl markers shall be supplied to identify each fiber to be spliced within the closure.

Each splice tray shall be capable of accommodating a minimum of 6 fusion splices for the single mode fiber (refer to Specification 505 Optical Fiber Cable (12 Strand)). The splice tray shall be compatible with the splice closure and shall be constructed of rigid plastic.

All fiber connection shall be identified on a label permanently affixed to the door of the secondary field cabinet. The label shall show the connector position and the designated Optical Fiber transmission equipment.

The OFTPP shall protect the fiber splices from mechanical damage, shall provide strain relief for the fiber, and shall be manufactured of non-corroding materials.

All splice trays shall have a contrasting background for splicing colored fibers. The splice trays shall include clear snap-on covers, and tie-wraps to secure the buffer or transport tubes to the tray. The splice trays shall be of adequate size to prevent induced attenuation due to fiber bending.

The splice tray shall have features that retain the fiber loops and control the bend radius. The splice tray cover shall be clear plastic to allow for inspection of the fibers without opening the tray.

Warranty Requirements

The OFTPP shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The OFTPP shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting equipment from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged equipment, as may be determined by the Engineer or a designated Department representative.

OFTPPs, associated tools, and any other materials required for correct provision of OFTPPs per this specification shall be stored in a clean, dry, cool indoor environment.

Adequate storage space shall be provided for these materials in order to ensure that no mechanical stress is exerted on the materials.

Materials that have come in contact with water will be replaced at cost to the Contractor.

Installation

The OFTPP shall be mounted in secondary communication cabinets at platforms at stations as shown on the Drawings.

The Contractor shall install the OFTPP at the locations shown on the Drawings and shall provide and install all fiber patch cords between the optical equipment and the OFTPP as shown on the Drawings.

All fiber splicing shall use modern, high quality fusion type splicing equipment.

All splices shall be arranged neatly in splice trays, supported and protected with a suitable splice protector.

The Contractor shall neatly train all fiber and pigtails together when routing them along the same path and shall neatly train them along the support rails equipment cabinet.

No fibers shall be installed with a bend radius less than the manufacturer's minimum recommended bending radius.

The Contractor shall install and provide all splicing and termination required to connect Optical Fiber Distribution Cable (refer to Specification 505 – Optical Fiber Cable (12 Strand)) to the equipment shown on the Drawings and specified elsewhere in this project.

Security/Maintenance

All internal components, including all installed modules, shall be removable and replaceable by a single technician with basic hand tools.

Documentation and Training

The OFTPP and all associated equipment and cabling shall conform to the documentation and training requirements stated in Specification 100 – General Provisions and Specification 300 – Training.

Testing

The OFTPP and all associated equipment and cabling shall conform to the testing requirements stated in the Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The fiber path shall be tested and verified in accordance with this Contract prior to the connection to the equipment.

The Contractor shall be responsible for all testing that may be required to establish approval and acceptance of the OFTPP.

METHOD OF MEASUREMENT

This work shall be measured for payment by the number of units of Optical Fiber Termination Patch Panels (12-port) of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each Optical Fiber Termination Patch Panels (12-port) shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the CT***fastrak*** ITS and Communications Systems shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 511 – CCTV CAMERA ASSEMBLY (BUSWAY)

SPECIFICATION 512 – CCTV CAMERA ASSEMBLY (STATIONS)

DESCRIPTION

This item shall consist of furnishing, installing, integrating, and testing IP-based Closed Circuit Television (CCTV) Camera Assemblies for stations and for busway locations, including all needed components and accessories required for a full and complete installation.

Specification 511 – CCTV Camera Assembly (Busway)

The CCTV Camera Assembly (Busway) shall be used to capture, record, and transmit video images of strategic locations along the busway to support safe and efficient busway operations. The CCTV Camera Assembly (Busway) shall consist of the following components:

- Network Dome CCTV Cameras, with Pan/Tilt/Zoom capability, integrated video encoder and camera firmware.
- Field hardened Camera Dome Housing and Assemblies.
- Power supplies as needed
- Separate 2-conductor 18awg power cable per camera
- All cable and wiring, connections, connectors, jumpers and cable management
- Associated signage.

The CCTV Camera Assemblies (Busway) shall be installed at locations along the busway either on existing camera poles with existing camera lowering systems or on existing traffic poles located at key grade crossing intersections as shown on the Drawings.

Specification 512 – CCTV Camera Assembly (Station)

The CCTV Camera Assembly (Stations) shall be used to capture, record, and transmit video images of passengers at the stations. The CCTV Camera Assembly (Stations) shall consist of the following components:

- Network Dome CCTV Cameras, with Pan/Tilt/Zoom capability, integrated video encoder and camera firmware.
- Field hardened Camera Dome Housing and Assemblies.

- Power supplies as needed
- Separate 2-conductor 18awg power cable per camera
- All cable and wiring, connections, connectors, jumpers and cable management
- Mounting extension posts and tenon arms (if mounted above a Variable Message Sign or as necessary to provide the required field of view).
- Mounting brackets and hardware.
- Associated signage.

The CCTV Camera Assemblies (Station) shall be installed at station locations either on existing light poles, on station canopies, or on new Variable Message Sign (VMS) poles or brackets as shown on the Drawings.

References and Standards

Product Safety

- Underwriters Laboratory (UL) 60950: Information technology equipment – safety, International Electrotechnical Commission (IEC) 60950: Safety of information technology equipment, European Norm (EN) 60950: Safety of information technology equipment, Canadian Standards Association (CSA) 60950-95: Safety of Information Technology Equipment, or similar

Environmental and Enclosure

- Federal Communications Commission (FCC) Code of Federal Regulations 47 Part 15 Class A
- European Norm (EN) 55022: Information technology equipment. Radio disturbance characteristics
- International Electrotechnical Commission (IEC) Standard 60529 – Degrees of Protection provided by Enclosures
- National Electrical Manufacturers Association (NEMA) Standard 250: Enclosures for Electrical Equipment (1000 Volts Maximum)

Installation

- National Fire Protection Association (NFPA) 70 – National Electric Code
- National Fire Protection Association (NFPA) 731: Standard for the Installation of Electronic Premises Security Systems

- ULC-S317 – Installation and Classification of Closed Circuit Video Equipment (CCVE) Systems for Institutional and Commercial Security Application

Technical

- UL 983 – Standard for Surveillance Camera Units
- National Transportation Communications for ITS Protocol (NTCIP) Standard 1205: NTCIP Objects for CCTV Camera Control
- ISO/IEC JTC1/SC29/WG11 – Coding of moving pictures and audio (Moving Picture Experts Group – MPEG)
- Institute of Electrical and Electronics Engineers (IEEE) 802.3 Ethernet Standards collection
- Electronic Industries Alliance / Telecommunications Industry Association (EIA/TIA) 568: Commercial Building Telecommunications Wiring Standard.
- EIA/TIA-606: Administration Standard for the Telecommunication Infrastructure:
- EIA/TIA-607: Commercial Building Grounding and Bonding Requirements for Telecommunications.

MATERIALS

General

The CCTV Cameras shall be Internet Protocol (IP) cameras with digital color capture. They shall be capable of capturing 4CIF (704*480 pixel) images, with optical magnification of 35X, transmitting MPEG-4 video over Ethernet using Cat 6 cables (refer to Specification 501 – Category 6 Copper Patch Cable).

The Contractor shall have the option of proposing HD 1.3 megapixel CCTV Cameras if those cameras meet or exceed all of the requirements contained in this specification and the price difference is deemed acceptable to the Department.

CCTV Camera Assemblies shall be connected to the busway communications system through Ethernet switches in cabinets at the base of poles or nearby traffic signal control cabinets.

The CCTV Camera Assemblies shall support communication via multicast traffic.

The Contractor shall comply with relevant NTCIP standards for the CCTV Camera Assemblies.

The CCTV Camera Assemblies shall comply with UL standards referenced in References and Standards.

The CCTV Camera Assemblies, and all associated equipment and cabling shall comply with the Materials requirements stated in Specification 100 – General Provisions. If conflicts exist, this Item specification shall govern.

Manufacturer Requirements

The manufacturer of the CCTV Cameras shall be regularly engaged in the manufacture and production of cameras and video encoding hardware for use in outdoor security systems.

Physical Requirements

Network Dome CCTV Camera

Cameras shall provide Electronic Image Stabilization (EIS) to compensate for physical movement and vibration of the dome with a user-selectable bandwidth of 5 or 10Hz.

The CCTV Camera shall have a color sensitive imager.

The CCTV Camera shall include motors for high-speed pan/tilt/zoom (PTZ) functionality.

The Camera Dome Assembly shall have an internal heater of sufficient power to keep the dome clear and enable clear and unobstructed image capture in all seasons and weather conditions except rain.

High-speed, DC direct-drive motors shall be used to maintain high torque through the entire operating range. These motors shall use pulse-width modulation and encoder feedback to control the acceleration, speed, and deceleration of the motors to ensure smooth, precise, accurate, and fluid movement. The design shall use DC direct-drive motors and no belt to ensure long-term, reliable operation.

The Camera Dome Assembly housing shall include a clear bubble with no light loss. The bubble shall be constructed from high quality, clear, optically graded, thermoformed acrylic or approved equal. The bubbles shall be free of imperfections, scratches and blemishes. The bubble shall be sealed with a gasket and secured with tamperproof screws. The appropriate security screwdriver bit must be provided with the housing.

The Camera Dome Assembly environmental enclosure shall be manufactured from high-quality acrylic substrate, aluminum, cell-cast or an approved equal. The enclosure shall be coated with an off-white, beige or gray finish, and outfitted with a sunshield to reflect direct rays from the sun from the control equipment within the housing without adversely effecting the optical qualities of the camera and lens. The sunshield shall have a means for dissipating heat to protect

the camera from failing due to excessive sun exposure. The enclosure shall not allow external moisture to intrude into the bubble of the Camera Dome Assembly.

The CCTV Camera Assemblies shall comply with the following requirements:

Criteria	**Minimum Conditions to be Met**
Optical Zoom (minimum)	35X
Focal Length Range	3.5mm – 115mm
Digital Zoom (minimum)	10X
Aperture	f/1.6
Minimum Illumination	.74 lux (color), .5 lux (B/W)
Signal to Noise Ratio	50 dB
Pan Range	360° of continuous rotation
Pan Speed	1° - 360° per second
Tilt Range	110° of travel
Tilt Speed	1° - 360° per second

Environmental Requirements

The Camera Assemblies, as fully installed, shall comply with the following environmental requirements:

Criteria	**Minimum Conditions to be Met**
Operating Temperatures	Between -40°F to 122°F (-40°C and 50°C)
Storage Temperatures	Between -40°F to 158°F (-40°C and 70°C)
Humidity	5-90% relative humidity, non-condensing
Solid Object and Moisture Protection	IEC IP66
Water and Solvents	Shall withstand water spray on equipment from cleaning floors and walls, industrial solvents, rain, mud, snow and slush, all of which may contain salt, which may come in contact with equipment.

A thermostat-controlled heater/defroster and blower circulation system shall be provided to maintain the temperature in the specified range and ensure clear viewing during cold weather

operation. The heater shall turn on and off based on configured thermostat settings to ensure a stable operational environment within the Camera Dome Assembly.

Electrical Requirements

Item	Requirement
Operating Voltage	120 VAC ± 5%, 60 Hz
Input Current	1 Amperes (Maximum)
Maximum Power Dissipation	40 Watts (with Heater off); 100 Watts (with Heater on)

The Contractor shall provide any power adapters that may be necessary to power the cameras through the AC power supply.

Functional Requirements

General

CCTV Camera Assembly (Busway) shall provide operations control center staff with a view of the strategic locations of operational importance, suitable for dispatching and monitoring purposes and to inform drivers of unsafe conditions at points of limited visibility. The locations and coverage of busway cameras is shown in the Drawings.

CCTV Camera Assembly (Stations) shall provide coverage of key station areas including clear views of TVMs, platforms, plazas immediately outside the fare area and pedestrian approaches to fulfill a security surveillance function by providing deterrence and forensic evidence. The locations and coverage of station cameras is shown in the Drawings.

The CCTV Camera Assembly field equipment shall be interfaced with the Specification 534 – Network Video Recorder (NVR) located at the BOC, through the busway communications system.

CCTV Cameras shall provide clear visibility in widely varying degrees of light including bright daylight conditions and unlit night-time conditions.

CCTV Cameras shall provide Wide Dynamic Range (WDR) for viewing of detailed images when observing scenes with widely varying degrees of light.

CCTV Cameras shall provide autoflip, autoiris, and anti-bloom functionality.

Cameras shall support up to six (6) preset positions.

Upon initial power up and after the Camera Dome Assembly resets, diagnostic tests shall be run, including communication loopback, camera loopback, and motor circuit tests. After

initialization, the Camera Dome Assembly shall automatically pan, tilt, and zoom to its previous position.

The CCTV Camera Assembly shall have capabilities to turn on or off the heater and blower systems manually from remote locations.

All CCTV Camera Assembly control functions shall be available within the field equipment cabinet for each CCTV Camera Assembly. Activation of local camera control shall disable remote camera control.

The CCTV Camera Assembly must support a minimum of eight (8) privacy zones to prevent users from viewing sensitive or secured areas. So as not to interfere with normal surveillance operations, these on-screen "shields" must block out only the area that has been defined as sensitive. The privacy zones shall not cause the screen to blank out when the sensitive area is within the camera's field of view. On the monitor, the privacy zones should appear larger or smaller depending on the camera's zoom factor.

Camera Dome Assembly direction indicators, azimuth reading, Dome, Area, Preset, Pattern, Preset Sequence, alarm names, zoom, focus, and iris status must be displayable on the BOC monitor. All on-screen text character attributes must be user-selectable solid or translucent white, with or without black outline.

The camera shall be capable of automatically re-establishing video and data communications upon the restoration of communications or power to the cameras.

NVR System Integration

The CCTV cameras shall send digitized video stream, compressed using MPEG-4, or Department-approved alternate compression format, to the NVR.

The integrated video encoder shall support multicast traffic.

The Contractor shall not require an annual license renewal for software used to interface with and control CCTV Camera Assemblies.

Performance Specifications

Each CCTV Camera Assembly shall be capable of continuously encoding thirty (30) frames per second (fps) at resolutions up to 4CIF (704 x 480, NTSC) with a lag of less than one (1) second. Individual adjustments to both resolution and fps shall be possible to meet a given integration requirement for video retention.

Warranty Requirements

All equipment supplied shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. All equipment supplied shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

Spare Parts Requirements

The Contractor shall provide the following spare parts:

- Quantities equivalent to 10% of the total number of installed Network Dome CCTV Cameras
- Quantities equivalent to 10% of the total number of installed Field hardened Camera Dome Housing and Assemblies.
- Quantities equivalent to 10% of the total number of Power supply cords, adapters and other associated cables and wiring

All the spare parts shall be of the same make and model as the originals used to operate the CCTV Camera Assemblies.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting equipment from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged equipment, as may be determined by the Engineer.

Installation

Specification 511 – CCTV Camera Assembly (Busway)

The Busway CCTV Camera Assemblies shall be mounted on existing camera poles with existing camera lowering systems or on existing traffic signal mast arms, as shown in the Drawings. The Contractor shall be responsible for installing the Camera Assemblies onto existing camera lowering systems.

Specification 512 – CCTV Camera Assembly (Station)

The Contractor shall be responsible for the following (as shown on the Drawings):

- If mounted to a station canopy or a separate shelter at the station, the Contractor shall provide a custom bracket and mounting. The Engineer shall review all proposed

brackets and mountings to ensure consistency with the station's overall design and character.

- If mounted to an existing lighting pole, the Contractor shall provide a pole bracket with stainless steel straps or an assembly appropriate to the construction of the pole for mounting CCTV equipment.
- If mounted to a new VMS pole or bracket, the Contractor shall provide a pole bracket with stainless steel straps or an assembly appropriate to the construction of the pole for mounting CCTV equipment.
- If mounted near any obstruction to the intended field of view, complete or partial, permanent, temporary, or recurring the Contractor shall provide an extension pole and/or tenon arm to provide clear line-of-sight to the intended field of view.

The Contractor shall procure and install all additional support structures and/or mounting brackets and equipment required for installation of the cameras as per the Drawings.

General

In all cases, the Contractor shall provide stamped shop drawings verifying that the complete camera mounting assembly will not overstress the structure to which the Camera Assembly is being mounted including withstanding wind and ice loads with galloping. When mounted at a height of greater than thirty (30) feet, the camera shall be able to be lowered by means of an existing (i.e. not provided by the Contractor) Camera Lowering System (CLS).

The Contractor shall verify with the Engineer the mounting location and the intended field of view of each camera as shown approximately in the Drawings. The CCTV Camera Assembly shall be mounted in such a way that all designated areas are available for viewing by operating the pan, tilt and zoom functions. The Contractor shall coordinate with the Engineer to confirm mount for maximum or preferred view.

Prior to installation, the Camera Dome Assembly shall be pressurized to ensure that no condensation accumulates. The Contractor shall be responsible for verifying the quality of the gas used to pressurize the dome.

The Contractor shall pay particular attention to protection of the Camera Dome Assembly enclosure acrylic face during installation. It is important that any clear surfaces not be scratched or marred. If any damage is observed by the Engineer, the Contractor will be required to replace the affected equipment at no cost to the Department.

All heaters and blowers shall be mounted to the non-rotating housing of the dome.

The Contractor shall connect all cameras to a designated power supply and to the Gigabit Ethernet Switch at the station using Cat 6 Cabling for signals and single pair cable for power.

The Contractor shall be responsible for connection of all power supplies, including for both the CCTV Camera and the Camera Dome Assembly heater.

Specifications of all cable assemblies, including connectors, shall be submitted to the Engineer as part of the shop drawings for review.

Existing conduit between the Camera Assemblies' locations and the communications cabinets at the station shall be provided.

The Contractor shall install signage near the surveillance areas. The signage shall indicate the presence of cameras and warn people that they are being recorded.

The Contractor shall be responsible for configuration of all cameras. Each camera shall be assigned an IP address as approved by the Engineer in the Contractor's IP Address Coordination Plan.

The Contractor shall configure all characteristics of the video feed being sent to the BOC, including the resolution, the frame rate, and the labeling displayed on the video feed. Proposed settings shall be submitted along with shop drawings for review.

The video feed shall initially be configured at a 4CIF resolution (704 x 480, NTSC) and 7.5 frames per second (fps).

Security and Maintenance

All internal components, including all installed modules, shall be removable and replaceable by a single technician with basic hand tools.

Documentation and Training

The CCTV Camera Assembly and all associated equipment and cabling shall conform to the documentation and training requirements stated in Specification 100 – General Provisions and Specification 300 – Training.

The Contractor shall provide documentation and training on all the installation, configuration, management functions, operating features and maintenance procedures for the CCTV Camera Assemblies.

Testing

The CCTV Camera Assembly, and all associated equipment and cabling shall conform to the testing requirements stated in the Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

Local CCTV Camera Assembly Installation Tests

As part of Installation Testing, the Contractor shall test each CCTV Camera Assembly at each installation location:

- Local operation of all CCTV equipment, exercising the pan, tilt, zoom, focus, iris opening, shutter control, power on/off and all other functions described in this specification while observing the video picture on a laptop computer.
- Demonstration of camera sensitivity at low light levels to meet the specified requirements.
- Demonstration of the wide dynamic range and back light compensation features against a bright background.
- Demonstration of pan/tilt speed and extent of movement to meet the specified requirements.
- Measurement of video signal level at the field equipment cabinet with video testing equipment. Minimum acceptable video output level shall be 30 IRE at the specified light and shutter settings.
- Test for absence of perceptible latency in control of camera PTZ functions. Perceptible latency in camera control shall be a systemic defect. Presence of latency shall impede acceptance.
- Verification that video output from the camera is MPEG-4 compressed digital video or other approved format.
- Random test of at least two (2) installed cameras to verify camera enclosure environmental resistance.
- Preset test to ensure camera consistently goes to the proper preset position.

These tests must be performed before system commissioning. All locally configurable controls and settings shall be properly set, calibrated, tested and demonstrated to be functioning as specified before commissioning activities may begin.

Upon initial power up and after Camera Dome Assembly resets, diagnostic tests must be run, including communication loopback, camera loopback, and motor circuit tests. The results of these tests must be displayable on the laptop computer. After initialization, the Camera Dome Assembly shall automatically pan, tilt, and zoom to its previous position.

Post-Installation Video Quality Testing

Daytime Tests

All central control and monitoring equipment shall be tested from the BOC during daytime hours. The Contractor shall contact the Engineer to arrange and coordinate the testing procedure. The tests shall include, but not be limited to the following:

- Operation of all newly installed CCTV Camera Assemblies from the central controller, exercising the pan, tilt, zoom, focus, presets, iris opening and all other functions and features described in this specification while observing the video picture on a local laptop computer.
- Display of each camera on a designated video monitor to verify proper operation and picture quality from each camera.
- Display of each camera by CCTV Camera Management Software (refer to Specification 554 – CCTV Camera Management Software), from the Network Video Recorder, and on a BOC video monitor to verify video quality.
- Viewing of every camera by CCTV Camera Management Software to confirm that the desired field of view has been achieved in each station area and on the busway.
- Verification of the conformance of the images observed with the characteristics specified herein and in the relevant standards documents. Parameters including but not limited to: view angle; image captured; image quality; PTZ control fluency and absence of control or video latency; suitability of the image captured to the surveillance strategy described herein and in the design documents.
- Verification of the suitability of the video surveillance image storage/retrieval system, including but not limited to: searchability and accuracy of the search tools; quality of images played back; metadata and watermarking integrity; ease with which retrieved images can be stored on a portable media for long term storage or inclusion in court exhibit.

The Contractor shall correct any operational problems encountered with the camera system during this test.

Night-time Tests

A second central control test shall be performed during the hours of darkness to verify proper operation of the auto iris lenses, shutter control and the absence of video signal noise. This test shall be conducted in the presence of the Engineer or his designated representative at the BOC. The test shall include the following as a minimum:

- Operation of all newly installed camera assemblies from the central controller, exercising the pan, tilt, zoom, focus, presets, iris opening and shutter control functions while observing the video picture on a local laptop computer.
- Display of each camera on a designated video monitor to observe both the brightest and darkest scenes available from each camera location.

- Display of each camera by CCTV Camera Management Software from the Network Video Recorder to verify video quality.
- Demonstration of the "on motion" video recording feature in low-light conditions
- Demonstration of the quality of video recorded showing objects or persons in motion under low-light conditions. Ghosting, fading, and doubling of moving images are unacceptable
- Proper operation of the day/night filter

The Contractor shall correct any problem encountered with the video camera system during this test.

METHOD OF MEASUREMENT

Specification 511 – CCTV Camera Assembly (Busway)

This work shall be measured for payment by the number of units of CCTV Camera Assembly (Busway) of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each CCTV Camera Assembly (Busway) shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

Specification 512 – CCTV Camera Assembly (Stations)

This work shall be measured for payment by the number of units of CCTV Camera Assembly (Stations) of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each CCTV Camera Assembly (Stations) shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the CT***fastrak*** ITS and Communications Systems shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 513 – EMERGENCY CALL BOX

DESCRIPTION

This item shall consist of furnishing, installing, integrating, and testing Emergency Call Boxes (ECBs) and all accessories required for a full and complete installation, including all associated equipment, infrastructure, and cabling, as described herein. The ECBs shall provide travelers with a way to directly communicate with the appropriate local public safety dispatch center (911 emergency dispatch) through the local telephone exchange in the event of an emergency.

Upon activation of an ECB, in addition to connecting travelers directly to local public safety dispatchers, the ECB will simultaneously send a notification to the Busway Operations Center (BOC) through the busway communications system, informing them that the ECB has been activated. This will enable BOC staff to operate the CCTV system in the vicinity of the ECB to better assess the impact of the emergency on busway operations. This communications interface to the BOC will also enable the BOC to continuously monitor the operational status of the ECB.

Each ECB shall consist of the following components:

- Emergency Call Box (ECB)
- ECB freestanding pedestal with concrete foundation
- ECB mount with blue flashing LED light
- Directional signage, as necessary

References and Standards

The ECB shall have the following communication standard:

- ADA compliance
- FCC CFR 47 Part 15

ASTM International:

- ASTM F967-95: Standard Practice for Security Engineering Symbols.

Electronic Industries Alliance / Telecommunications Industry Association (EIA/TIA):

- EIA/TIA-568: Commercial Building Telecommunications Wiring Standard.
- EIA/TIA-606: Administration Standard for the Telecommunication Infrastructure:
- EIA/TIA-607: Commercial Building Grounding and Bonding Requirements for Telecommunications.
- International Electrotechnical Commission (IEC) 60268: Sound system equipment

MATERIALS

General

The ECB shall communicate directly with the local public safety dispatch center (911 emergency dispatch) via standard telephone cabling connecting through a local pots point of presence to the local telecommunications service provider's telephone exchange. The ECBs at each station shall also be connected to the Gigabit Ethernet Switch (refer to Specification 502 – Gigabit Ethernet Switch (Type A) and Specification 503 – Gigabit Ethernet Switch (Type B)) at that station using Cat 6 Cabling (refer to Specification 501 – Category 6 Copper Patch Cabling).

The ECBs at each station shall also be connected to an Uninterruptible Power Supply (refer to Specification 519 – Uninterruptible Power Supply for Emergency Call Boxes (UPS-ECB)), which will ensure that the ECB continues to function even under loss of direct power supply.

The Contractor shall ensure that the ECB meets all required State and National technical requirements for an Emergency Communications System.

The ECB, and all associated equipment and cabling shall comply with the Materials requirements stated in Specification 100 – General Provisions. If conflicts exist, this Item specification shall govern.

Manufacturer Requirements

The manufacturer of the ECB shall be regularly engaged in the manufacture and production of emergency communications systems.

Physical Requirements

General

The ECB shall consist of the following:

- High visibility, tamper and vandal-proof enclosure;
- A Push Button to initiate emergency calls;
- LED indicators to indicate a call is in progress, and then that a call is connected;
- Appropriate signage, in accordance with ADA requirements;
- Built-in Loudspeaker and Microphone for hands-free operation; and
- Bi-directional communication.

Enclosure

The ECB shall be easily identified through unique markings, striping or paint, signage, and lighting. ECB markings and designations shall be approved by the Department.

The ECB shall remain easily visible during low light conditions.

A blue flashing light and other visual recognition devices such as strobes or beacons located at the platform and connected to the, but not part of the ECB itself shall be provided to indicate that the ECB has been activated.

Components that are exposed to exterior environmental conditions shall be able to operate within the range of these environmental conditions.

The enclosure shall be equipped with a retro reflective sticker that is clearly visible at night. The sticker shall read "SOS", "EMERGENCY" or other message required by the Department.

The ECB shall be designed to resist physical damage due to vandalism. All external hardware shall be constructed tamper resistant.

The enclosure shall be vandal/graffiti resistant and washable.

The ECB shall have a brushed stainless steel finish.

ECB components shall be corrosion resistant and any PC boards coated to prevent water or moisture damage and fungus growth.

Push Button

A suitable method of identifying the push button shall be provided.

The Push Button shall be uniquely identified with lettering on the button or beside it.

The Push Button shall be ADA compliant with features such as Braille "HELP" label.

LED light

L.E.D indicators shall be provided for hearing impaired users.

Loudspeaker and Microphone

A hearing assist jack shall be provided to assist hearing impaired persons to use the ECB.

Environmental Requirements

The ECB shall comply with the environmental requirements listed in the table below:

Criteria	Minimum Conditions to be Met
Operating Temperatures	Between - 40ºF to +150ºF (- 40ºC to +66ºC)
Storage Temperatures	Between - 40ºF to +150ºF (- 40ºC to +66ºC)
Humidity	5-95% relative humidity, non-condensing
Solid Object and Moisture Protection	IEC IP66 or NEMA 3R
Water and Solvents	Shall withstand water spray on equipment from cleaning floors and walls, industrial solvents, rain, mud, snow and slush, all of which may contain salt, which may come in contact with equipment.

The ECB shall be suitably protected against external EMI / ESI Interference through shielding / grounding.

Electrical Requirements

Item	Requirement
Operating Voltage	24VDC or 48VDC
Input Current	<2.5 Amperes

The Contractor shall ensure that the electrical power supply input of the ECB matches the power supply output of the UPS-ECB.

Functional Requirements

The ECB shall be interfaced with the ECB Management Software (refer to Specification 556 – ECB Management Software) and shall send activation alerts to the BOC via the busway communications system Category 6 (Cat 6) cable.

The ECB shall respond to SNMP messages from the Network Management Software (NMS). The ECB shall be able to be configured to respond appropriately to the SNMP messages in the context of data and functionality required

General

The ECB shall provide passengers at each station a quick and reliable means of reporting emergencies or summoning assistance in time of need. The ECB shall communicate with the appropriate local public safety dispatch center as determined by the station location.

The ECB shall be ADA compliant and be accessible for all users including the hearing and speaking impaired, the visually impaired, and the mobility impaired.

Push Button

Pushing and releasing the button shall initiate a call-in to a pre-programmed auto-dial number (911).

Once the button is pushed, hands free operation shall occur.

Loudspeaker

Automatic Level Control (ALC) shall be provided for automatic adjustment of the volume of audible media to overcome varying ambient noise levels.

The loudspeaker shall be accompanied by an assistive listening system (ALS) that allows those with hearing impaired persons to use the ECB.

Microphone

The microphone shall be capable of clearly picking up voice communications despite the presence of background noise, such as buses and trains.

Communications

There shall be at least four (4) programmable auto-dial numbers associated with the Push Button.

The ECB shall automatically dial subsequent numbers if the first number is busy or unavailable. The ECB shall be configurable to disable up to three of these four numbers if desired

The ECB shall have ringing tone to indicate progress of call when button is pressed; confidence tone to indicate call is still connected when on hold; and recorded message in case the line is busy.

The ECB shall automatically end the call connection without the user having to push any buttons when the far-end telephone is disconnected.

“Call Received” LED indicators shall be provided for hearing impaired users.

ECB Management Software Interface

The ECB shall be interfaced with the ECB Management Software.

The ECB shall send notification of activation, along with an indication of the location of the activated ECB, to the BOC via the ECB Management Software. Loss of communication with the ECB shall trigger an alert at the BOC. Loss of telephony connection to the ECB shall trigger an alert at the BOC.

The ECB shall be capable of monitoring and reporting real-time over TCP/IP application, email, and embedded SMTP client and shall provide automatic fault reporting.

In case of loss of communication with the BOC, the ECB shall keep records of all call events locally on a hard disk, or other approved medium.

The ECB shall send indications of fault detections to the ECB management software.

All fault reporting of all features and functionality shall be available to the NMS

The ECB, including the emergency numbers, speakerphone and microphone volumes, and resetting ECB activation, shall be remotely configurable via the ECB management software.

Diagnostics and Failure Modes

The ECB shall have in-built features for automatic fault detection and diagnosis in case of damages such as line faulty, low DC voltage, defective speaker or microphone.

Once a fault is detected, the ECB shall be capable of automatically reporting to the ECB management software and to the NMS.

The ECB control system shall allow remote diagnostics and provide printed reports of diagnostics and operations information.

The ECB control system shall allow for permanent trouble-shooting and maintenance test-result information to be stored locally on a hard disk, or other medium.

The ECB shall operate in a full duplex mode.

The ECB shall have built-in programming port / feature for addressing using a Laptop or Palmtops in the field

The ECB shall be connected to power through a UPS to ensure continued system operation during power outages for a minimum of eight (8) hours.

Performance Requirements

The ECB shall be audible even while operating in a noise level of up to 95 dB.

The ECB shall provide a speaker volume of at least 62 dB at 1 meter.

The loudspeaker shall demonstrate through testing good coverage, the correct Sound Pressure Level (SPL) and good intelligibility, with a Speech Transmission Index (STI – refer to IEC 60268 Part 16) of 0.5 or better under all conditions.

The ECB shall have a mean time between failures (MTBF) of at least 50,000 hours.

Warranty Requirements

The ECB and all associated equipment and cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The ECB and all associated equipment and cabling shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

The Contractor shall be responsible for any loss of communications at the ECB due to improper functioning of the ECB or any of its components, or improper connection of the ECB to the telephone line drop from the communications cabinet.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting equipment from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged equipment, as may be determined by the Engineer.

Installation

An ECB shall be installed on each station platform and other station locations as shown on the Drawings.

In areas at stations where ECBs are not immediately visible, signs or markings shall be placed to indicate the direction and approximate distance to the closest ECB.

The ECB shall meet all ADA and accessibility requirements and shall not conflict with ADA accessibility guidelines in normal operation.

The Contractor shall be responsible for installation of the ECB, including installation of the ECB freestanding pedestal.

The Contractor shall be responsible for designing and installing all necessary Emergency Call Box foundations, concrete pads, mounting bolts, and pavement matching. The foundation design shall be stamped by a structural engineer licensed in the State of Connecticut.

The Contractor shall be responsible for providing and installing all necessary support structures and mounting hardware.

The Contractor shall furnish all mounting hardware (i.e., machine screws, nuts, locking washers) to install the ECB.

The blue LED light shall be installed in a visible location to assist law enforcement officials identify the location of the incident and shall be seamlessly integrated into the design of the shelter. The Contractor shall be responsible for connecting the blue LED light to the ECB, and

shall coordinate with the Department to finalize the location and wiring details during Design Review.

Existing conduit between the proposed ECB location and the station power and communication cabinets will be available. The Contractor shall be responsible for providing and installing all cabling and connectors necessary to provide power and communications to the ECB.

The dedicated telephone line drops for the ECBs at each station shall be available for connection at that station's communications cabinet, as shown in the Drawings. The Contractor shall be responsible for connecting each ECB to the telephone lines, including all cabling, connectors, labor and other incidentals. The Contractor shall coordinate with the Department to finalize the installation details during Design Review.

The Contractor shall coordinate with utilities to ensure that the Emergency Call Box address and location is properly established within the appropriate local public safety dispatch call center database.

Security/Maintenance

All internal components, including all installed modules, shall be removable and replaceable by a single technician with basic hand tools.

Documentation and Training

The ECB, and all associated equipment and cabling shall conform to the documentation and Training requirements stated in Specification 100 – General Provisions and the Specification 300 – Training.

Testing

The ECB, and all associated equipment and cabling shall conform to the testing requirements stated in the Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 206 – Integration Test, and Specification 207 – Acceptance Test.

The Contractor is responsible for all testing and documentation required for establishing approval and acceptance of ECBs.

The ECBs shall be tested for, as a minimum, the following:

- Verification of communications from each ECB to the local public safety dispatch center
- Verification of ADA compliance
- Verification of remote monitoring of ECB from the ECB Management Software
- Verification of ECB functioning under loss of power to the UPS (ECB)

METHOD OF MEASUREMENT

This work shall be measured for payment by the number of units of ECBs of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each ECB shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the CT***fastrak*** ITS and Communications Systems shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 515 – PUBLIC ADDRESS SYSTEM

DESCRIPTION

This item shall consist of furnishing, installing, and testing a Public Address (PA) System for each station platform, all needed components and accessories required for a full and complete installation, including all associated equipment and cabling. The PA System shall be used to provide passenger announcements on the platforms.

References and Standards

Technical Standards

- International Electrotechnical Commission (IEC) 60268: Sound system equipment
- Underwriters Laboratories (UL) 813: Commercial Audio Equipment

Environmental and Enclosure

- International Electrotechnical Commission (IEC) Standard 60529 – Degrees of Protection provided by Enclosures
- Federal Communications Commission (FCC) Code of Federal Regulations 47 Part 15 Class A
- US Military Standard MIL-STD-810 –Department of Defense Test Method Standard for Environmental Engineering Considerations and Laboratory Tests

Product Safety

- Underwriters Laboratory (UL) 60950: Information technology equipment – safety, International Electrotechnical Commission (IEC) 60950: Safety of information technology equipment, European Norm (EN) 60950: Safety of information technology equipment, Canadian Standards Association (CSA) 60950-95: Safety of Information Technology Equipment, or similar.

Installation

- Electronic Components, Assemblies & Materials Association (ECA) EIA/ECA-310-E: Cabinets, Racks, Panels, and Associated Equipment

MATERIALS

General

The PA System shall consist of the following components:

- An IP input based, digital signal processing, Audio Amplifier
- PA Speakers
- Ambient Noise Level Sensors (referred to as Ambient Noise Sensor)
- Mounting equipment and hardware

The PA System shall be connected to a TIS Controller located in a communications cabinet using audio cabling and other associated communications hardware (Refer to Specification 518 – TIS Controller).

The PA System and all included components shall be compliant with UL 813 and IEC 60268.

The PA System, and all associated equipment and cabling shall comply with the Materials requirements stated in Specification 100 – General Provisions. If conflicts exist, this Item specification shall govern.

Manufacturer Requirements

The manufacturer of the PA System shall be regularly engaged in the manufacture and production of audio and message announcement systems for use in transportation stations.

Physical Requirements

The Audio Amplifier shall be rack-mountable in a standard 19” EIA-310-E compliant rack.

PA Speakers

The PA Speakers shall have a form factor and size suitable for installation inside the busway station clam-shell shelters and exterior installation along the canopy of the platform. They shall be fully integrated into the shelter design.

The PA Speakers shall support a frequency range of 275 Hz - 14 KHz and shall have a suitable input power rating based on the required drive level.

The PA Speakers shall be of a weatherproof design. They shall be housed in vandal-proof enclosures.

The Ambient Noise Sensor shall support a frequency range of 275 Hz - 14 KHz.

The PA Speakers shall have input impedance matching the output impedance of the amplifier.

Environmental Requirements

The PA System shall be compliant with FCC Part 15 Class A electromagnetic compatibility requirements.

Audio Amplifier

The Audio Amplifier shall comply with the following environmental requirements:

Criteria	Minimum Conditions to be Met
Operating Temperatures	Between -13°F to 131°F (-25°C and 55°C)
Storage Temperatures	Between -13°F to 158°F (-25°C and 70°C)
Humidity	5-90% relative humidity, non-condensing
Mechanical Shock	Compliant with MIL-STD-810
Solid Object and Moisture Protection	IEC IP53
Water and Solvents	Shall withstand water spray on equipment from cleaning floors and walls, industrial solvents, rain, mud, snow and slush, all of which may contain salt, which may come in contact with equipment.

PA Speakers and Ambient Noise Sensors

The PA Speakers and Ambient Noise Sensors shall comply with the following environmental requirements:

Criteria	Minimum Conditions to be Met
Operating Temperatures	Between -13°F to 131°F (-25°C and 55°C)
Storage Temperatures	Between -40°F to 158°F (-40°C and 70°C)
Humidity	5-95% relative humidity, non-condensing
Operating Vibration	Compliant with MIL-STD-810
Mechanical Shock	Compliant with MIL-STD-810
Solid Object and Moisture Protection	IEC IP66
Water and Solvents	Shall withstand water spray on equipment from cleaning floors and walls, industrial solvents, rain, mud, snow and slush, all of which may contain salt, which may come in contact with equipment.

Electrical Requirements

Audio Amplifier and Ambient Noise Sensors

The Audio Amplifier shall comply with the following electrical requirements:

Item	Requirement
Operating Voltage	120 VAC ± 5%, 60 Hz
Input Current	5 Amperes (Maximum)
Maximum Power Dissipation	500 Watts

The Ambient Noise Sensors will be powered by the Audio Amplifier.

PA Speakers

The PA Speakers shall comply with the following electrical requirements:

Item	Requirement
Operating Voltage	120 VAC ± 5%, 60 Hz
Input Current	1 Amperes (Maximum)
Maximum Power Dissipation	50 Watts

Functional Requirements

General

The PA System at each busway station shall be used to broadcast audio announcements received from the TIS Controller at proper level and with sufficient clarity to make those announcements easily understood by passengers at the station. Announcements shall be intelligible throughout the entire platform area but not more than ten feet beyond the platform area.

The PA System shall be capable of being monitored and controlled by a TIS Controller located in the communications cabinet at each busway station.

The Ambient Noise Sensor will provide feedback to the Audio Amplifier and TIS Controller of local ambient human-audible noise in the station.

Microphone and Auxiliary Audio Inputs

Each audio input shall have the capability to control and manage audio gain, dynamics, filtering and ducking.

Audio Amplifier and PA Speakers

PA Speakers shall play all audio output by the TIS Controller.

The PA Audio Amplifier shall have sufficient gain to ensure the minimum target Speech Transmission Index (STI – refer to IEC 60268 Part 16) is achieved through the speakers under the full range of ambient sound conditions.

The PA Audio Amplifier shall incorporate audio digital signal processing including at a minimum audio equalization, feedback cancelation, ambient noise level monitoring and digital gain control.

Automatic Level Control (ALC) shall be provided for automatic adjustment of the volume of announcements to overcome varying ambient noise levels.

Each PA Audio Amplifier shall be capable of supporting up to 10 speakers.

TIS Controller Integration

Manual control of PA Speaker volume shall be available using the TIS Controller.

Automatic reset/reboot and firmware download for the amplifier by the TIS controller shall be supported.

All PA System communications parameters and settings shall be user configurable remotely from the BOC and through a local maintenance port.

The Contractor shall ensure that the requirements of local noise by-laws shall be respected by this system.

Performance Requirements

The PA System shall have a MTBF of at least 25,000 hours.

The PA System shall have good coverage, as controlled by the correct Sound Pressure Level (SPL) and good intelligibility, with a Speech Transmission Index (STI) of 0.5 or better under all conditions from all platform areas.

Warranty Requirements

The PA System and all associated equipment and cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The PA System and all associated equipment and cabling shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

Spare Parts Requirements

The Contractor shall provide the following spare parts with the PA Systems:

- Quantities equivalent to 5% of all installed Audio Amplifiers, including any wiring required to connect to the TIS Controller
- Quantities equivalent to 10% of all installed Ambient Noise Sensors, including any wiring required to connect to the Audio Amplifiers
- Quantities equivalent to 10% of all installed PA Speakers, including any wiring required to connect to the Audio Amplifiers

All the spare parts shall be of the same make and model as the modules originally installed in the PA System.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting equipment from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged equipment, as may be determined by the Engineer.

Installation

The Contractor shall install the PA System speakers on existing station canopies as shown on Drawings.

The PA Speakers mounted to platform canopies shall conform to the size constraints and form factors as defined in the platform and station architectural designs.

The PA Speakers shall be installed in such a manner as to facilitate ease of maintenance.

The PA Speakers shall be closely spaced on each side of the platform and shall be directed down to direct sound towards the passengers and minimize neighbourhood noise pollution.

The Audio Amplifier shall be installed in the communications cabinet at each busway station.

Ambient noise level sensors shall be situated so as to enable effective automated volume control to ensure understandable announcements throughout the station platforms. There will be a minimum of two Ambient Noise Sensor installed per Busway platform, with a sufficient quantity implemented to achieve the requirements for intelligibility from all platform areas under the full range of ambient sound conditions.

The Contractor shall be responsible for all cabling required providing power and communications to the PA System components.

The PA System and all components shall be connected to a power supply in the power cabinet using appropriately shielded cabling.

Existing conduit between the speaker locations and the power and communications cabinets at the station shall be provided.

Security/Maintenance

All internal components, including all installed modules, shall be removable and replaceable by a single technician with basic hand tools. Speakers shall be capable of being quickly removed and replaced by spares.

Documentation and Training

The PA System, and all associated equipment and cabling shall conform to the documentation and Training requirements stated in Specification 100 – General Provisions and the Specification 300 – Training.

The Contractor shall provide documentation and training on all the installation, configuration, management functions, operating features and maintenance procedures for the PA System.

Testing

The PA System, and all associated equipment and cabling shall conform to the testing requirements stated in Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The Contractor shall be responsible for all testing that may be required to establish approval and acceptance of the PA System.

The Contractor shall employ industry-standard methods and tools to measure and monitor PA System performance and compliance with availability requirements throughout the term of the Contract, including all ongoing technical support and maintenance periods.

The Contractor shall test the PA System for the following:

- Sound pressure level and Speech Transmission Index at a minimum of three (3) different locations on each platform, at all stations. Locations shall be chosen by the Department in coordination with the Contractor.
- Verification of functioning of Ambient Noise Sensor, its feedback to Audio Amplifier and the Automatic Level Control feature
- Verification of audio output from TIS Controller, through the Audio Amplifier to ten (10) PA Speakers
- Verification of all configuration features of the PA System

METHOD OF MEASUREMENT

This work shall be measured for payment by the number of units of PA Systems of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each PA System shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the CT***fastrak*** ITS and Communications Systems shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 518 – TRAVELER INFORMATION SYSTEM CONTROLLER

DESCRIPTION

This item shall consist of furnishing, installing, integrating, and testing Traveler Information System (TIS) Controllers, all needed components and accessories required for a full and complete installation, including all associate equipment and cabling. The TIS Controller shall be capable of accepting information from both the centralized Traveler Information Software (refer to Specification 559 – Traveler Information Software) at the Busway Operations Center (BOC) and the local Busway Communications Cabinet to control the Public Address System (PA System – refer to Specification 515 – Public Address System) and Variable Message Signs (VMSs – refer to Specification 520 – Variable Message Sign (Double-sided), Specification 521 – Variable Message Sign (Single-sided, Pole-Mounted), and Specification 522 – Variable Message Sign (Single-sided, Cantilever Mounted)) on all platforms and remote locations at each CT***fastrak*** station. The TIS Controller at each station shall include both software and hardware to manage and control the VMS and PA System for all platforms at that station.

References and Standards

Technical Standards

- International Electrotechnical Commission (IEC) 60268: Sound system equipment
- Underwriters Laboratories (UL) 813: Commercial Audio Equipment
- NTCIP 1403 – Transit Communications Interface Profiles – Standard on Passenger Information (PI) Objects.
- Transit Cooperative Research Program (TCRP) Report 45 – Passenger Information Services: A Guidebook for Transit Systems

Environmental and Enclosure

- International Electrotechnical Commission (IEC) Standard 60529 – Degrees of Protection provided by Enclosures
- Federal Communications Commission (FCC) Code of Federal Regulations 47 Part 15 Class A

Product Safety

- Underwriters Laboratory (UL) 60950: Information technology equipment – safety, International Electrotechnical Commission (IEC) 60950: Safety of information technology equipment, European Norm (EN) 60950: Safety of information

technology equipment, Canadian Standards Association (CSA) 60950-95: Safety of Information Technology Equipment, or similar.

Installation

- Electronic Components, Assemblies & Materials Association (ECA) EIA/ECA-310-E: Cabinets, Racks, Panels, and Associated Equipment

MATERIALS

General

The TIS Controller shall consist of the following:

- Equipment/communications case
- Digital clock
- Microphone
- Local data entry keyboard
- Driving electronics
- Environmental control and protection
- Mounting hardware
- Associated cables and wiring

The TIS Controller shall be connected to the Gigabit Ethernet Switch (refer to Specification 502 – Gigabit Ethernet Switch (Type A), Specification 503 – Gigabit Ethernet Switch (Type B)) in the Communications Cabinet using Category 6 (Cat 6) Ethernet Cabling (see Specification 501 – Category 6 (Cat 6) Copper patch cable).

The TIS Controller shall be connected to the controller for each VMS furnished at the station, including the integrated speaker and associated readout actuation device for each VMS, using Cat 6 Ethernet Cabling.

The TIS Controller shall be connected to the PA System Audio Amplifier using Cat 6 Ethernet Cabling.

The TIS Controller shall be connected to a designated power supply in the power cabinet using appropriately shielded cabling.

The TIS Controller, and all associated equipment and cabling shall comply with the Materials requirements stated in Specification 100 – General Provisions. If conflicts exist, this Item specification shall govern.

Manufacturer Requirements

The manufacturer of the TIS Controllers shall be regularly engaged in the manufacture and production of high quality computational, messaging and audio announcement equipment for use in transportation stations.

Physical Requirements

The TIS Controller hardware shall be a rack-mountable micro-processor based system. It shall be rack-mountable in a standard 19" EIA-310-E compliant rack.

The TIS Controller shall incorporate a digital, real-time clock that shall be capable of maintaining the current date/time for a minimum of five (5) years without external power supply.

The TIS Controller shall have dedicated, redundant environmentally-hardened flash disk drives rated for high reliability.

The TIS Controller shall include a button or switch to place the controller in a local mode of operation.

The TIS Controller shall have a minimum of two USB ports which shall allow local control and communications by a connected laptop.

The TIS Controller shall include a local ruggedized keyboard, suitable for outdoor use as a method to select messages for display on the VMS.

The TIS Controller shall include a local microphone station with the capability to create new recorded announcements, or initiate live messages, and carry out other system actions in emergency situations.

Environmental Requirements

The TIS Controller shall comply with the following environmental requirements:

Criteria	**Minimum Conditions to be Met**
Operating Temperatures	Between -13°F to 131°F (-25°C and 55°C)
Storage Temperatures	Between -13°F to 158°F (-25°C and 70°C)
Humidity	5-90% relative humidity, non-condensing
Solid Object and Moisture Protection	IEC IP53
Water and Solvents	Shall withstand water spray on equipment from cleaning floors and walls, industrial solvents, rain, mud, snow and slush, all of which may contain salt, which may come in contact with equipment.

The TIS Controller shall comply with FCC Class A electromagnetic compatibility requirements.

Electrical Requirements

The TIS Controller shall comply with the following electrical requirements:

Item	Requirement
Operating Voltage	120 VAC ± 5%, 60 Hz
Input Current	<5 Amperes
Maximum Power Dissipation	500 Watts

Functional Requirements

General

The TIS Controller at each busway station shall be capable of being controlled remotely from the BOC through the Traveler Information Software as well as locally (in case of emergency or loss of communications with the BOC).

The TIS Controller at each busway station shall accept information from the Traveler Information Software to control the PA System and VMSs on all platforms at each busway station. The TIS Controller shall be interfaced with the Traveler Information Software through the busway communications network.

The TIS Controller at each busway station shall be capable of managing and controlling the VMSs and PA Systems for that station, and their synchronization.

When communication to the Traveler Information Software is lost or during emergency situations, the TIS Controller shall allow use of a local microphone over the PA System to make announcements on all platforms at each busway station. The TIS Controller shall also allow local control of VMSs on station platforms through selecting messages using a local keyboard.

The TIS Controller shall be assigned an IP address within the busway communications network.

Logon and Logoff

The TIS Controller shall support a logon feature that is password protected.

The TIS Controller shall allow users to log on with varying privileges depending on their access level.

The TIS Controller shall allow users logged in as system administrators to assign specific privileges to each access level; add, remove, or change access levels; assign access levels to each user; and add/remove users.

The TIS Controller shall allow users to logoff.

Digital Clock

The TIS Controller shall incorporate a digital, real-time clock capable of maintaining the current date/time for five years without external power supply.

The TIS Controller shall be capable of periodically synchronizing its real-time clock with the Traveler Information Software.

General Control

The TIS Controller shall be capable of configuring the VMS and PA System for its station.

The TIS Controller shall be able to be placed in a local mode of operation by a button or switch within the equipment cabinet.

The TIS Controller shall be able to accept messages of three classes from the Traveler Information Software: bus arrival predictions, ad hoc, and emergency at the station.

The TIS Controller shall be able to maintain and execute priority rules for the three classes of message, including whether messages of each type should be completed or interrupted if being delivered when receiving a higher priority message. These rules should be able to be established remotely from the BOC.

The TIS Controller shall be able to direct an audio announcement or text message, of any of the three classes, received from the BOC central software to the VMS and PA speakers associated with a designated set of the platforms associated with the station. Its delivery will be subject to the priority rules for this class of message.

The TIS Controller shall be able, when configured to do so remotely from the BOC, include the current clock time in the displays for all VMSs at the station.

The TIS Controller shall allow a laptop computer to be connected locally through the RS232 or USB ports, and shall operate as programmed in response to commands provided from the connected laptop in the same format as provided by the Traveler Information Software.

All communications parameters and settings shall be user configurable remotely from the BOC or when using the local laptop connection.

Traveler Information Software Integration

The TIS Controller shall accept periodic prediction information messages from the Traveler Information Software at the BOC containing multiple expected bus arrivals for each station platform.

The TIS Controller shall accept ad-hoc and emergency text messages from the Traveler Information Software at the BOC.

The TIS Controller shall accept audio announcements sent by the Traveler Information Software at the BOC.

Upon request from the Traveler Information Software, the TIS Controller shall send back to the Traveler Information Software for display the information it most recently directed to each VMS and the PA System.

The logon/logoff functionality at TIS Controllers shall be controlled by the Traveler Information Software.

Automatic reset/reboot and firmware download from the Traveler Information Software shall be supported.

VMS Integration

The TIS Controller shall be able to deliver messages from the Traveler Information Software at the BOC directed to the VMS on any possible combination of station platforms in any of three classes: prediction, ad hoc, and emergency messages.

Unless overridden by a requirement to display emergency information, and when communication with the Traveler Information Software via the controller is operating, each VMS associated with a station platform shall be able to display information for all the upcoming arriving vehicles as received from the Traveler Information Software indicates as expected to stop at that platform, with each bus displayed on a separate line, as well as ad hoc messages on the fourth line. When the number of upcoming arriving vehicles to be displayed exceeds the three lines allocated for this purpose on the VMS, the information shall be presented using multiple “pages” of three rows each (with a configurable duration for displaying each page and a configurable blank interval between “pages”).

Each update of the bus arrival time predictions from the Traveler Information Software shall cause an update of the list of expected arrivals and arrival times for each platform VMS.

The lowest line of each VMS shall be used for ad hoc messages originating at the Traveler Information Software or locally at the TIS Controller, scrolling and interleaving them as needed to present all such information.

The entire VMS message area shall be usable when commanded by the BOC dispatcher, or through local intervention at the TIS Controller, to display messages under emergency conditions, by overriding current “next bus" content.

The VMSs at each platform and station PA system shall be usable by the BOC dispatcher, or through local intervention at the TIS Controller, to broadcast messages under emergency conditions, by overriding any ad hoc content.

When placed in local mode, the TIS Controller shall accept keyboard entry of a temporary default message and program its delivery in terms of frequency and platform (direction of

travel), and shall direct the display of the this override messages at all associated VMSs in lieu of the messages as commanded by the Traveler Information Software.

When the TIS Controller receives a request from the VMS Readout Activation Device to annunciate the content lines of the VMS, then the TIS Controller shall convert the content into voice announcement and send it to the VMS Speaker for annunciation.

PA System Integration

The TIS Controller shall be able to direct announcements received from the Traveler Information Software at the BOC for any possible combination of station platforms to the PA systems for the associated platforms.

In the local mode of operation, when the microphone provided is connected, it shall be possible to record live messages and direct the output to any possible combination of station platform PA systems.

When in local mode, temporary default messages entered via keyboard shall be directed to the PA speakers after being converting to a voice announcement by a text-to-speech engine.

The TIS Controller shall be able to convert text messages being displayed on VMS into voice messages, and broadcast these voice messages from both station PA speakers and speakers associated with VMSs as required.

Ad hoc text messages received from the Traveler Information Software shall be able to be converted to a voice announcement by the TIS controller and broadcast over the PA System at selected periodic intervals.

The PA System shall allow for manual control of speaker volumes by the TIS Controller.

The PA System shall be usable, by the BOC dispatcher or through local intervention at the TIS Controller, to broadcast messages under emergency conditions that override any ad hoc content.

Failure Modes

The TIS Controller shall be able to receive and store a default message for each VMS with which it is interfaced, and shall direct it to be displayed in the absence of communication from the BOC.

The TIS Controller shall be able to receive and store a default message for the station PA System with which it is interfaced, and shall direct it to be announced in the absence of communication from the BOC.

The TIS Controller shall communicate faults and failure messages to the Traveler Information Software. The TIS Controller shall also generate a periodic “heartbeat” message to the Traveler Information Software that can be used to detect a loss of communications.

Performance Specifications

The TIS Controller shall operated in real-time, with a maximum lag of five (5) seconds between receipt of messages or announcements from the BOC to processing and display/broadcasting at the station.

Warranty Requirements

The TIS Controller and all associated equipment and cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The TIS Controller and all associated equipment and cabling shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

Spare Parts Requirements

The Contractor shall provide the following spare parts:

- Quantities equivalent to 10% of the total number of installed TIS Controllers, including all needed components and accessories required for a full and complete installation, including all associate equipment and cabling

All the spare parts shall be of the same make and model as the originals used to operate the original TIS Controller.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting equipment from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged equipment, as may be determined by the Engineer or a designated Department representative.

Installation

The TIS Controller and all included accessories and components shall be installed within the communications cabinet at each busway station as shown in the Drawings. The Contractor shall confirm locations with the Engineer or a designated Department representative.

The Contractor shall be responsible for all cabling required providing power and communications to the TIS Controllers.

Existing conduit between the power and communications cabinets at the station shall be provided.

The Contractor shall connect the TIS Controller to a designated power supply output receptacle in the power cabinet.

The Contractor shall connect the TIS Controller to the Gigabit Ethernet Switch.

The Contractor shall connect the TIS Controller to the PA System Audio Amplifier.

The Contractor shall connect all internal components of the TIS Controller, including the microphone and the keyboard.

The Contractor shall be responsible for all required configuration of the TIS Controllers, as directed by the Department, including synchronizing VMS and PA System messages, and allowing for local control of VMS and PA Systems during an emergency or when communications with the BOC is lost.

Security/Maintenance

All internal components, including all installed modules, shall be removable and replaceable by a single technician with basic hand tools.

Documentation and Training

The TIS Controller, and all associated equipment and cabling shall conform to the documentation and training requirements stated in Specification 100 – General Provisions and Specification 300 – Training.

The Contractor shall provide documentation and training on all the installation, configuration, management functions, operating features and maintenance procedures for the TIS Controller.

Testing

The TIS Controller, and all associated equipment and cabling shall conform to the testing requirements stated in the Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The Contractor shall be responsible for all testing that may be required to establish approval and acceptance of the TIS Controller.

The TIS Controller shall be tested for the following:

- Verification of time calibration between the digital clock and the Traveler Information Software
- Verification of information exchange between TIS Controller at each station and Traveler Information Software installed on BOC Servers
- Verification of all configuration features, including configuration of communications parameters, and number of bus predictions.

- Verification of configuration of TIS Controller remotely, from the Traveler Information Software at the BOC.
- Verification of display on all the VMSs from the TIS Controller, at each station.
- Verification of display from Traveler Information Software on VMSs for all combinations of platforms
- Verification of execution of priority rules for the three classes of messages.
- Verification of default display from VMS during communications failure mode
- Verification of manual override for local control of TIS Controller
- Verification of VMS display through local keyboard entry and PA System message announcement through local microphone
- Verification of manual control for speaker volumes

METHOD OF MEASUREMENT

This work shall be measured for payment by the number of units of TIS Controllers of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each TIS Controller shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the CT***fastrak*** ITS and Communications Systems shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 519 – UNINTERRUPTIBLE POWER SUPPLY FOR EMERGENCY CALL BOXES (UPS-ECB)

DESCRIPTION

This item shall consist of furnishing, installing, integrating and testing Uninterruptible Power Supply (UPS) units to support Emergency Call Boxes (ECBs) (refer to Specification 513 – Emergency Call Box) located at busway stations. The UPS-ECB shall provide regulated uninterruptible DC power supply for operation of an ECB in the event of main utility power supply failure and voltage or frequency fluctuations located on busway station platforms.

References and Standards

The following standards shall apply for the following categories:

Electronic Industries Alliance / Telecommunications Industry Association

- EIA/TIA-232-E: Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Binary Data Interchange
- EIA-RS-310-E: Cabinets, Racks, Panels and Associated Equipment

American National Standards Institute (ANSI)

- ANSI C62.41-1991: Guide on Surge Voltages in AC Power Circuits Rated up to 600V (formerly known as IEEE 587)

Other

- National Electrical Code
- UL508
- IEC 60950-1
- EN-61000-3-2

MATERIALS

General

Each UPS-ECB shall consist of the following components:

- Re-chargeable Batteries
- Charging station
- Associated cabling

The UPS-ECB shall be connected to a power supply in the location specified by the Engineer using appropriately shielded cabling.

The UPS-ECB, and all associated equipment and cabling shall comply with the Materials requirements stated in Specification 100 – General Provisions. If conflicts exist, this Item specification shall govern.

Manufacturer Requirements

The manufacturer of the UPS-ECB shall be regularly engaged in the manufacture and production of high quality devices for use in communications networks for at least ten (10) years.

Physical Requirements

The UPS-ECB shall include self-contained, sealed, maintenance-free batteries with a minimum lifetime of five (5) years.

The UPS-ECB shall be enclosed to prevent accidental contact with energized parts.

The UPS-ECB shall have an in-built input fuse and a circuit breaker for protection from over voltage and current variations.

The UPS-ECB shall provide an over voltage shutdown.

The UPS-ECB unit shall include the wiring and connection accessories necessary to interconnect the unit to the power source.

Environmental Requirements

Criteria	**Minimum Conditions to be Met**
Operating Temperatures	Between -4° F to 131° F (20°C to 55°C)
Storage Temperatures	Between -22° F to 158° F (-30°C to 70°C)
Humidity	5-90% relative humidity, non-condensing
Solid Object and Moisture Protection	IP 56

The UPS-ECB shall be compliant with the standards referenced in the References and Standards section.

Electrical Requirements

Item	Requirement
Operating Voltage	120 VAC ± 5%, 60 Hz
Input Current	<1 Amperes

The Contractor shall ensure that the electrical power supply output of the UPS-ECB matches the power supply input of the ECB.

Functional Requirements

The UPS-ECB shall provide uninterruptible power and conditioning of the utility power required for operation of Emergency Call Box equipment in the event of main utility power supply failure and voltage or frequency fluctuations.

The UPS-ECB shall have automatic voltage regulation, and provide a nominal output voltage sufficient to power the Emergency Call Box for eight (8) hours and shall have a current rating sufficient for the application.

The UPS-ECB shall include automatic restart. Upon restoration of utility AC power and after complete battery discharge, the unit shall automatically restart and resume operation. The battery charger shall automatically recharge the battery.

The UPS-ECB shall include full-time protection from sudden voltage increase with inrush protection and AC line filtering.

The UPS-ECB shall provide an alarm for the following circumstances:

- Low mains shutdown
- High temperature shutdown
- Rectifier failure
- Over voltage shutdown at output
- Low voltage at ECB operating threshold

The UPS-ECB shall comply with UL and NEC safety requirements.

The UPS-ECB shall comply with FCC part 15 as a Class B device requirements.

The UPS-ECB shall be tested and approved to ANSI C62.41-1991 (IEEE 587, Category A).

The UPS-ECB shall include an Ethernet communication port to support remote management and monitoring capabilities using SNMP including alarm contacts, inverter contacts, and remote shutdown. Remote monitoring software shall be included. The manufacturer shall provide all SNMP traps.

Performance Specifications

The UPS-ECB shall have a Mean Time Between Failure (MTBF) of at least 35,000 hours.

Warranty Requirements

The UPS-ECB and all associated equipment and cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The UPS-ECB and all associated equipment and cabling shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting equipment from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged equipment, as may be determined by the Engineer.

Installation

The Contractor shall ensure that the device is installed in a manner that is compliant with the NEC and applicable local codes.

The UPS-ECB shall be integrated into the ECB, installed in locations as shown in the Drawings. Prior to installation, the Contractor shall confirm installation design and locations with the Engineer or a designated Department representative.

The Contractor shall install and activate the units in accordance with the manufacturer recommended installation procedure.

The Contractor shall neatly dress, label and organize all cables in a manner acceptable to the Engineer.

Security/Maintenance

The Contractor shall be responsible for protecting equipment from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged equipment, as may be determined by the Engineer.

Documentation and Training

The Contractor shall comply with the documentation and training requirements stated in Specification 100 – General Provisions and Specification 300 – Training.

The Contractor shall deliver any remote monitoring software and documentation as part of the system documentation.

Testing

The Contractor shall comply with the testing requirements stated in the Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The Contractor shall be responsible for all testing that may be required to establish approval and acceptance of the UPS-ECB.

The Contractor shall employ industry-standard methods and tools to demonstrate that the UPS-ECB is compliant with specified requirements and monitor UPS-ECB performance and compliance with availability requirements throughout the term of the Contract, including all ongoing technical support and maintenance periods.

METHOD OF MEASUREMENT

This work shall be measured for payment by the number of units of Uninterruptible Power Supply For Emergency Call Boxes (UPS-ECB)s of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each UPS-ECB shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the CT***fastrak*** ITS and Communications Systems shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 520 – VARIABLE MESSAGE SIGN (DOUBLE-SIDED)

SPECIFICATION 521 – VARIABLE MESSAGE SIGN (SINGLE-SIDED, POLE MOUNTED)

SPECIFICATION 522 – VARIABLE MESSAGE SIGN (SINGLE-SIDED, CANTILEVER MOUNTED)

DESCRIPTION

This item shall consist of furnishing, installing, integrating and testing a Variable Message Sign (VMS) assembly. The VMS shall be used to display textual traveler information to passengers on bus platforms. The VMS shall either be double sided (Specification 520 – Variable Message Sign (Double-sided)) or single sided (Specification 521 – Variable Message Sign (Single-sided, Pole Mounted) and Specification 522 (Single-sided, Cantilever Mounted)).

The VMS shall be able to display textual information received from the TIS Controller. The VMS assembly shall also incorporate a customer-actuated readout device, which when actuated shall cause the TIS Controller to announce the textual contents of the sign plus the current time, if displayed, over the integrated VMS speaker.

Specification 520 – Variable Message Sign (Double-sided)

The double-sided VMS shall consist of the following:

- Sign case/housing
- Sign faces
- LED Display Module(s)
- Integrated speaker
- Readout actuation device
- Driving electronics
- Mounting post/brackets and hardware
- Associated cables and wiring

Specification 521 – Variable Message Sign (Single-sided, Pole Mounted)

The single-sided, pole mounted VMS shall consist of the following:

- Sign case/housing
- Sign face
- Light Emitting Diodes (LED) Display Module(s)
- Integrated speaker
- Readout actuation device
- Driving electronics
- Post support structure with foundation
- Mounting post/brackets and hardware
- Associated cables and wiring

Specification 522 – Variable Message Sign (Single-sided, Cantilever Mounted)

The single-sided, cantilever mounted VMS shall consist of the following:

- Sign case/housing
- Sign face
- Light Emitting Diodes (LED) Display Module(s)
- Integrated speaker
- Readout actuation device
- Driving electronics
- Cantilever bracket and support structure
- Mounting post/brackets and hardware
- Associated cables and wiring

References and Standards

Technical Standards

- National Transportation Communications for ITS Protocol (NTCIP) Standard 1203 version 03: Object Definitions for Dynamic Message Signs
- NTCIP Standard 9012: Testing Guide for User
- National Electrical Manufacturers Association (NEMA) Standard TS-4: Hardware Standards for Dynamic Message Signs (DMS) with NTCIP Requirements

Environmental and Enclosure

- Federal Communications Commission (FCC) Code of Federal Regulations 47 Part 15 Class A
- International Electrotechnical Commission (IEC) Standard 60529 – Degrees of Protection provided by Enclosures
- NEMA Standard 250: Enclosures for Electrical Equipment (1000 Volts Maximum)
- US Military Standard MIL-STD-810 –Department of Defense Test Method Standard for Environmental Engineering Considerations and Laboratory Tests

Installation

- National Fire Protection Association (NFPA) 70 – National Electric Code
- National Fire Protection Association (NFPA) 731: Standard for the Installation of Electronic Premises Security Systems
- Electronic Industries Alliance / Telecommunications Industry Association (EIA/TIA) 568: Commercial Building Telecommunications Wiring Standard.
- EIA/TIA-606: Administration Standard for the Telecommunication Infrastructure
- EIA/TIA-607: Commercial Building Grounding and Bonding Requirements for Telecommunications.

Product Safety

- Underwriters Laboratory (UL) 60950: Information technology equipment – safety, International Electrotechnical Commission (IEC) 60950: Safety of information technology equipment, European Norm (EN) 60950: Safety of information technology equipment, Canadian Standards Association (CSA) 60950-95: Safety of Information Technology Equipment, or similar

MATERIALS

General

The VMS shall use LED technology, all display modules of which shall be of identical make and model.

The VMS shall be connected to the TIS Controller (refer to Specification 518 – TIS Controller) in the Communications Cabinet using Category 6 (Cat 6) Ethernet Cabling (refer to Specification 501 – Category 6 (Cat 6) Ethernet Cabling).

The VMS Readout Actuation Device shall be connected to the TIS Controller in the Communications Cabinet using Cat 6 Ethernet Cabling or approved alternate cabling.

The VMS shall be connected to a power supply in the power cabinet using appropriately shielded cabling.

The Contractor shall comply with relevant NTCIP and NEMA standards for the VMS.

The VMS, and all associated equipment and cabling shall comply with the Materials requirements stated in Specification 100 – General Provisions. If conflicts exist, this Item specification shall govern.

Manufacturer Requirements

The manufacturer of the VMSs shall be regularly engaged in the manufacture and production of dynamic message signs for use in transportation stations.

Physical Requirements

General

The dimensions for each four line single-sided VMS shall not exceed 26 inches (H) x 80 inches (W) x 12 inches (D). The dimensions for each four line double-sided VMS shall not exceed 26 inches (H) x 80 inches (W) x 30 inches (D).

The weight of the four line single-sided LED display shall not exceed 150-lbs. and the weight of the four line double-sided LED display shall not exceed 300-lbs.

An "LED" display must contain pixels constructed solely of high-intensity discrete LEDs. These outdoor displays must utilize a sign cabinet meeting NEMA 4X design requirements.

Sign Case

For displays that will ever have direct sunlight on the sign face, an optional sunshade shall be provided with the sign case. The sunshade shall extend out horizontally from the top of the sign case at least one-quarter of the sign face's vertical dimension. The sunshade shall minimize solar gain and maximize the display contrast.

The VMS sign case and front face border pieces shall be coated with Flat Black automotive-grade paint.

Electrical display components shall be 100% solid-state.

The sign case shall include heating elements as necessary to prevent any build up of ice over the sign face, to avoid obscuring sign readability.

The sign case, including the sign face, should be vandal/graffiti resistant and washable.

For ease of installation, double-sided displays up to 32 pixels high shall be housed in a single sign case, as opposed to consisting of two separate sign cases bolted together.

The Contractor shall be responsible for bird-proofing the sign-case using bird-proof gel or other similar methods, to ensure that birds do not roost on the VMS and deface it.

Sign Face and LED Display Modules

The sign face shall be protected by weather tight, scratch resistant, ultraviolet radiation stabilized, Lexan polycarbonate with antireflective/antiglare treatment (or approved alternate material).

LED display modules shall be comprised to form a display matrix for 4 lines of at least 24 characters per line, with each character being three inches in vertical dimension and incorporating at least 5-pixel columns by 7-pixel rows. Pixels shall be viewable in direct sunlight.

Each display line shall be separated vertically by a minimum 4 intervening -pixel spaces.

The luminous intensity of the pixel shall not decrease more than 40% when viewed at a minimum angle of 30 degrees (15 degrees at 1/2 angle) centered about the optical axis and perpendicular to the surface of the display.

The VMS LEDs shall be amber on a black background.

The number of LED pixels comprising each character and the number of individual LEDs in each sign pixel shall ensure that the overall sign considering the background and the polycarbonate sheet in front of the pixels, achieves the optical output, contrast, viewing angle, legibility and reliability requirements.

The LED pixel design shall provide for effective heat dissipation and incorporate other measures to minimize the effects of heat build-up within the individual pixel elements.

The LEDs shall operate within the LED's manufacturer's rated temperature range under the worst case operating conditions.

The LED pixels shall be waterproofed to protect the LEDs.

The soldering of the LEDs to the driving electronics shall be in accordance with the manufacturer's recommended guidelines.

Speaker

The VMS assembly shall incorporate a speaker that can be driven and controlled by the TIS Controller to make audio announcements. Refer to Specification 518 – TIS Controller.

The audio volume shall automatically adjust to ensure that it is only loud enough to be understandable within a 15-foot radius from the sign.

The speaker or speaker casing shall be designed for outdoor operations and inclement conditions and shall be weatherproofed and vandal resistant.

Readout Actuation Device

A button or similar easily operated device shall be placed in close proximity to each VMS that, when pressed or actuated, shall initiate an annunciation of the content lines of the VMS through the incorporated speaker.

The height of and reach to the device shall meet ADA requirements and shall be placed at a consistent and accessible location adjacent to the sign.

The device shall indicate its location to the sight impaired using an approved method (e.g., "periodic soft chirp").

Proper signage in accordance with ADA requirements with visual and tactile characters shall be placed near or on the Readout Actuation Device to communicate its function to passengers.

Mounting Post, Bracket and Hardware

All mounting posts, brackets, and hardware supplied for the single-sided and double-sided VMS shall be constructed on stainless steel, anodized aluminum, or equivalent corrosion resistant material.

Environmental Requirements

Criteria	**Minimum Conditions to be Met**
Operating Temperatures	Between -40°F to 122°F (-40°C and 50°C)
Storage Temperatures	Between -40°F to 158°F (-40°C and 70°C)
Humidity	0-90% relative humidity, non-condensing
Operating Vibration	Compliant with MIL-STD-810-F or equivalent
Shock	Compliant with MIL-STD-810-F or equivalent
Solid Object and Moisture Protection	IEC IP65 or NEMA 4X
Water and Solvents	Shall withstand water spray on equipment from cleaning floors and walls, industrial solvents, rain, mud, snow and slush, all of which may contain salt, which may come in contact with equipment.

Electrical Requirements

Item	Requirement
Operating Voltage	120 VAC ± 5%, 60 Hz

Connection to power shall be inside the housing. A knock-out shall be provided in the housing to allow for the entrance of the power conductors. This entrance shall provide a seal around the power conductors so as to retain the environmental rating of the sign case enclosure.

Functional Requirements

General

The VMS shall be able to display text information as generated by and received from the Traveler Information System (TIS) Controller. The VMS's integrated speaker shall be able to play audio messages generated by and received from the TIS Controller.

Both the VMS and the Readout Actuation Device shall be interfaced with the station TIS Controller at the station. If a Readout Actuation Device button is pushed, it will send an indication to the TIS Controller. Upon receipt of the indication, the TIS Controller will generate an audio message based on the text contents (plus the current time, if to be displayed) of the VMS logically associated with the activated Readout Actuation Device, for annunciation by the logically associated VMS speaker.

The VMS shall be able to display the current time of day in digital format, if a user-configurable flag in the TIS Controller is set to require this.

The VMS System shall be IP based.

All VMS communications parameters and settings shall be user configurable through a local maintenance port.

LED Sign Display

Two VMS configurations shall be provided:

- Specification 520 – Variable Message Sign (Double-sided): a four (4) line display shall be shown on both sides of the sign. Both sides of a two-sided display shall be housed in one cabinet. Information displayed on two-sided displays shall be the same on both sides.
- Specification 521 – Variable Message Sign (Single-sided, Pole Mounted) and Specification 522 – Variable Message Sign (Single-sided, Cantilever Mounted): a four (4) line display shall be shown on one side of the sign with a sign case on the backside

The VMS shall be able to display three (3) types of messages: static messages, flashing messages, and scrolling messages.

The VMS shall be able to display a message composed of any combination of alphanumeric character fonts, punctuation symbols and full graphics.

VMS display characteristics shall include both variable and fixed width fonts, proportional spacing and fully configurable fonts.

The VMS shall provide four-line matrices with a minimum of twenty-four (24) fixed width font characters per line.

The VMS shall support display of current clock time from the TIS Controller in a portion of any one of the four line matrices, using a subset of the matrix's characters configured in the TIS Controller.

All modules shall be securely mounted so that the nominal axis of the pixel light output shall be perpendicular to the sign face.

Speaker

The speaker shall provide good coverage and high level of speech intelligibility to overcome limitations such as reverberation, echo, delay and feedback to the most extreme listening positions.

Readout Actuation Device

The Readout Actuation Device when pressed or actuated shall indicate to the TIS Controller that a request to annunciate the content lines of the VMS through the incorporated speaker has been made.

Actuation of this device shall result in the audible reading of the sign text once in English annunciated through the incorporated VMS speaker.

TIS Controller Integration

The VMS display shall be refreshed whenever the TIS Controller sends an update to any content.

Automatic reset/reboot and firmware download from the Traveler Information Software via the TIS Controller shall be supported.

Failure Modes

Failure of a pixel or module shall not cause failure of any other pixel.

When communication with the TIS Controller is lost, and if not overridden for emergency messages, the VMS shall display a preset default message, which can be updated from the TIS Controller when it is in communication with the VMS.

When communication with the TIS Controller is lost, the activation of the VMS Readout Actuation Device shall cause a preset default message to be broadcast over the associated VMS speaker, which can be updated from the TIS Controller when it is in communication with the VMS.

Performance Specifications

The VMS shall have a mean time between failure (MTBF) of at least 50,000 hours.

When operating at full intensity, the sign display shall be clearly legible from any viewing distance between 3-ft and 75-ft along a line perpendicular to the face of the sign. This legibility distance shall be required:

- During all normally encountered weather and lighting conditions, and at all times of the day
- During dawn and dusk hours when sunlight is shining directly on the display face or when the sun is shining from directly behind the VMS

At least 50% of this viewing distance shall be maintained within a cone spanning 22 degrees in any direction from this perpendicular axis.

Failure and reset recovery time for both hard and soft reset shall be less than 45-seconds.

Warranty Requirements

The VMS and all associated equipment and cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The VMS and all associated equipment and cabling shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

Spare Parts Requirements

The Contractor shall provide the following spare parts:

- Quantities equivalent to 10% of the total number of installed Variable Message Signs (Double-sided), included all needed components and accessories
- Quantities equivalent to 10% of the total number of installed Variable Message Signs (Single-sided, Pole Mounted), included all needed components and accessories
- Quantities equivalent to 10% of the total number of installed Variable Message Signs (Single-sided, Cantilever Mounted), included all needed components and accessories

All the spare parts shall be of the same make and model as the originals used to operate the original VMS.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting equipment from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged equipment.

Installation

General

The VMS assemblies shall be installed at locations at stations as shown in the Drawings. The Contractor shall confirm locations with the Engineer or a designated Department representative.

The installed VMS assembly shall not occupy a footprint exceeding that defined in station design plans.

The VMS shall be placed in a location so that it does not conflict with ADA accessibility guidelines in normal operation.

All power supply and communications wiring, conduit and connections shall be installed in accordance with all applicable electrical and building codes.

The Contractor shall connect and configure an IP address in accordance with the Contractor-developed IP Address Coordination Plan and as approved by the Engineer.

The Contractor shall confirm date of VMS installation with the Engineer. Under no circumstances shall the Contractor begin installation of any VMS without written approval of the installation date from the Engineer.

Specification 520 – Variable Message Sign (Double-sided)

The Contractor shall be responsible for the installation of the entire double-sided VMS assembly on existing station canopies.

The Contractor shall mount the VMS case and speaker from the existing station canopy frame using mounting brackets or other suspension apparatus. The Contractor shall supply all required mounting hardware to safely suspend double-sided VMS from existing station canopies.

The VMS shall be mounted such that the lower edge of the sign is at a height that meets safe head clearance requirements.

The Contractor shall have a structural engineer licensed in the State of Connecticut confirm that the Contractor's proposed double-sided VMS signs can be safely accommodated by the structural strength of the station canopy frame at the designated locations.

The Contractor shall coordinate with others to ensure that the physical appearance of the station canopy is not diminished due to the installation of the VMS, and any cracks, or fractures in the canopy resulting from the installation process shall be repaired completely to reinstate its appearance.

The VMS Readout Actuation Device (button) shall be mounted on the interior face of the existing canopy pier as shown in the Drawings in a manner to meet ADA requirements.

The Contractor shall supply all required mounting hardware, conduit, cabling, signage, etc. for the VMS Readout Actuation Device (button).

Existing conduit between the proposed VMS location and the communications cabinets shall be available. The Contractor shall be responsible for extending the conduits as necessary to the VMS components through the canopy, mounting post and hardware. The Contractor shall be responsible for providing and installing all cabling necessary to provide power and communications to the VMS.

Specification 521 – Variable Message Sign (Single-sided, Pole Mounted)

The Contractor shall be responsible for the design, procurement and installation of the single-sided, pole mounted VMS assembly.

The Contractor shall be responsible for designing and installing all necessary VMS foundations, concrete pads, mounting bolts, and pavement matching. The foundation design shall be stamped by a structural engineer licensed in the State of Connecticut.

Single-sided, pole mounted VMS shall be installed a dedicated galvanized steel pole to be provided and installed by the Contractor. The Contractor shall have the design of the galvanized steel pole stamped by a structural engineer licensed in the State of Connecticut.

The Contractor shall be responsible for providing and installing all necessary support structures and mounting hardware. The Contractor shall be responsible for installing the mounting post on the concrete foundation using the required mounting brackets and associated hardware, and mounting the sign case, speaker, and Readout Actuation Device on mounting posts.

Where indicated on the station Drawings, CCTV camera domes are to be installed on the single-sided VMS mounting posts. The structural strength of these mounting posts shall be evaluated to ensure that it can accommodate the load of the camera and its associated mounting hardware and cabling. Each mounting post shall be designed to accommodate a minimum of one (1) single-sided VMS, one (1) CCTV camera, and one (1) Readout Actuation Device. Refer to Specification 512 – CCTV Camera Assembly (Stations).

The physical design of the mounting system including the height of the pole and the heights at which the LED signs, speakers, and Readout Actuation Devices are mounted shall meet ADA requirements.

The Contractor shall be responsible for designing the pole mount and bracket to safely support itself, the VMS, the CCTV camera, and all extension arms and mounting materials, as well as suitable wind and ice loads (with galloping), along with a suitable safety factor to accommodate human-equivalent active loads. The bracket design shall be stamped by a structural engineer licensed in the State of Connecticut.

All bracket material shall be consistent with the structural steel requirements of Form 816, Section 6.03, including all relevant ASTM, ANSI, and AASHTO standards.

The physical design of the mounting system shall be submitted to the Engineer for approval, before being finalized for installation.

The VMS Readout Actuation Device (button) shall be installed on the VMS mounting post and located in a manner to meet ADA requirements. The Contractor shall be responsible for providing and installing any necessary mounting hardware, conduit, cabling, signage, etc. necessary to install the Readout Actuation Device on the VMS mounting post.

Existing conduit between the proposed VMS location and the power and communications cabinets shall be available. The Contractor shall be responsible for extending the communication cabling and power conduits to the VMS components through the mounting post and hardware. The Contractor shall be responsible for providing and installing all cabling necessary to provide power and communications to the VMS.

Specification 521 – Variable Message Sign (Single-sided, Cantilever Mounted)

The Contractor shall be responsible for the design, procurement and installation of the single-sided, cantilever mounted VMS assembly.

The Contractor shall be responsible for designing and installing all necessary VMS foundations, concrete pads, mounting bolts, and pavement matching. The foundation design shall be stamped by a structural engineer licensed in the State of Connecticut.

The Contractor shall be responsible for providing and installing all necessary support structures and mounting hardware.

Single-sided, cantilever mounted VMS shall be installed on a cantilevered bracket attached to the station platform pylon.

The Contractor shall be responsible for designing the cantilevered bracket to safely support itself, the VMS, the CCTV camera, and all extension arms and mounting materials, as well as suitable wind and ice loads (with galloping), along with a suitable safety factor to accommodate human-equivalent active loads. The bracket design shall be stamped by a structural engineer licensed in the State of Connecticut.

All bracket material shall be consistent with the structural steel requirements of Form 816, Section 6.03, including all relevant ASTM, ANSI, and AASHTO standards.

The physical design of the cantilevered bracket shall be submitted to the Engineer for approval, before being finalized for installation.

The Contractor shall also have a structural engineer licensed in the State of Connecticut confirm that the Contractor's proposed design can be safely accommodated by the pylon foundation.

The VMS Readout Actuation Device (button) shall be mounted on the front side of the pylon, facing the curb, in close proximity to the VMS, and located in a manner to meet ADA requirements.

The Contractor shall supply all required mounting hardware for the VMS Readout Actuation Device (button).

The Contractor shall be responsible for designing and installing the necessary mounting hardware, conduit, cabling, signage, etc. for the Readout Actuation Device.

The physical design of the mounting system including the height of the pole and the heights at which the LED signs, speakers, and Readout Actuation Devices are mounted shall meet ADA requirements. The physical design of the mounting system shall be submitted to the Engineer for approval, before being finalized for installation.

Existing conduit between the proposed VMS location and the power and communications cabinets shall be available. The Contractor shall be responsible for extending the communication cabling and power conduits to the VMS components through the cantilever arm and hardware. The Contractor shall be responsible for providing and installing all cabling necessary to provide power and communications to the VMS.

Security/Maintenance

All internal components shall be removable and replaceable by a single technician with basic hand tools. Removal of a module will not be required to access the internal components of the display.

The VMS maintenance doors shall be self-supporting (through hinges or other mechanism).

The enclosure shall incorporate a side-hinged door into the front face that opens to allow unimpeded maintenance access to the interior of the VMS for diagnosis/replacement of all internal components.

Documentation and Training

The VMS and all associated equipment and cabling shall comply with the documentation and training requirements stated in Specification 100 – General Provisions and Specification 300 – Training.

The Contractor shall provide documentation and training on all the installation, integration, configuration, management functions, operating features and maintenance procedures for the VMS.

Testing

The VMS and all associated equipment and cabling shall comply with the testing requirements stated in Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The Contractor shall be responsible for performing all testing that may be required to establish approval and acceptance of the VMS.

The Contractor shall employ industry-standard methods and tools to measure and monitor VMS performance and compliance with availability requirements throughout the term of the Contract, including all ongoing technical support and maintenance periods.

Testing for the VMS shall include:

- Demonstration of all matrix display pixels activated/deactivated in alternating mode using a test pattern for minimum 15 minutes.

- Demonstration of uniformity of light intensity and color, using a calibrated photometer or similar device. Confirmation of compliance with the luminance and contrast ratio specifications shall be performed.

- Demonstration of continuous operation over 168 hours using a checker board pattern change every 15 minutes.

Any pixels which fail during testing shall be replaced and the complete test repeated.

VMS testing shall include initiation of all commands required in the software specifications. The Controller Unit must respond correctly within five (5) seconds of issuing the command and must transmit the correct reply.

VMS testing shall include downloading of messages that shall be carried out using all variations of attributes or other variables.

VMS testing shall include demonstrated recovery of all messages from the appropriate memory slots at least two (2) times.

Visibility tests shall be conducted during the full range of ambient illumination conditions to verify the legibility distance, including dawn or sunset depending on site location.

METHOD OF MEASUREMENT

Specification 520 – Variable Message Sign (Double-sided)

This work shall be measured for payment by the number of units of Variable Message Sign – Double-sided of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each Variable Message Sign – Double-sided shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

Specification 521 – Variable Message Sign (Single-sided, Pole Mounted)

This work shall be measured for payment by the number of units of Variable Message Sign (Single-sided, Pole Mounted) of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each Variable Message Sign (Single-sided, Pole Mounted) shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

Specification 522 – Variable Message Sign (Single-sided, Cantilever Mounted)

This work shall be measured for payment by the number of units of Variable Message Sign (Single-sided, Cantilever Mounted) of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each Variable Message Sign (Single-sided, Cantilever Mounted) shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the CT***fastrak*** ITS and Communications Systems shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 531 – BOC RACK

DESCRIPTION

This Item shall consist of furnishing, installing, integrating and testing a server rack, herein called the "BOC Rack", and all needed components and accessories required for a full and complete installation, including all associated equipment and cabling. The BOC Rack shall be used to house communications and computer equipment within the Busway Operations Center (BOC). The BOC Rack shall include the following:

- Rack Enclosure
- Rack Cooling Fans
- Rack Power Distribution Units (PDUs)

References and Standards

Environmental and Enclosure

- International Electrotechnical Commission (IEC) Standard 60529 – Degrees of Protection provided by Enclosures
- Federal Communications Commission (FCC) Code of Federal Regulations 47 Part 15 Class A

Product Safety

- Underwriters Laboratory (UL) 60950: Information technology equipment – safety, International Electrotechnical Commission (IEC) 60950: Safety of information technology equipment, European Norm (EN) 60950: Safety of information technology equipment, Canadian Standards Association (CSA) 60950-95: Safety of Information Technology Equipment, or similar.

Installation

- Electronic Components, Assemblies & Materials Association (ECA) EIA/ECA-310-E: Cabinets, Racks, Panels, and Associated Equipment
- National Fire Protection Association (NFPA) 70 – National Electric Code

MATERIALS

General

The contractor shall equip the BOC with one (1) Rack Enclosure, including all required accessories and cabling. The BOC Rack shall be configured with Rack Cooling Fans and a minimum of four (4) Rack PDUs.

The BOC Rack shall house the following equipment, as shown in the Drawings and as directed by the Engineer, or a designated Department representative:

- Firewalls (refer to Specification 532 – Firewall)
- Modular Chassis Switch (refer to Specification 533 – Modular Chassis Switch)
- Servers (refer to Specification 535 – Server)
- Network Video Recorders (refer to Specification 534 – Network Video Recorders)

The BOC Rack shall comply with EIA-310-E requirements for a 19-inch rack enclosure.

The BOC Rack shall comply with the Safety Standards referenced in References and Standards.

The BOC Rack, and all associated equipment and cabling shall comply with the Materials requirements stated in Specification 100 – General Provisions. If conflicts exist, this Item specification shall govern.

Manufacturer Requirements

The manufacturer of the BOC Rack shall be regularly engaged in the manufacture and production of high quality rack equipment and accessories for use in data centers.

Physical Requirements

The BOC Rack shall be designed to provide a secure, managed environment for server and networking equipment.

The BOC Rack shall have a minimum usable height of 42 Rack Units (RU) and minimum usable depth of 35 inches.

The BOC Rack shall have lockable front and rear doors. A minimum of two (2) copies of the keys per door shall be provided.

All doors shall have lift-off hinges. (i.e., upon opening the door, it shall be possible to simply lift the door off its hinge to remove the door.)

All side panels shall be removable.

Grounding points should be provided on frame to externally bond each unit to building ground.

The BOC Rack shall have the provision to mount Rack PDUs and other power distribution components.

BOC Rack shall have the provision for stabilization by using mounting brackets or other hardware to attach to the enclosure frame on the front and rear (on the interior or exterior). The Contractor shall provide mounting brackets and all other accessories to bolt the BOC Rack to the ground.

The BOC Rack shall have four (4) adjustable leveling feet to help provide a stable base.

Rack Cooling Fans

The BOC Rack shall have the provision to mount Rack Cooling Fans and other cooling accessories.

The BOC Rack shall be equipped with Rack Cooling Fans at the top of the rack. The fans shall run continuously. The fans shall be ball bearing, low noise type with minimum capacity of 560 CFM. The fans shall exhaust air through the top of the enclosure. In addition, if the rack is loaded to more than 60% of capacity, the Contractor shall supply one (1) additional fan tray (1 RU) with each rack. This shall be considered incidental to the rack.

Environmental Requirements

Criteria	Minimum Conditions to be Met
Operating Temperatures	Between 32°F to 122°F (0°C and 50°C)
Storage Temperatures	Between -13°F to 158°F (-25°C and 70°C)
Humidity	5-90% relative humidity, non-condensing
Solid Object and Moisture Protection	IEC IP20
Water and Solvents	Shall withstand water spray on equipment from cleaning floors, walls and industrial solvents that may come in contact with equipment.

The BOC Rack and all included accessories shall be compliant with the electromagnetic compatibility standards referenced in the References and Standards section.

Electrical Requirements

Rack Cooling Fans

The Rack Cooling Fans shall comply with the following minimum electrical requirements:

Item	Requirement
Operating Voltage	120 VAC ± 5%, 60 Hz
Input Current	2.5 Amperes (Maximum)
Maximum Power Dissipation	250 Watts

Rack Power Distribution Units

The Rack PDUs shall comply with the following electrical requirements:

Item	Requirement
Input Voltage	120 VAC ± 5%, 60 Hz
Output Voltage	120 VAC ± 5%, 60 Hz
Output Power Capacity	10000 Watts (Minimum for all PDUs combined)

Functional Requirements

The BOC Rack shall provide suitable housing to install communications equipment complying with EIA-310-E 19-inch rack specifications.

The BOC Rack shall be capable of leveling.

Rack Power Distribution Units

The Contractor shall equip the BOC Rack with Rack PDUs which shall supply power to all the equipment housed in the BOC Rack.

The Rack PDUs shall be capable of supporting power supply cords from all equipment housed in the BOC Rack (including all redundant power supplies) and compatible with the types of power plugs being used by each kind of equipment.

Rack Cooling Fans

The Contractor shall equip the BOC Rack with a minimum of three (3) Rack Cooling Fans which shall circulate air through the BOC Rack.

Performance Specifications

The BOC Rack shall be capable of withstanding a static load of up to 2500 lbs (1134 kgs).

Warranty Requirements

The BOC Rack and all associated equipment and cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The BOC Rack and all associated equipment and cabling shall have a manufacturer-provided equipment warranty for a period of at least five (5) years.

Spare Parts Requirements

The Contractor shall provide the following spare parts with the BOC Rack:

- two (2) Rack PDUs
- three (3) Rack Cooling Fans

All the spare parts shall be of the same make and model as the modules installed in the BOC Rack.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting equipment from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged equipment, as may be determined by the Engineer.

Installation

The Contractor shall assemble and install the BOC Rack and all included accessories in accordance with the manufacturer recommended installation procedure.

The Contractor shall install the BOC Rack at the BOC as shown in the Drawings and as directed by the Engineer, or a designated Department representative. The Contractor shall be responsible for coordinating with the Engineer to ensure installation of the BOC Rack is coordinated with the installation of other BOC equipment, furnishings, ancillaries, etc.

The manufacturer should supply structural calculations by an Engineer registered in the state of Connecticut showing compliance with the local Uniform Building Code (UBC) for floor anchoring.

The Contractor shall secure the BOC Rack to the ground using brackets which shall be provided with the Rack Enclosure.

The Contractor shall install the Rack Cooling Fans and PDUs in the BOC Rack. The Rack Cooling Fans shall be installed in such a manner as to maximize the cross-circulation of air and prevent interference between the airs circulated from the various Rack Cooling Fans.

The Contractor shall connect the Rack PDUs to the designated power supply output receptacles from the Uninterruptible Power Supply BOC (refer to Specification 536 – Uninterruptible Power Supply BOC)

The Contractor shall neatly dress, organize, label and secure all cables. No cables shall be installed with a radius less than the manufacturer's minimum recommended bending radius.

Security/Maintenance

All internal components, including all installed modules, shall be removable and replaceable by a single technician with basic hand tools.

Documentation and Training

The BOC Rack, and all associated equipment and cabling shall comply with the documentation and training requirements stated in Specification 100 – General Provisions and the Specification 300 – Training.

The Contractor shall provide documentation and training on the installation, configuration and maintenance procedures for the BOC Rack and all included accessories.

The Contractor shall provide a wiring diagram showing the connections of all the BOC equipment to the BOC Rack PDUs, ensuring that none of the BOC Rack PDUs is loaded more than its rating. The diagram shall also illustrate the maximum power ratings for all the equipment installed in the BOC Rack, including the following:

- Firewalls
- Modular Chassis Switch
- Servers
- Network Video Recorders
- Rack Cooling Fans

Testing

The BOC Rack, and all associated equipment and cabling shall comply with the testing requirements stated in Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The Contractor shall provide all documentation required for verification that the BOC Rack complies with the minimum technical requirements specified, including all regulatory and environmental requirements.

The BOC Rack shall be tested for, as a minimum, the following:

- Verification of the total load capacity.
- Verification of the load capacity handled by each Rack PDU.
- Verification of the stability of the rack under full load.

The Contractor shall verify the compatibility of the Rack PDUs with all equipment being housed in the BOC Rack.

METHOD OF MEASUREMENT

This work shall be measured for payment by the number of units of BOC Racks of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each BOC Rack shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the ITS and Communications Systems for CT***fastrak*** shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 532 – FIREWALL

DESCRIPTION

This Item shall consist of furnishing, installing, and testing Firewalls, with all accessories required for a complete, fully functional installation, including all associated equipment and cabling. The Firewalls shall protect the Busway Operations Center (BOC) LAN network from the external threats, shall support an access control strategy, and shall monitor local and external network resources.

References and Standards

Product Safety

- Underwriters Laboratory (UL) 60950: Information technology equipment – safety, International Electrotechnical Commission (IEC) 60950: Safety of information technology equipment, European Norm (EN) 60950: Safety of information technology equipment, Canadian Standards Association (CSA) 60950-95: Safety of Information Technology Equipment, or similar.

Environmental and Enclosure

- Federal Communications Commission (FCC) Code of Federal Regulations 47 Part 15 Class A
- International Electrotechnical Commission (IEC) Standard 60529 – Degrees of Protection provided by Enclosures
- National Electrical Manufacturers Association (NEMA) Standard 250: Enclosures for Electrical Equipment (1000 Volts Maximum)

Installation

- Electronic Components, Assemblies & Materials Association (ECA) EIA/ECA-310-E: Cabinets, Racks, Panels, and Associated Equipment

Security

- Federal Information Processing Standard Publication 140-2: Security Requirements for Cryptographic Modules

MATERIALS

General

The contractor shall equip the BOC with two (2) Firewalls to be mounted in a rack as designated in the Drawings. The Firewalls shall be connected with each other, as well as to the Modular Chassis Switch using Cat 6 copper patch cabling (refer to Specification 501 - Category 6 Copper Patch Cabling).

The Contractor shall coordinate procurement of the Firewalls with the Department's Office of Information Systems (OIS), to ensure that all equipment is the latest make and model available at time of submittal of Final Design Documentation and all equipment is consistent with the Department's latest IT standards.

The Firewalls, and all associated equipment and cabling shall comply with the Materials requirements stated in Specification 100 – General Provisions. If conflicts exist, this Item specification shall govern.

Obsolete, no-longer-supported, or no-longer-produced equipment shall not be acceptable.

Manufacturer Requirements

The Firewall manufacturer shall have been regularly engaged in the manufacture of network security hardware devices for commercial and industrial applications, meeting internationally accepted quality standards in the manufacture of such equipment.

Physical Requirements

The Firewalls shall be rack-mountable in an EIA 19-inch rack.

The Firewalls shall comply with the physical requirements listed in the table below:

ITEM	REQUIREMENT
Integrated Network Ports	Minimum of 4 Gigabit Ethernet Copper, 4 Gigabit Ethernet SFP Fiber
Serial Ports	Minimum of 2 RJ-45 console and auxiliary ports
Minimum Memory	4 GB
Minimum System Flash	256 MB
Form Factor	2RU (Maximum)

Environmental Requirements

The Firewall shall comply with the environmental requirements listed in the table below:

Criteria	Minimum Conditions to be Met
Operating Temperatures	Between 32°F to 122°F (0°C and 50°C)
Storage Temperatures	Between -13°F to 158°F (-25°C and 70°C)
Humidity	5-90% relative humidity, non-condensing
Solid Object and Moisture Protection	IEC IP53, NEMA 12 or greater

The Firewall shall be compliant with the referenced electromagnetic compatibility standards referenced in the References and Standards section of this specification.

Electrical Requirements

The Firewall shall comply with the electrical requirements listed in the table below:

ITEM	REQUIREMENT
Operating Voltage	120 VAC ± 5%, 60 Hz
Input Current	2 Amperes (Maximum)
Maximum Power Dissipation	200 Watts

Functional Requirements

The Firewalls shall be certified to provide FIPS 140-2 Level 2 or higher security.

The Firewalls shall protect the BOC LAN network from any external threats attempting to access the network.

The Firewall shall incorporate unified threat management capabilities.

The Firewall shall have intrusion detection and prevention capability. The supported detection methods shall include signature-based detection, statistical anomaly based detection, stateful protocol, analysis detection, layer-2 detection and IP spoofing detection.

The Firewall shall support the implementation of access control strategies and shall support monitoring of the local and external resources.

The Firewall shall include predefined signatures for identifying threats. It shall support customization of signatures to personalize the attack database.

The Firewall shall have application awareness and identification capabilities, and shall support configuration of rules and policies based on application traffic.

The Firewalls shall protect the BOC LAN network from external internet-borne threats such as malicious software, spyware, viruses, adware, spam, virtual attackers, and hackers. The Firewall shall be capable of protecting the BOC LAN network against denial-of-service attacks, distributed denial-of-service attacks, replay attacks, brute force attacks and malware attacks.

The Firewalls shall protect standard BOC operations, allow for high availability and for Virtual Private Networking (VPN) system support. 3DES and AES encryption methods shall be supported.

The Firewall shall allow remote access to devices on the BOC LAN by laptops or computers on the internet, using VPN or other similar secure access methods.

The Firewall shall include regular software updates to provide protection against newly discovered vulnerabilities, and against newly detected viruses, malware, spyware and adware. Updates shall be licensed for a minimum of 2 years from the date of installation and configuration at the BOC.

The Firewall shall include a modular operating system to provide for easy updates and reduce downtime.

The Firewalls shall be configured in an active/standby configuration mode. The secondary Firewall shall duplicate the functionality of the primary Firewall at all times.

Performance Specifications

The Firewall shall comply with the performance requirements listed in the table below:

ITEM	REQUIREMENT
Firewall Throughput	2 Gbps (Minimum)
3DES/AES VPN Throughput	1 Gbps (Minimum)
IPsec VPN Peers	5000 (Minimum)
Concurrent Connections	650,000 (Minimum)
New Connections/Second	33,000 (Minimum)
Users/Nodes	50000 (Minimum)
Virtual Interfaces (VLANs)	400 (Minimum)
Redundancy Configuration	Active/Active and Active/Standby

Warranty Requirements

The Firewall and all associated equipment and cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The

Firewall and all associated equipment and cabling shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting equipment from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged equipment.

Installation

The Contractor shall install the Firewalls in accordance with the manufacturer recommended installation procedure.

The Contractor shall install the Firewalls in a rack at the BOC as shown in the Drawings and as directed by the Engineer. The Contractor shall be responsible for coordinating with the Engineer or a designated Department representative to ensure installation of the Firewalls is coordinated with the installation of other BOC equipment, furnishings, ancillaries, etc.

The Contractor shall connect the Firewalls to each other in an active/standby redundant configuration.

The Contractor shall connect the Firewalls to the Modular Chassis Switch.

The Contractor shall connect the Firewall power supply cord to the designated power supply output receptacles in the rack power distribution assembly.

The Contractor shall neatly train and organize all cables. No cables shall be installed with a radius less than the manufacturer's minimum recommended bending radius.

The Contractor shall be responsible for the complete configuration of the Firewalls to implement network security policies, as directed by the Department.

Security/Maintenance

All internal components, including all installed modules, shall be removable and replaceable by a single technician with basic hand tools.

Documentation and Training

The Firewall, and all associated equipment and cabling shall comply with the documentation and training requirements stated in Specification 100 – General Provisions and the Specification 300 – Training specification.

The Contractor shall provide documentation and training on all the installation, configuration, operating features, management functions, and maintenance procedures for the Firewall.

Testing

The Firewall, and all associated equipment and cabling shall comply with the testing requirements stated in Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The Firewalls shall be tested for, as a minimum, the following:

- Verification of firewall throughput, 3DES/AES VPN throughput and all other performance requirements.
- Demonstration of Firewall operation in active/active and active/standby configurations when interfaced with another firewall.
- Verification of the Firewall configuration, as directed by the Department

METHOD OF MEASUREMENT

This work shall be measured for payment by the number of units of Firewalls of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each Firewall shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the ITS and Communications Systems for CT***fastrak*** shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 533 – MODULAR CHASSIS SWITCH

DESCRIPTION

This Item shall consist of furnishing, installing, integrating and testing a Modular Chassis Switch, all needed components and accessories required for a full and complete installation, including all associated equipment and cabling. The Modular Chassis Switch shall serve as the network head-end switch for the BOC LAN, interfacing with all the devices within the BOC (servers, workstations etc.) and, via the optical fiber communications network, with all of the field and station equipment.

References and Standards

Institute of Electrical and Electronics Engineers (IEEE) standards

- 802.17 Resilient Packet Ring
- 802.3ae 10-Gigabit Ethernet
- 802.3ab Gigabit Ethernet over Copper
- 802.3x Flow Control
- 802.3ad Link Aggregation
- 802.1Q VLAN Tagging
- 802.1D Bridging
- 802.1w Rapid STP
- 802.1s Multiple Spanning Tree Protocol
- 802.1X User authentication

Product Safety

- Underwriters Laboratory (UL) 60950: Information technology equipment – safety, International Electrotechnical Commission (IEC) 60950: Safety of information technology equipment, European Norm (EN) 60950: Safety of information technology equipment, Canadian Standards Association (CSA) 60950-95: Safety of Information Technology Equipment, or similar.
- International Electrotechnical Commission (IEC) 60825-1: Safety of laser products - Part 1: Equipment classification and requirements
- International Electrotechnical Commission (IEC) 60825-2: Safety of laser products - Part 2: Safety of optical fibre communication systems (OFCS)

Environmental and Enclosure

- Federal Communications Commission (FCC) Code of Federal Regulations 47 Part 15 Class A
- European Norm (EN) 55022: Information technology equipment. Radio disturbance characteristics
- International Electrotechnical Commission (IEC) Standard 60529 – Degrees of Protection provided by Enclosures
- National Electrical Manufacturers Association (NEMA) Standard 250: Enclosures for Electrical Equipment (1000 Volts Maximum)

Installation

- Electronic Components, Assemblies & Materials Association (ECA) EIA/ECA-310-E: Cabinets, Racks, Panels, and Associated Equipment

MATERIALS

General

The contractor shall equip the BOC with one (1) Modular Chassis Switch including all required modules and cabling. The Modular Chassis Switch shall be connected through fiber patch cables from the Optical Fiber Termination Patch Panel (refer to Specification 508 – Optical Fiber Termination Patch Panel) installed at the BOC to the optical fiber communications network, the Internet and dedicated leased lines. The Modular Chassis Switch shall be connected to the Servers, Workstations, Network Video Recorders, Firewalls and Video Display Processor using Cat 6 Copper Patch Cabling (refer to Specification 535 – Server, Specification 540 – Workstation, Specification 534 – Network Video Recorder, Specification 537 – Video Display Processor, Specification 532 – Firewall and Specification 501 – Category 6 Copper Patch Cable).

The Modular Chassis Switch, and all associated equipment and cabling shall comply with the Materials requirements stated in Specification 100 – General Provisions. If conflicts exist, this Item specification shall govern.

The Modular Chassis Switch shall be equipped and configured with dual management modules, one (1) 48-port 1-GbE RJ-45 module, one (1) 24-port SFP/SFP+ module and dual (2) switching fabric modules.

The Modular Chassis Switch shall be compatible and interoperable with all Gigabit Ethernet Switches (refer to Specification 502 – Gigabit Ethernet Switch (Type A) and Specification 503 – Gigabit Ethernet Switch (Type B))

The Contractor shall coordinate procurement of the Modular Chassis Switch with the Department's Office of Information Systems (OIS), to ensure that all equipment is the latest make and model available at time of submittal of Final Design Documentation and all equipment is consistent with the Department's latest IT standards.

The Modular Chassis Switch shall be modular. For the purposes of this Work, "modular" shall be interpreted to include, but not be limited to, equipment composed of standardized units or sections that allow for easy construction, flexible arrangement, and ease of removal/replacement. Items shall not be considered "modular" if equipment modules cannot be removed without permanent damage to the equipment, or if modules are permanently fastened to the chassis or motherboard.

Manufacturer Requirements

The manufacturer of the Modular Chassis Switch shall be regularly engaged in the manufacture and production of high performance Ethernet switching equipment for use in telecommunications switching center, transportation management systems and other high-reliability and critical system applications.

Physical Requirements

The Modular Chassis Switch shall be an industry standard product and shall be the latest model available that complies with the technical requirements of this specification.

The Modular Chassis Switch shall be rack-mountable in a standard EIA 19-inch rack and shall require no more than 14 RU.

The Modular Chassis Switch shall have a minimum of 8 input/output module slots.

The Modular Chassis Switch shall be capable of supporting up to 48 SFP/SFP+ ports with the installation and configuration of additional modules.

The Modular Chassis Switch shall be capable of supporting up to 256 1-GbE ports with the installation of additional modules.

The Modular Chassis Switch shall support 1-GbE and 10-GbE ports through the input/output modules.

The Modular Chassis Switch shall be configured with dual management modules, one (1) 48-port 1-GbE RJ-45 module, one (1) 24-port SFP/SFP+ module and dual (2) switching fabric modules.

The Modular Chassis Switch RJ-45 module shall be speed and duplex selectable.

Environmental Requirements

Criteria	Minimum Conditions to be Met
Operating Temperatures	Between 32°F to 122°F (0°C and 50°C)
Storage Temperatures	Between -13°F to 158°F (-25°C and 70°C)
Humidity	5-90% relative humidity, non-condensing
Solid Object and Moisture Protection	IEC IP53 or NEMA 12
Water and Solvents	Shall withstand water spray on equipment from cleaning floors, walls and industrial solvents that may come in contact with equipment.

The Modular Chassis Switch shall be compliant with the electromagnetic compatibility standards referenced in the References and Standards section.

Electrical Requirements

Item	Requirement
Operating Voltage	120 VAC ± 5%, 60 Hz
Input Current	25 Amperes (Maximum)
Maximum Power Dissipation	3000 Watts

Functional Requirements

The Modular Chassis Switch shall have dual supervisor modules and shall provide a modular network operating system such that failure or modification of any of the network operating system functions shall not affect any of the other functions of the Modular Chassis Switch.

The Modular Chassis Switch shall be compliant with the IEEE standards referenced in the References and Standards section.

The Modular Chassis Switch shall support the following protocols: Border Gateway Protocol Version 4 (BGPv4), Open Shortest Path First (OSPF), Intermediate System To Intermediate System (IS-IS), Routing Information Protocol (RIP), Internet Protocol (IP) Multicast, Internet Protocol version 6 (IPv6) Core, IPv6 Routing, IPv6 Multicast and IPv6 Transitioning.

The Modular Chassis Switch shall support PIM Dense (PIM-DM) and PIM Sparse (PIM-SM) multicast routing protocols.

The Modular Chassis Switch shall support at least one of JFlow, NetFlow, sFlow or similar traffic monitoring protocols.

The Modular Chassis Switch shall support all Network Management capabilities described in Specification 558 – Network Management System and Specification 532 – Firewall.

The Modular Chassis Switch shall provide security capabilities, including at a minimum, AAA, Radius, Secure Shell (SSH v2), Secure Copy (SCP), TACACS, TACACS+, Username/Password.

The Modular Chassis Switch shall act as a communications gateway for cellular and bulk data (high-speed wireless) communications.

The Modular Chassis Switch shall be interfaced with the Firewalls, with the Firewalls functioning in active/standby configuration.

Performance Specifications

The Modular Chassis Switch shall have a minimum switching capacity of 800 Gbps.

The Modular Chassis Switch shall have a minimum packet forwarding capacity per system of 571 Mpps.

The Modular Chassis Switch shall be capable of interconnecting with a minimum of 30 other switches in a ring topology. In this configuration the ring described shall support a data payload of 30% without adverse effect on specified latency or recovery times.

The Modular Chassis Switch shall have a minimum MTBF of 50,000 hours.

Warranty Requirements

The Modular Chassis Switch and all associated equipment and cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The Modular Chassis Switch and all associated equipment and cabling shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

Spare Parts Requirements

The Contractor shall provide the following spare parts with the Modular Chassis Switch:

- one (1) 48-port 1-GbE port
- one (1) 24-port SFP/SFP+ module

All the spare parts shall be of the same make and model as the modules installed in the Modular Chassis Switch.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting equipment from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged equipment, as may be determined by the Engineer.

Installation

The Contractor shall install the Modular Chassis Switch in accordance with the manufacturer recommended installation procedure.

The Contractor shall install the Modular Chassis Switch in a rack at the BOC as shown in the Drawings and as directed by the Engineer. The Contractor shall be responsible for coordinating with the Engineer to ensure installation of the Modular Chassis Switch is coordinated with the installation of other BOC equipment, furnishings, ancillaries, etc.

The Contractor shall be responsible for proper configuration of the Modular Chassis Switch and its connection to the Optical Fiber Termination Patch Panel installed at the BOC.

The Contractor shall connect the Modular Chassis Switch to both the Firewalls.

The Contractor shall connect the Modular Chassis Switch power supply cord to the designated power supply output receptacles in the rack power distribution assembly.

The Contractor shall configure the network, including IP addressing schema, VLAN configurations, network security configurations, and all other relevant network configuration work in accordance with its Engineer-approved IP Address Coordination Plan.

The Contractor shall ensure that the configuration of the switch and connection to local and remote Ethernet equipment does not result in oversubscribed ports on the switch.

The Contractor shall install all interface cable connections between the device and associated equipment. All cables shall be labeled identifying the associated equipment connection.

The Contractor shall neatly dress, organize, label and secure all cables. No cables shall be installed with a radius less than the manufacturer's minimum recommended bending radius.

Security/Maintenance

All internal components, including all installed modules, shall be removable and replaceable by a single technician with basic hand tools.

Documentation and Training

The Modular Chassis Switch, and all associated equipment and cabling shall comply with the documentation and training requirements stated in Specification 100 – General Provisions and the Specification 300 – Training.

The Contractor shall provide documentation and training on all the network management functions, switch configuration, operating features and maintenance procedures for the Modular Chassis Switch.

Testing

The Modular Chassis Switch, and all associated equipment and cabling shall comply with the testing requirements stated in Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration , Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The Contractor shall provide all documentation required for verification that the Modular Chassis Switch complies with the minimum technical requirements specified, including all regulatory and environmental requirements.

The Modular Chassis Switch shall be tested for, as a minimum, the following:

- Demonstration of the maximum switching capacity.
- Demonstration of the maximum packet forwarding capacity.
- Demonstration of the specified security features.
- Demonstration of network performance monitoring and verification of network configuration.
- Verification of functioning of spares

METHOD OF MEASUREMENT

This work shall be measured for payment by the number of units of Modular Chassis Switches of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each Modular Chassis Switch shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the ITS and Communications Systems for CT***fastrak*** shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 534 – NETWORK VIDEO RECORDER

DESCRIPTION

This item shall consist of furnishing, installing, integrating, and testing Network Video Recorders (NVRs), all needed components and accessories required for a full and complete installation, including all associate equipment and cabling. The system shall facilitate the data compression, storage, retrieval, analysis and display of CCTV Camera video data received from throughout the entire CT***fastrak*** system.

The NVR system shall consist of:

- NVR Software to manage the CCTV Camera video image streams, store the camera data and interface with the CCTV Camera Management Software (refer to Specification 554 – CCTV Camera Management Software)
- NVR Server hardware to host the NVR software, encode or decode the CCTV Camera (refer to Specification 511 – CCTV Camera Assembly (Stations) and Specification 512 – CCTV Camera Assembly (Busway)) data and store the encoded CCTV Camera data.

References and Standards

Technical Standards

- IEEE 802.3 Ethernet Standards collection
- ISO/IEC JTC1/SC29/WG11 – Coding of moving pictures and audio (Moving Picture Experts Group – MPEG)

Environmental and Enclosure

- Federal Communications Commission (FCC) Code of Federal Regulations 47 Part 15 Class A
- European Norm (EN) 55022: Information technology equipment. Radio disturbance characteristics
- International Electrotechnical Commission (IEC) Standard 60529 – Degrees of Protection provided by Enclosures

Installation

- Electronic Components, Assemblies & Materials Association (ECA) EIA/ECA-310-E: Cabinets, Racks, Panels, and Associated Equipment

Product Safety

- Underwriters Laboratory (UL) 60950: Information technology equipment – safety, International Electrotechnical Commission (IEC) 60950: Safety of information technology equipment, European Norm (EN) 60950: Safety of information technology equipment, Canadian Standards Association (CSA) 60950-95: Safety of Information Technology Equipment, or similar

MATERIALS

General

The Contractor shall furnish and install NVRs in the Busway Operations Centre (BOC), at the locations as shown in the Drawings or as directed by the Engineer or a designated Department representative. The number of NVRs shall be decided based on the following parameters:

- The combined minimum storage capacity of all the NVRs (as described in Physical Requirements)
- The capability to simultaneously compress and store data (in the format specified in Functional Requirements) from a minimum of one hundred and forty (140) CCTV Cameras.

The NVRs shall be connected to the Modular Chassis Switch located in the Busway Operations Center (BOC) using Category 6 (Cat 6) cabling (refer to Specification 533 – Modular Chassis Switch and Specification 501 – Category 6 (Cat 6) Copper Patch Cable).

The NVR, and all associated equipment and cabling shall comply with the Materials requirements stated in Specification 100 – General Provisions. If conflicts exist, this Item specification shall govern.

Manufacturer Requirements

The manufacturer of the NVRs shall be regularly engaged in the manufacture and production of video encoding, storage and playback equipment for use in security systems.

Physical Requirements

The Contractor shall furnish and install all necessary cables and any other hardware necessary, within the BOC facilities, to provide complete and fully functional NVRs. Minimum technical requirements for each NVR are provided in the following table:

ITEM	REQUIREMENT
Form Factor	19-inch EIA Rack-mountable
Storage	Non-volatile data storage to prevent data loss during power outages. Storage drives shall be hot-swappable. A minimum of 8TB shall be pre-installed. Each hard disk drive will have a minimum storage capacity of 1TB @7200RPM and 16MB Cache, operating using SATA 3.0Gbps.
Storage Controller	Must support up to RAID 6
Serial Ports	One (1) RS232 port
USB Port	Two (2) USB 2.0 ports
Optical Drive	DVD+/-RW Drive
Communications	Internal Network Card with Dual 1-Gb Ethernet Ports

The combined minimum usable storage capacity of all the NVRs together shall be the higher of the two from the following:

- 48TB
- capacity required for the storage of a minimum of 30 days of video for one hundred and forty (140) cameras along the busway and at busway stations

The NVRs shall be rack-mountable in an EIA 19 inch rack and shall require a maximum combined rack space of 12 RU.

Environmental Requirements

Criteria	Minimum Conditions to be Met
Operating Temperatures	Between 32°F to 104°F (0°C and 40°C)
Storage Temperatures	Between -13°F to 158°F (-20°C and 70°C)
Humidity	5-95% relative humidity, non-condensing
Solid Object and Moisture Protection	IEC IP53
Water and Solvents	Shall withstand water spray on equipment from cleaning floors and walls and industrial solvents that may come in contact with equipment.

The NVR shall be compliant with the electromagnetic compatibility standards referenced in References and Standards.

Electrical Requirements

Item	Requirement
Operating Voltage	120 VAC ± 5%, 60 Hz
Input Current	25 Amperes (Combined maximum, for all NVRs)
Maximum Power Dissipation	2500 Watts (Combined, for all NVRs)

Functional Requirements

Network Video Recorder (NVR)

The NVRs shall use MPEG-4 compression or Department-approved alternate compression format. The NVRs shall record all incoming CCTV Camera data feeds in the MPEG-4 or other approved format.

Each NVR shall be capable of storage and playback of real-time camera data feeds at minimum 4CIF (704 x 480, NTSC) resolution @ 7.5 frames per second (fps) per input channel (refer to Specifications 511 and 512 for more information on CCTV Camera Assembly requirements). Individual adjustments to both resolution and fps (frames per second) shall be possible per input to meet a given installation requirement for video retention.

The NVRs shall have the ability to store at least thirty (30) days of video at minimum 4CIF resolution and at least 7.5 fps from each camera, with automatic rewrite of the oldest video as its storage term expires. The camera management software must be able to archive stored images without shutting down regular CCTV camera video storage operations. The camera management software shall allow users to configure automatic archiving operations so that no image is necessarily lost to over-writing.

The NVRs shall be capable of simultaneous recording and playback of a minimum of 140 CCTV camera channels.

The NVR Software shall support simultaneous recording and playback of a minimum of 200 CCTV camera channels through hardware expansion.

The NVRs shall allow the export of stored video data via USB port, DVD±RW optical drive, or other means approved by the Engineer.

The NVR Software shall allow the user the ability to view and control all the NVR Servers across a local or wide area network.

When stored video data is exported from the NVR, encryption protocols shall be used to prevent tampering and allow enforcement personnel to establish chain of custody.

The NVR Software shall support external backup and archiving of stored video data.

The NVR Software shall support automatic programming, whenever needed, for daylight savings time changes and updates to the timing of daylight savings time changes.

The NVR shall support issuing programmable event notifications by e-mail.

CCTV Camera Assembly Interface

NVRs shall be installed in the BOC and shall be interfaced with the CCTV Camera Assemblies through the busway communications network and the BOC LAN network. The NVRs shall be able to receive and process video data feeds from all busway and station area cameras.

CCTV Camera Management Software Integration

The NVRs shall function as video servers and shall interface with the CCTV Camera Management Software, providing users access to video through the CCTV Camera Management Software desktop clients installed on dispatcher Workstations (refer to Specification 540 – Workstation).

The NVRs shall support all functionality required as per Specification 554 – CCTV Camera Management Software.

Performance Specifications

Each NVR shall have a Mean Time Between Failure (MTBF) of at least 15,000 hours.

Warranty Requirements

The NVRs and all associated equipment and cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The NVRs and all associated equipment and cabling shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

The hard disk drives and all associated equipment and cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The hard disk drives and all associated equipment and cabling shall have a manufacturer-provided equipment warranty for a period of at least three (3) years.

Spare Parts Requirements

The Contractor shall provide the following spare parts with each of the NVRs:

- Hard disk drives with a combined minimum storage capacity of 25% of each NVR's total storage capacity.

All the spare parts shall be of the same make and model as the modules installed in the NVR.

CONSTRUCTION METHODS

Delivery, Storage and Handling

The Contractor shall be responsible for protecting equipment from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged equipment, as determined by the Engineer or a designated Department representative.

Installation

The Contractor shall install and configure all hardware and software for the NVR in accordance with the manufacturer recommended installation and configuration procedures.

The Contractor shall install the NVRs in a rack at the BOC as shown in the Drawings and as directed by the Engineer or a designated Department representative. The Contractor shall be responsible for coordinating with the Engineer to ensure installation of the NVRs is coordinated with the installation of other BOC equipment, furnishings, ancillaries, etc.

The Contractor shall connect the NVR power supply cords to the designated power supply output receptacles in the rack power distribution assembly.

The Contractor shall connect the NVRs to the Modular Chassis Switch.

The Contractor shall assign an IP address to each NVR Server as approved by the Engineer or a designated Department representative.

The Contractor shall coordinate with the Department to create a list assigning specific CCTV Camera Assemblies to each NVR. Each NVR shall be configured to interface with the assigned CCTV Cameras along the busway and shall be responsible for all data compression, storage and playback for the assigned cameras.

Maintenance

All internal components shall be removable and replaceable by a single technician with basic hand tools.

Documentation and Training

The NVR and all associated equipment and cabling shall comply with the documentation and training requirements stated in Specification 100 – General Provisions and Specification 300 – Training.

The Contractor shall provide documentation and training on all the installation, configuration, operating features, management functions, and maintenance procedures for the NVRs.

Testing

The NVR and all associated equipment and cabling shall comply with the testing requirements stated in the Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype

Demonstration Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The Contractor shall be responsible for all testing that may be required to establish approval and acceptance of the NVR. The NVR shall be tested for, as a minimum, the following:

- Verification of total installed storage capacity of each NVR and combined storage capacity of all NVRs together
- Verification of simultaneous recording and playback capability of each NVR in the format specified.
- Verification of simultaneous recording and playback capabilities for up to 140 CCTV Camera data channels together.
- Verification of control of all NVRs through the CCTC Camera Management Software
- Verification of functioning of spares
- Absence of any delay or latency
- Absence of stuttering video, overall system slowdown, hourglass (please wait icon) or other indication of bandwidth or throughput limitation either in the displayed images, or from the CMS software or the operating systems involved

The system shall be tested for stability and smoothness under normal and very intense use conditions; under simultaneous storage and search conditions; with many users logged on simultaneously; and while automated archiving is taking place. Symptoms of unbalanced or slow system or inability or unwillingness of the system to perform all required tasks simultaneously and without delay shall be unacceptable.

METHOD OF MEASUREMENT

This work shall be measured for payment by the number of units of NVRs of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each NVR shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the ITS and Communications Systems for CT***fastrak*** shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 535 – SERVER

DESCRIPTION

This Item shall consist of furnishing, installing, and testing Servers, with all accessories required for a complete, fully functional installation, including all associated equipment, and cabling. The Servers shall host the software applications used by the Busway Operations Center (BOC) for monitoring and managing the busway stations and buses.

References and Standards

Product Safety

- Underwriters Laboratory (UL) 60950: Information technology equipment – safety, International Electrotechnical Commission (IEC) 60950: Safety of information technology equipment, European Norm (EN) 60950: Safety of information technology equipment, Canadian Standards Association (CSA) 60950-95: Safety of Information Technology Equipment, or similar.

Environmental and Enclosure

- Federal Communications Commission (FCC) Code of Federal Regulations 47 Part 15 Class A
- International Electrotechnical Commission (IEC) Standard 60529 – Degrees of Protection provided by Enclosures
- National Electrical Manufacturers Association (NEMA) Standard 250: Enclosures for Electrical Equipment (1000 Volts Maximum)

Installation

- Electronic Components, Assemblies & Materials Association (ECA) EIA/ECA-310-E: Cabinets, Racks, Panels, and Associated Equipment

MATERIALS

General

The Contractor shall furnish and install two (2) Servers at the locations as shown on the Drawings or as directed by the Engineer or a designated Department representative.

The Servers shall be connected to the Modular Chassis Switch using Cat 6 Copper Patch Cabling (refer to Specification 533 – Modular Chassis Switch and Specification 501 – Category 6 Copper Patch Cable).

The Contractor shall coordinate procurement of the Servers with the Department's Office of Information Systems (OIS), to ensure that all equipment is the latest make and model available at time of submittal of Final Design Documentation and all equipment is consistent with the Department's latest IT standards.

The Servers, and all associated equipment and cabling shall comply with the Materials requirements stated in Specification 100 – General Provisions. If conflicts exist, this Item specification shall govern.

Obsolete, no-longer-supported, or no-longer-produced equipment shall not be acceptable.

Manufacturer Requirements

The Server manufacturer shall have been regularly engaged in the manufacture of servers for commercial and industrial applications, meeting internationally accepted quality standards in the manufacture of such equipment.

Physical Requirements

The Server shall be rack mountable in a standard EIA 19-inch rack.

The Server shall have the technical requirements provided in the table below:

ITEM	REQUIREMENT
Form Factor	4U (Maximum)
Chipset	Industry standard Intel Xeon Series
RAM Memory	Minimum of sixteen (16) DIMM slots, each slot capable of supporting modules with 8-GB DDR3 SDRAM at 1333MHz. Minimum of eight (8) modules with 4-GB DDR3 SDRAM at 1333MHz shall be preinstalled.
Processor	Minimum of two (2) Processor sockets. Each socket must be capable of supporting Quad-core or higher Intel® Xeon® series processors with processor speed of 3.0GHz and 12MB Cache. Minimum of twelve (12) processor cores (three (3) quad-core or two (2) six-core processors), each with a minimum 2.0GHz, 12MB cache shall be pre-installed.

ITEM	REQUIREMENT
Local Hard Drive	Minimum of five (5) 3.5" or five (5) 2.5" high performance SAS drive bays. Each drive bay socket must support up to 2-TB hot pluggable drives, with total supported capacity of up to 10GB. Minimum of 6-TB @ 10000 RPM shall be pre-installed.
Internal Storage	Controller shall support up to RAID Level 6
External Storage	Controller shall support up to RAID Level 6
Communications	Two (2) Dual-port 1-GbE Network Cards
Video	Embedded Video Adapter
Power Supply	Hot-pluggable redundant power supply
Virtualization	Must support virtualization

Environmental Requirements

Criteria	Minimum Conditions to be Met
Operating Temperatures	Between 32°F to 113°F (0°C and 45°C)
Storage Temperatures	Between -13°F to 158°F (-25°C and 70°C)
Humidity	5-95% relative humidity, non-condensing
Solid Object and Moisture Protection	IEC IP53 or NEMA 12
Water and Solvents	Shall withstand water spray on equipment from cleaning floors and walls and industrial solvents that may come in contact with equipment.

The Servers shall be compliant with the referenced electromagnetic compatibility standards referenced in the References and Standards section.

Electrical Requirements

The Servers shall comply with the electrical requirements listed in the following table:

ITEM	REQUIREMENT
Operating Voltage	120 VAC ± 5%, 60 Hz
Input Current	8 Amperes (Maximum)

ITEM	REQUIREMENT
Maximum Power Dissipation	900 Watts (in redundant power supply configuration)

Functional Requirements

The Servers shall have server Operating System (OS) software installed, including all required licenses.

The Servers shall have database management software installed, including all required licenses.

The Servers shall be capable of clustering.

The Servers shall be capable of running at least twenty (20) virtualized software environments.

The Servers shall support the following as virtualized software:

- APC Management Software (refer to Specification 551 – APC Management Software)
- Bulk Data Gateway Software (refer to Specification 552 – Bulk Data Gateway Software)
- CAD/AVL Central Software (refer to Specification 553 – CAD/AVL Central Software)
- CCTV Camera Management Software (refer to Specification 554 – CCTV Camera Management Software)
- Cellular Data Communication Gateway Software (refer to Specification 555 – Cellular Data Communication Gateway Software)
- ECB Management Software (refer to Specification 556 – ECB Management Software)
- Network Management System (refer to Specification 558 – Network Management System)
- Traveler Information Software (refer to Specification 559 – Traveler Information Software)

The Servers shall have automatic failover capabilities and shall be capable of operating in redundant configuration, with each duplicating the functionality of the other. This means that all data and processing shall be continuously mirrored (i.e. both servers kept in "hot-standby" for each other) in such a way that one is available for use within one (1) second when the other fails with both always containing identical information.

Performance Specifications

The servers shall be sufficient to support at least thirty (30) concurrent users of the BOC application software, without affecting real-time performance. For this contract, "real-time" is defined as information reaching all users in a usable format within 100 milliseconds from when the information was first generated within the system.

Warranty Requirements

The Servers and all associated equipment and cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The Servers and all associated equipment and cabling shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

Spare Parts Requirements

The Contractor shall provide the following spare parts with each Server:

- one (1) hot-pluggable power supply unit
- one (1) hard disk drive of 2 TB capacity

All the spare parts shall be of the same make and model as the modules originally installed in the Server.

CONSTRUCTION METHODS

Delivery, Storage, Handling

The Contractor shall be responsible for protecting equipment from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged equipment, as determined by the Engineer or a designated Department representative.

Installation

The Contractor shall confirm interoperability with all other system equipment connected to the BOC LAN network and the busway communications network.

The Contractor shall install the central Servers in accordance with the manufacturer recommended installation procedures.

The Contractor shall install Servers in a rack at the BOC as designated in the Drawings and as directed by the Department or a designated representative.

The Servers shall be connected to the Department's BOC LAN network through Ethernet cabling connected to the Modular Chassis Switch.

The Contractor shall connect the Server power supply cord to the designated rack power distribution assembly.

The Contractor shall neatly train and organize all cables. No cables shall be installed with a radius less than the manufacturer's minimum recommended bending radius.

The Contractor shall be responsible for the complete configuration of the Servers, which shall include all hardware and operating system software configuration.

The Servers shall be configured in a hot-standby configuration, as described in the Functional Requirements.

On each Server, the Contractor shall install and configure all application software, as directed by the Department or a designated representative. The software shall be configured to run in virtualized cluster environments on both Servers.

Security/Maintenance

All internal components, including all installed modules, shall be removable and replaceable by a single technician with basic hand tools.

Documentation and Training

The Servers, and all associated equipment and cabling shall comply with the documentation and training requirements stated in Specification 100 – General Provisions and Specification 300 – Training.

The Contractor shall provide all documentation and training for the Server, including instructions on:

- Installation and configuration of Server
- Maintenance including replacement procedure for the power supply units, replacement procedure for the hot-plug hard disk drives, memory and other field-replaceable components
- Software configuration procedure for the Servers, including configuration for running Server in a redundant hot-standby mode with other Servers and configuration procedure for the Servers to run virtualized software
- Software operation and configuration procedure for operating system software, database management software and any other software installed on the Servers

Testing

The Contractor shall perform all testing of the Server and all associated equipment and cabling in accordance with the testing requirements specified in Specification 201 – Factory Acceptance

Tests, Specification 202 – Prototype Demonstration Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The Contractor shall demonstrate that the installed Servers can failover within specified parameters.

The Contractor shall demonstrate that the Servers can run virtualized software on each Server and all software installed on the Servers is running properly.

The Contractor shall verify that the spares are of the same make and model as the modules installed in the Server.

METHOD OF MEASUREMENT

This work shall be measured for payment by the number of units of Servers of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each Server shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the ITS and Communications Systems for CT***fastrak*** shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 536 – UNINTERRUPTIBLE POWER SUPPLY (BOC)

DESCRIPTION

This item shall consist of furnishing, installing, integrating, and testing an Uninterruptible Power Supply (UPS) at the Busway Operations Center (BOC). The UPS (BOC) unit shall provide regulated uninterrupted power supply for the operation of the electronic equipment installed in the Busway Operations Center (BOC) in the event of main utility power supply failure and voltage or frequency fluctuations.

References and Standards

Installation

- EIA-RS-310-E: Cabinets, Racks, Panels and Associated Equipment

Technical Standards

- Underwriters Laboratory (UL) 1778 - Uninterruptible Power Systems
- National Fire Protection Association (NFPA) 70 – National Electric Code
- ANSI C62.41-1991: Guide on Surge Voltages in AC Power Circuits Rated up to 600V (formerly known as IEEE 587)

Product Safety

- Underwriters Laboratory (UL) 60950: Information technology equipment – safety, International Electrotechnical Commission (IEC) 60950: Safety of information technology equipment, European Norm (EN) 60950: Safety of information technology equipment, Canadian Standards Association (CSA) 60950-95: Safety of Information Technology Equipment, or similar.

Environmental and Enclosure

- International Electrotechnical Commission (IEC) Standard 60529 – Degrees of Protection provided by Enclosures
- Federal Communications Commission (FCC) Code of Federal Regulations 47 Part 15 Class A

MATERIALS

General

The contractor shall equip the BOC with a UPS capable of providing 120VAC output with a total power output of 10kW for one (1) continuous hour. The one (1) hour capacity may be achieved by attaching extendable power and battery modules to the main UPS (BOC) unit.

The UPS (BOC) shall supply power to the following equipment in the BOC through the BOC Rack Power Distribution Units (PDUs) (refer to Specification 531 – BOC Rack):

- Modular Chassis Switch (refer to Specification 533 – Modular Chassis Switch)
- All Firewall(s) (refer to Specification 532 – Firewall)
- All Server(s) (refer to Specification 535 - Server)
- All Network Video Recorders (refer to Specification 534 – Network Video Recorder)
- At least one (1) Workstation with two (2) attached Monitors (refer to Specification 540 – Workstation and Specification 539 – Workstation Monitor)

The UPS (BOC) shall be interfaced with the BOC LAN network through an RJ-45 Ethernet port.

The UPS (BOC), and all associated equipment and cabling shall comply with the Materials requirements stated in Specification 100 – General Provisions. If conflicts exist, this Item specification shall govern.

Obsolete, no-longer-supported, or no-longer-produced equipment will not be acceptable.

Manufacturer Requirements

The manufacturer must be regularly engaged in the manufacture of uninterruptible power supply equipment for commercial and industrial applications, meeting internationally accepted quality standards in the manufacture of such equipment.

Physical Requirements

The UPS (BOC) shall comply with the safety standards referenced in References and Standards.

The UPS (BOC) shall be tested and approved to ANSI C62.41-1991 (IEEE 587, Category A).

The UPS (BOC) shall include self-contained, sealed, maintenance-free regulated lead acid batteries with a minimum lifetime of five (5) years. Battery modules shall be hot-swappable.

The UPS (BOC) shall have terminals for adding extra batteries for increased back-up capacity.

The UPS (BOC) shall be enclosed to prevent accidental contact with energized parts.

The UPS (BOC) shall have an in-built input fuse and a circuit breaker for protection from over voltage and current variations.

The UPS (BOC) shall provide an over voltage shutdown and shall have a zener diode for protection.

The UPS (BOC) shall include an RJ-45 Ethernet communication port to enable remote management and monitoring.

Environmental Requirements

Criteria	Minimum Conditions to be Met
Operating Temperatures	Between 32°F to 104°F (0°C and 40°C)
Storage Temperatures	Between 14°F to 104°F (-10°C and 40°C)
Humidity	0-95% relative humidity, non-condensing
Solid Object and Moisture Protection	IEC IP53
Water and Solvents	Shall withstand water spray on equipment from cleaning floors and walls, industrial solvents, rain, mud, snow and slush, all of which may contain salt, that may come in contact with equipment.

The UPS (BOC) shall be compliant with the electromagnetic compatibility standards referenced in References and Standards.

Electrical Requirements

The UPS (BOC) shall be compliant with the following electrical requirements.

Item	Requirement
Input Voltage	3-phase 208VAC
Input Current	75 Ampere (Maximum)
Output Voltage	120 VAC ± 5%, 60 Hz
Output Power Capacity	10000 Watts (Minimum)

Nominal voltage frequency shall be 60Hz and include tracking of UPS (BOC)'s output frequency to input frequency within 5% tolerance.

The UPS (BOC) shall have a hard-wired input power supply connection. The Contractor shall coordinate with the Department during Design Review to finalize the input cabling and connection of the UPS (BOC).

Functional Requirements

The UPS (BOC) shall provide uninterruptible power and conditioning of the utility power required for operation of sensitive electronic equipment in the event of main utility power supply failure and voltage or frequency fluctuations.

The UPS (BOC) shall be an "on-line" type with automatic voltage regulation.

At full battery charge and when not receiving any input power, the UPS (BOC) shall be capable of sustaining a connected load of 10kW for at least one (1) continuous hour.

When the batteries are completely drained, and upon restoration of utility AC power, the unit shall automatically restart and resume operation. The battery charger shall automatically recharge the battery.

The UPS (BOC) shall include full-time protection from sudden voltage increase with inrush protection and AC line filtering.

The UPS (BOC) shall provide an audible alarm for at least the following conditions:

- Utility (supply) voltage below configurable threshold
- High temperature shutdown
- Rectifier failure
- Over voltage shutdown at output
- Low battery level

The alarm decibel level shall be configurable.

The Contractor shall ensure that the UPS (BOC) provides sufficient number of output power supply connections to supply power to all the BOC Rack PDUs. The Contractor shall supply any accessories such as Power Distribution Units if needed. The Contractor shall submit wiring diagrams and other documentation showing all connections from the UPS (BOC) the BOC Rack PDUs, and shall ensure that the power ratings of the BOC Rack PDUs are compliant with the output power supply connections to which they are connected.

Communications

The UPS (BOC) shall be capable of being remotely managed and monitored using Simple Network Management Protocol (SNMP) including alarm, inverter status, and remote shutdown. Remote monitoring software shall be included. The manufacturer shall provide all SNMP traps.

Performance Specifications

The UPS (BOC) shall have a power factor > 0.98 at 60% load.

The UPS (BOC) shall have a Mean Time Between Failure (MTBF) of at least 10,000 hours.

The UPS (BOC) shall have an online thermal dissipation of no more than 7,000 BTU/hour.

Warranty Requirements

The UPS (BOC) and all associated equipment and cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The UPS (BOC) and all associated equipment and cabling shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

The battery modules and all associated equipment and cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The battery modules and all associated equipment and cabling shall have a manufacturer-provided equipment warranty for a period of at least two (5) years.

Spare Parts Requirements

The Contractor shall provide the following spare parts with the UPS (BOC):

- Hot-pluggable battery modules whose combined power capacity totals at least 5% of the total installed power supply capacity of the UPS (BOC)
- Hot pluggable PDU modules

All the spare parts shall be of the same make and model as the modules originally installed in the UPS (BOC).

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting equipment from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged equipment.

Installation

The UPS (BOC) and associated battery cabinet, if required, shall be installed in the BOC, as directed by the Engineer or a designated representative. The Contractor shall be responsible for

coordinating with the Department or a designated representative to ensure installation of the UPS (BOC) is coordinated with the installation of other BOC equipment, furnishings, ancillaries, etc.

The Contractor shall install the UPS (BOC) units in accordance with the manufacturer recommended installation procedure and the National Electric Code. The installation shall be performed by an Electrical Engineer licensed in the State of Connecticut.

The UPS (BOC) shall be connected to a utility power supply at a designated panel as shown in the Drawings using Department-approved cabling and power connections.

The Contractor shall connect the UPS (BOC) to the BOC LAN network using Category 6 Copper Patch Cable with RJ-45 connectors, connected to the Modular Chassis Switch on one end and the RJ-45 communications port on the UPS (BOC) at the other. The Contractor shall configure an IP address provided by the Department for communications and SNMP functionality.

The Contractor shall activate the unit in accordance with the manufacturer's recommendations.

The Contractor shall neatly dress, label and organize all cables.

Security/Maintenance

All internal components, including all installed modules, shall be removable and replaceable by a single technician with basic hand tools.

Documentation and Training

The UPS (BOC), and all associated equipment and cabling shall comply with the documentation and Training requirements stated in Specification 100 – General Provisions and the Specification 300 – Training specification.

The UPS (BOC) shall include the wiring, circuit protection devices, transfer and bypass switches, panel and all other connection accessories necessary to interconnect the unit to the power source and load in accordance with the requirements of the National Electric Code. The Contractor shall submit diagrams for the installation detailing all conductor sizes and electrical equipment ratings, including associated calculations, stamped by an Electrical Engineer licensed in the State of Connecticut.

The Contractor shall furnish the remote monitoring software and documentation as part of the system documentation.

Testing

The UPS (BOC), and all associated equipment and cabling shall comply with the testing requirements stated in Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 204 – System Demonstration Test, Specification 205

– Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The UPS (BOC) shall be tested for, as a minimum, the following:

- Measurement of the output voltage while the input power is switched off, using an oscilloscope. The test shall also include a comparison of the input and output voltage.
- Verification of the auto-restart mechanism, upon complete battery drain.
- Verification of the auto recharging mechanism upon going from a situation of no input power to one with normal input power.
- Verification of the remote communication and configuration capability.
- Verification of the audible alarm configuration capability.
- Verification of the maximum total power supply supported

METHOD OF MEASUREMENT

This work shall be measured for payment by the number of units of UPS (BOC)s of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each UPS (BOC) shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the ITS and Communications Systems for CT***fastrak*** shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 537 – VIDEO DISPLAY PROCESSOR

DESCRIPTION

This item shall consist of furnishing, installing, and testing a Video Display Processor and all needed accessories required for a full and complete installation, including all associated equipments, and cabling. The Video Display Processor shall be installed in the Busway Operations Center (BOC) and shall serve as the display processor interface between the Local Area Network (LAN) and the Video Monitors (see Specification 538 – Video Monitor).

References and Standards

Product Safety

- Underwriters Laboratory (UL) 60950: Information technology equipment – safety, International Electrotechnical Commission (IEC) 60950: Safety of information technology equipment, European Norm (EN) 60950: Safety of information technology equipment, Canadian Standards Association (CSA) 60950-95: Safety of Information Technology Equipment, or similar.

Environmental and Enclosure

- Federal Communications Commission (FCC) Code of Federal Regulations 47 Part 15 Class B
- International Electrotechnical Commission (IEC) Standard 60529 – Degrees of Protection provided by Enclosures
- National Electrical Manufacturers Association (NEMA) Standard 250: Enclosures for Electrical Equipment (1000 Volts Maximum)

Technical Standards

- High-Definition Multimedia Interface Standard V.1.4a
- Video Electronics Standards Association (VESA) DisplayPort Standard V.1.2
- Digital Display Working Group (DDWG) Digital Video Interface (DVI) Standard Rev. 1.0.

MATERIALS

General

The Contractor shall coordinate procurement of the Monitors with the Department's Office of Information Systems (OIS), to ensure that all equipment is the latest make and model available at time of submittal of Final Design Documentation and all equipment is consistent with the Department's latest IT standards.

The contractor shall furnish and install one (1) Video Display Processor in the BOC as shown on the Drawings. The Video Display Processor shall consist of a computer with a high performance graphics display driver and shall include all cabling and connections.

The Video Display Processor shall interface with the BOC LAN network using Category 6 Copper Patch Cabling. Through the LAN, the Video Display Processor shall interface with the CCTV Camera Management Software installed on the Servers.

The Video Display Processor shall interface with the Video Monitors installed at the BOC using one of HDMI, DisplayPort or DVI cabling (complying with the relevant standards referenced in References and Standards).

The Video Display Processor and all associated equipment and cabling shall comply with the Materials requirements stated in Specification 100 – General Provisions. If conflicts exist, this Item specification shall govern.

Manufacturer Requirements

The Video Display Processor manufacturer shall have been regularly engaged in the manufacture of computer and display equipment for commercial and industrial applications, meeting internationally accepted quality standards in the manufacture of such equipment.

Physical Requirements

Minimum technical requirements for the Video Display Processor are provided in the table below:

ITEM	REQUIREMENT
RAM Memory	6 DIMM slots capable of supporting up to 24 GB DDR3 SD RAM at 1333 MHz. Minimum of 3 * 4 GB DDR3 SD RAM at 1333 MHz preinstalled.
Processor	Intel® Xeon® E3-1200 series, 2nd generation Intel® Core™ processors or similar with a minimum processor speed of 3.0 GHz at 1333MHz and 6MB Cache.

ITEM	REQUIREMENT
Hard Drive	Nonvolatile storage for data storage to prevent data loss during power outages with a minimum (500) GB hard disk – 7200RPM, SATA 3.0Gbps, 16MB Cache.
Serial Ports	Two Asynchronous RS232-C ports
USB Port	Minimum of (6) USB ports
Optical Drive	DVD+/-RW
Communications	Internal Gigabit 10/100/1000 Ethernet Network Card with USB 2.0; Wireless Ethernet Card
Expansion Slots	Minimum of three (3) PCI, PCI-express or similar card expansion slots. At least (2) slots should be capable of accommodating graphics display cards of the type specified below.
Graphic Card	Discrete graphics card capable of supporting a minimum of 4 native displays using digital display ports. The digital display ports must all be of the same type and may either be HDMI, DVI or DisplayPort. The graphics card shall have a minimum dedicated VRAM of 1 GB.
Keyboard and Mouse	Optional 104 style keyboard with 12 programmable function keys and optical/laser mouse
Cables	Provide all required cables to connect peripherals and equipment.

Environmental Requirements

Criteria	Minimum Conditions to be Met
Operating Temperatures	Between 32°F to 104°F (0°C and 40°C)
Storage Temperatures	Between -13°F to 158°F (-25°C and 70°C)
Humidity	10-80% relative humidity, non-condensing
Solid Object and Moisture Protection	IEC IP53 or NEMA 12

The Video Display Processor shall be compliant with the electromagnetic compatibility standards referenced in the References and Standards section.

Electrical Requirements

Item	Requirement
Operating Voltage	120 VAC ± 5%, 60 Hz

Item	Requirement
Input Current	12 Amperes (Maximum)
Maximum Power Dissipation	1000 Watts (not inclusive of any attached Monitors)

Functional Requirements

The Video Display Processor shall meet, as a minimum, the current hardware and software requirements maintained by the Department Office of Information Systems (OIS). The Workstations shall demonstrate the capability of supporting the operation of the software required to reside on the Workstation in accordance with these specifications.

The Video Display Processor shall have the latest licensed version of the Microsoft Windows operating system software installed.

The Contractor shall coordinate with the Department to identify all commercial off-the-shelf software that shall be installed on the Video Display Processor, including:

- Antivirus software
- Office productivity software
- PDF Reader software

The Video Display Processor shall be capable of controlling a minimum of four (4) simultaneous independent displays. The displays should be able to function as a contiguous display area.

The Video Display Processor shall be configured to allow remote desktop connections from Workstations configured on the BOC LAN network.

The CCTV Camera Management Software shall be installed on the Video Display Processor. The Contractor shall verify that the Video Display Processor shall be capable of fulfilling all display functional requirements listed in Specification 554 – CCTV Camera Management Software. Operators shall be able to control the display on the Video Monitors by connecting to the Video Display Processor from their workstations and using the CCTV Camera Management Software desktop client.

Performance Specifications

The Video Display Processor shall be capable of supporting a minimum of four (4) simultaneous independent displays. Each display should run at a native resolution of 1920*1080 pixels at 60Hz refresh rate and should support a minimum 32-bit color depth.

Warranty Requirements

The Video Display Processor and all associated equipment and cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services.

The Video Display Processor and all associated equipment and cabling shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

Spare Parts Requirements

The Contractor shall provide the following spare parts with the Video Display Processor:

- One (1) network interface card
- One (1) power supply unit

All the spare parts shall be of the same make and model as the modules installed in the Video Display Processor.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting finished surfaces from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged hardware, as determined by the Engineer or a designated Department representative.

Installation

The Contractor shall install Video Display Processor equipment at the BOC as shown on the Drawings and in accordance with the equipment manufacturer's recommendations. The Contractor shall be responsible for coordinating with the Engineer or a designated Department representative to ensure installation of the Monitors is coordinated with the installation of other BOC equipment, furnishings, ancillaries, etc.

The Video Display Processor shall be connected to the Department's BOC LAN network through Category 6 Copper Patch Cable with RJ-45 connectors, connected to the Modular Chassis Switch at one end, and the Video Display Processor at the other end.

The Video Display Processor shall be connected to the Video Monitors using cabling complying with the chosen standard.

The Contractor shall connect the Video Display Processor power supply cord to the designated power supply output receptacles.

The Contractor shall be responsible for proper configuration of Video Display Processor equipment and connection of the Video Display Processor to the BOC LAN network.

The Contractor shall install and configure all software, as directed by the Department, on the Video Display Processor.

The Contractor shall neatly train and organize all cables. No cables shall be installed with a radius less than the manufacturer's minimum recommended bending radius.

Documentation and Training

The Video Display Processor, and all associated equipment and cabling shall comply with the documentation and Training requirements stated in Specification 100 – General Provisions and Specification 300 – Training.

The Contractor shall provide all documentation required for verification that the Video Display Processor, and included components such as the graphics display card, comply with the minimum technical requirements detailed in this document, including all regulatory and environmental compliances.

The Contractor shall provide documentation and training on all the installation, configuration, management functions, operating features and maintenance procedures for the Video Display Processor.

Testing

The Video Display Processor, and all associated equipment and cabling shall comply with the testing requirements stated in Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The Video Display Processor shall be tested for, as a minimum, the following:

- Demonstration of the ability to drive a minimum of four (4) simultaneous independent individual displays at the specified resolution, frame refresh rate and other technical requirement specified in the document
- Demonstration of remote login to the Video Display Processor from a Workstation on the BOC LAN network
- Demonstration of CCTV Camera Management Software operation on the Video Display Processor using the Workstations

METHOD OF MEASUREMENT

This work shall be measured for payment by the number of units of Video Display Processors of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each Video Display Processor shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the ITS and Communications Systems for CT***fastrak*** shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 538 – VIDEO MONITOR

SPECIFICATION 539 – WORKSTATION MONITOR

DESCRIPTION

This item shall consist of furnishing, installing, and testing Video Monitors and Workstation Monitors, and all needed accessories required for a full and complete installation, including all associated equipments and cabling. Video Monitors will be used in the Busway Operations Center (BOC) to display CCTV Camera Assembly Video. Workstation Monitors will be used in the BOC, as well as in New Britain station, as Workstation displays.

In this specification, wherever the term "Monitor" is used, it shall refer to both Video Monitors and Workstation Monitors. For any specific requirements, the complete reference – either "Video Monitor" or "Workstation Monitor" – shall be used.

References and Standards

Product Safety

- Underwriters Laboratory (UL) 60950: Information technology equipment – safety, International Electrotechnical Commission (IEC) 60950: Safety of information technology equipment, European Norm (EN) 60950: Safety of information technology equipment, Canadian Standards Association (CSA) 60950-95: Safety of Information Technology Equipment, or similar.

Environmental and Enclosure

- Federal Communications Commission (FCC) Code of Federal Regulations 47 Part 15 Class A/B
- International Electrotechnical Commission (IEC) Standard 60529 – Degrees of Protection provided by Enclosures
- National Electrical Manufacturers Association (NEMA) Standard 250: Enclosures for Electrical Equipment (1000 Volts Maximum)

Technical Standards

- High-Definition Multimedia Interface Standard V.1.4a
- Video Electronics Standards Association (VESA) DisplayPort Standard V.1.2

- Digital Display Working Group (DDWG) Digital Video Interface (DVI) Standard Rev. 1.0.
- VESA Flat Panel Display Measurements (FPDM) Standard Version 2.0

MATERIALS

General

The Contractor shall coordinate procurement of the Monitors with the Department's Office of Information Systems (OIS), to ensure that all equipment is the latest make and model available at time of submittal of Final Design Documentation and all equipment is consistent with the Department's latest IT standards.

The Monitors shall comply with the regulatory and environmental regulations referenced in References and Standards.

Specification 538 – Video Monitor

The contractor shall equip the BOC with three (3) Video Monitors to display video streamed from the CCTV Camera Management Software. Video Monitors shall be connected to the Video Display Processor using Department-approved digital cabling.

Specification 539 – Workstation Monitor

The contractor shall equip the three (3) Workstations in the BOC with two (2) Workstation Monitors each. The Workstation Monitors shall be connected to the Workstations using Department-approved digital cabling.

The contractor shall equip one (1) Workstation in New Britain station with two (2) Workstation Monitors each. The Workstation Monitors shall be connected to the Workstations using Department-approved digital cabling.

Manufacturer Requirements

The manufacturer shall have been regularly engaged in the manufacture of video display equipment for consumer, commercial and industrial applications, meeting internationally accepted quality standards in the manufacture of such equipment.

Physical Requirements

The Monitors shall support a minimum 1920x1080 native resolution.

The Monitor screens shall have anti-glare coating.

Monitors shall utilize flat-screen Liquid Crystal Display (LCD), Light Emitting Diode (LED) or Digital Light Processing (DLP) technology.

Monitors shall be designed to support 24x7 operation as part of a video wall display, with limited loss of color saturation and contrast.

The Monitor color elements (red, green and blue) shall fade at a consistent level. For example, the blue color elements shall not fade faster than the red and green color elements.

Specification 538 – Video Monitor

The Video Monitors shall provide a minimum 46 inches (measured diagonally) viewable area with a 16:9 aspect ratio.

The Video Monitors shall have at least one (1) digital input port, this being either a DVI, DisplayPort or HDMI port. This port must comply with the same standard as the output port on the Video Display Processor.

The Video Monitor shall be wall mountable and comply with VESA Mounting Interface Standard. A VESA Mounting Bracket capable of sustaining the load from the Video Monitor shall also be provided.

Specification 539 – Workstation Monitor

The Workstation Monitors shall provide a 27 inches (measured diagonally) viewable area with a 16:9 aspect ratio.

The Workstation Monitors shall have at least one digital input port, this being either a DVI, DisplayPort or HDMI port. This port must comply with the same standard as the output ports on the Workstations.

The Workstation Monitors shall have an adjustable stand with pan, tilt and height adjustment capabilities. The stand shall provide for a minimum height (with stand) of at most 3 inches, and a maximum height (with stand) of at least 7 inches where the measurement shall be from the bottom of the display panel to the surface that the monitor stand is placed upon. The stand shall be capable of a minimum pan angle of 50° each to the right and left direction. The stand shall be capable of a minimum tilt angle of 10° upwards and 5° downwards.

Environmental Requirements

The Monitors shall comply with the following environmental requirements:

Criteria	**Minimum Conditions to be Met**
Operating Temperatures	Between 32°F to 122°F (0°C and 50°C)
Storage Temperatures	Between -13°F to 158°F (-20°C and 70°C)

Criteria	Minimum Conditions to be Met
Humidity	10-90% relative humidity, non-condensing
Solid Object and Moisture Protection	IEC IP53 or NEMA 12
Water and Solvents	Shall withstand water spray on equipment from cleaning floors and walls, industrial solvents, rain, mud, snow and slush, all of which may contain salt, which may come in contact with equipment.

The Monitors shall comply with the electromagnetic compatibility standards referenced in References and Standards.

Electrical Requirements

Specification 538 – Video Monitor

The Video Monitors shall comply with the following electrical requirements:

Item	Requirement
Operating Voltage	120 VAC ± 5%, 60 Hz
Input Current	3 Amperes (Maximum)
Operating Power Consumption	250 W (Maximum)

Specification 539 – Workstation Monitor

The Workstation Monitors shall comply with the following electrical requirements:

Item	Requirement
Operating Voltage	120 VAC ± 5%, 60 Hz
Input Current	1 Amperes (Maximum)
Operating Power Consumption	100 W (Maximum)

Functional Requirements

Specification 538 – Video Monitor

The Video Monitor should be capable of at least the following adjustments using the front panel controls:

- Brightness

- Contrast
- Horizontal/Vertical position
- Color balance
- Color temperature

The remote control hardware device or software should be capable of selecting any specific monitor to control, from all of the installed monitors. When a specific monitor is selected to control, it shall display a menu screen. The size of the menu screen shall be configurable.

Specification 539 – Workstation Monitor

The Workstation Monitors should be capable of at least the following adjustments using the front panel controls:

- Brightness
- Contrast
- Horizontal/Vertical position
- Sharpness
- Color balance
- Color temperature

Performance Specifications

The Monitors shall support a minimum of 16.7M colors.

The Monitors shall have a maximum response time of 10ms.

The Monitors shall have a minimum refresh rate of 60Hz in their native resolution of 1920x1080.

Specification 538 – Video Monitor

The Video Monitors shall support a minimum static contrast ratio of 1000:1.

The Video Monitors shall have a minimum horizontal viewing angle of 120° and a minimum vertical viewing angle of 120° at a Contrast Ratio of 500:1, as measured according to "Threshold-based H&V viewing angles" referenced in the VESA FPDM standard.

The Video Monitors shall have a minimum brightness of 400cd/m^2.

Specification 539 – Workstation Monitor

The Workstation Monitors shall support a minimum static contrast ratio of 1000:1.

The Workstation Monitors shall have a minimum horizontal viewing angle of 100° and a minimum vertical viewing angle of 100° at a Contrast Ratio of 500:1, as measured according to "Threshold-based H&V viewing angles" referenced in the VESA FPDM standard.

The Workstation Monitors shall have a minimum brightness of 300cd/m^2.

Warranty Requirements

Specification 538 – Video Monitor

The Video Monitor and all associated equipment and cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The Video Monitors and all associated equipment and cabling shall have a manufacturer-provided equipment warranty for a period of at least three (3) years.

Specification 539 – Workstation Monitor

The Workstation Monitor and all associated equipment and cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The Workstation Monitor and all associated equipment and cabling shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

Spare Parts Requirements

Specification 538 – Video Monitor

The Contractor shall provide the following spare parts with each Video Monitor:

- one (1) display cable
- one (1) power supply cord

All the spare parts shall be of the same make and model as the originals used to operate the Video Monitors.

Specification 539 – Workstation Monitor

The Contractor shall provide the following spare parts with each Workstation Monitor:

- one (1) display cable
- one (1) power supply cord

All the spare parts shall be of the same make and model as the originals used to operate the Workstation Monitors.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting finished surfaces from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged hardware, as determined by the Engineer or a designated Department representative.

Installation

The Contractor shall install the Monitors in accordance with the manufacturer recommended installation procedure.

The Contractor shall connect the Monitor power supply cords to the designated power supply output receptacles.

The Contractor shall install all interface cable connections between the Monitors and associated equipment. All cables shall be labeled identifying the associated equipment connection.

Specification 538 – Video Monitor

The Video Monitors shall be installed in the BOC as shown on the Drawings. The Contractor shall be responsible for coordinating with the Department or their designated representative to ensure that installation of the Monitors is coordinated with the installation of other BOC equipment, furnishings, ancillaries, etc.

Video Monitors shall all be connected to the Video Display Processor using Department-approved cabling. All Video Monitors shall be connected using the same cabling to ensure easy replacement.

Specification 539 – Workstation Monitor

Workstation Monitors shall be installed in the BOC as shown on the Drawings. The Contractor shall be responsible for coordinating with the Department or their designated representative to ensure that installation of the Monitors is coordinated with the installation of other BOC equipment, furnishings, ancillaries, etc.

Workstation Monitors shall be installed in New Britain Station as shown on the Drawings.

The Workstation Monitors shall be connected to the Workstations using Department-approved cabling. All Workstation Monitors shall be connected using the same cabling to ensure easy replacement.

Documentation and Training

The Monitors, and all associated equipment and cabling shall comply with the documentation and training requirements stated in Specification 100 – General Provisions and the Specification 300 – Training.

Security/Maintenance

All internal components, including all installed modules, shall be removable and replaceable by a single technician with basic hand tools.

Testing

The Monitors, and all associated equipment and cabling shall comply with the testing requirements stated in Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The Monitors shall be tested using a demonstration of the display of video and software screens.

Any mounting brackets or stands used shall be tested to confirm that they are capable of sustaining the load of the specific Monitors.

The Contractor shall provide all documentation required for verification that the Monitors comply with the minimum technical requirements specified, including all regulatory and environmental requirements.

Specification 538 – Video Monitor

The Video Monitors shall be tested for, as a minimum, the following:

- Demonstration of monitor controls, both from the front panel and the remote.
- Demonstration of the ability to control individual monitors from the remote.
- Demonstration of three (3) simultaneous independent individual displays from the Video Display Processor.
- Verification of horizontal and vertical viewing angles.

Specification 539 – Workstation Monitor

The Workstation Monitors shall be tested for, as a minimum, the following:

- Demonstration of monitor controls from the front panel.

- Demonstration of simultaneous independent individual display from the same Workstation.
- Verification of horizontal and vertical viewing angles.

METHOD OF MEASUREMENT

Specification 538 – Video Monitor

This work shall be measured for payment by the number of units of Video Monitors of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each Video Monitor shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

Specification 539 – Workstation Monitor

This work shall be measured for payment by the number of units of Workstation Monitors of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each Workstation Monitor shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the ITS and Communications Systems for CT***fastrak*** shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 540 – WORKSTATION

DESCRIPTION

This item shall consist of furnishing, installing, and testing Workstations and all needed accessories required for a full and complete installation, including all associated equipment, and cabling. The Workstations shall consist of a computer, a keyboard and a mouse, and shall be used by dispatchers in the Busway Operations Center (BOC) and at New Britain Station to operate software such as the CAD/AVL Central Software (refer to Specification 553 – CAD/AVL Central Software) and the CCTV Camera Management Software (refer to Specification 554 – CCTV Camera Management Software).

References and Standards

Product Safety

- Underwriters Laboratory (UL) 60950: Information technology equipment – safety, International Electrotechnical Commission (IEC) 60950: Safety of information technology equipment, European Norm (EN) 60950: Safety of information technology equipment, Canadian Standards Association (CSA) 60950-95: Safety of Information Technology Equipment, or similar.

Environmental and Enclosure

- Federal Communications Commission (FCC) Code of Federal Regulations 47 Part 15 Class B
- International Electrotechnical Commission (IEC) Standard 60529 – Degrees of Protection provided by Enclosures
- National Electrical Manufacturers Association (NEMA) Standard 250: Enclosures for Electrical Equipment (1000 Volts Maximum)

Technical Standards

- High-Definition Multimedia Interface Standard V.1.4a
- Video Electronics Standards Association (VESA) DisplayPort Standard V.1.2
- Digital Display Working Group (DDWG) Digital Video Interface (DVI) Standard Rev. 1.0.

MATERIALS

General

The contractor shall furnish and install three (3) Workstations in the BOC, as shown in the Drawings and as directed by the Engineer. The contractor shall furnish and install one (1) Workstation in the New Britain Station, as shown in the Drawings and as directed by the Engineer.

Each Workstation shall consist of a computer, a keyboard and a mouse, and shall include all power and interconnect cabling necessary for a complete and fully functional workstation.

The Workstations at the BOC shall each be connected to the Modular Chassis Switch using Cat 6 Copper Patch Cabling (refer to Specification 533 – Modular Chassis Switch and Specification 501 – Category 6 Copper Patch Cable).

The Workstation at New Britain Station shall be connected to the Gigabit Ethernet Switch at the station using Cat 6 Copper Patch Cabling (refer to Specification 502 – Gigabit Ethernet Switch (Type A) and Specification 503 – Gigabit Ethernet Switch (Type B).

Each Workstation shall also be connected to two (2) Workstation Monitors using HDMI, DisplayPort or DVI cabling (refer to Specification 539 – Workstation Monitors). All the Workstation Monitors shall be connected using cabling conforming to the same standard.

The Contractor shall coordinate procurement of the Workstations with the Department's Office of Information Systems (OIS), to ensure that all equipment is the latest make and model available at time of submittal of Final Design Documentation and all equipment is consistent with the Department's latest IT standards.

The Workstations, and all associated equipment and cabling shall comply with the Materials requirements stated in Specification 100 – General Provisions. If conflicts exist, this Item specification shall govern.

Obsolete, no-longer-supported, or no-longer-produced equipment will not be acceptable.

All equipment shall comply with the safety standards referenced in References and Standards.

Manufacturer Requirements

The manufacturer shall be regularly engaged in the manufacture of workstation equipment for commercial and industrial applications, meeting internationally accepted quality standards in the manufacture of such equipment.

Physical Requirements

The Contractor shall furnish and install all necessary cables and any other hardware necessary, within the BOC facilities, to provide a complete and fully functional Workstation.

The Workstations shall comply with the minimum technical requirements provided in the table below:

ITEM	REQUIREMENT
RAM	4 DIMM slots, each capable of supporting one module of up to 32 GB DDR3 SD RAM at 1333 MHz. Minimum of 3 modules of 4 GB DDR3 SD RAM at 1333 MHz preinstalled.
Processor	One (1) quad-core processor (Intel® Xeon® E3-1200 series, 2nd generation Intel® Core™ processors or similar) with each core having a minimum processor speed of 3.0 GHz and 6MB Cache.
Hard Drive	Dual hard drives in a RAID 1 configuration with nonvolatile data storage to prevent data loss during power outages. Each shall have a minimum 500 GB hard disk with 7200RPM, SATA 3.0Gbps, 16MB Cache.
Serial Ports	Two (2) Asynchronous RS232-C ports
USB Port	Minimum of six (6) USB ports
Optical Drive	DVD+/-RW Drive
Communications	Internal Gigabit (10/100/1000) Ethernet Network Card with USB 2.0; Wireless Ethernet Card
Expansion Slots	Minimum of (4) PCI, PCI-express or similar card slots
Graphic Card	Dual graphic display with at least two (2) digital output display ports, which shall comply with the same display connector standard from among HDMI, DVI and DisplayPort. Each display output port shall be capable of producing color images with a minimum resolution of 1920*1080 pixels. Minimum of 1 GB VRAM.
Keyboard and Mouse	Wired keyboard and optical/laser mouse set, associated receiver and cabling. The keyboard shall have a minimum of twelve (12) programmable function keys. The mouse shall have a minimum of three (3) buttons.

Environmental Requirements

The Workstations shall comply with the environmental requirements indicated in the table below:

Criteria	Minimum Conditions to be Met
Operating Temperatures	Between 32°F to 104°F (0°C and 40°C)
Storage Temperatures	Between -13°F to 158°F (-25°C and 70°C)
Humidity	10-80% relative humidity, non-condensing
Solid Object and Moisture Protection	IEC IP53
Water and Solvents	Shall withstand water spray on equipment from cleaning floors and walls, industrial solvents, rain, mud, snow and slush, all of which may contain salt, which may come in contact with equipment.

The Workstations shall be compliant with the electromagnetic compatibility standards referenced in the References and Standards section.

Electrical Requirements

The Workstations shall comply with the electrical requirements indicated in the table below:

Item	Requirement
Operating Voltage	120 VAC ± 5%, 60 Hz
Input Current	5 Amperes (Maximum)
Maximum Power Dissipation	350 Watts (not inclusive of any attached Monitors)

Functional Requirements

The Workstations shall meet, as a minimum, the current hardware and software requirements maintained by the Department Office of Information Systems (OIS). The Workstations shall demonstrate the capability of supporting the operation of the software required to reside on the Workstation in accordance with these specifications.

The Contractor shall coordinate with the Department and CTTRANSIT to identify the approved operating system software for the Workstation. The Contractor shall be responsible for installing this approved operating system software on the Workstation. For pricing purposes, the Contractor shall assume that the Workstation shall have the latest licensed version of the Microsoft Windows operating system software installed.

The Contractor shall coordinate with the Department to identify all commercial off-the-shelf software that shall be installed on the Workstations, including:

- Antivirus software
- Office productivity software
- PDF Reader software

The Workstations shall be capable of remotely logging into the Video Display Processor (refer to Specification 537 – Video Display Processor) and operating the CCTV Camera Management Software thin client version installed.

The Workstation shall be capable of driving two (2) independent simultaneous displays at a native resolution of 1920*1080 @ 60Hz and 32-bit or higher color depth.

Warranty Requirements

The Workstation and all associated equipment and cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The Workstation and all associated equipment and cabling shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

Spare Parts Requirements

The Contractor shall provide the following spare parts with each Workstation:

- One (1) Power Supply Unit
- One (1) 500GB Hard Disk Drive
- One (1) Gigabit (10/100/1000) Ethernet Network Card

All the spare parts shall be of the same make and model as the original components installed in the Workstations.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting equipment from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged equipment, as determined by the Engineer or a designated Department representative.

Installation

General

The Contractor shall install the Workstations in accordance with the manufacturer recommended installation procedure.

The Contractor shall be responsible for installing and configuring all software, as directed by the Department, on the Workstations. The software to be installed shall include the following:

- The CAD/AVL Central System Software
- The CCTV Camera Management Software
- The Emergency Call Box Management Software
- The Network Management System software
- APC Management Software
- AVA and Trigger Location Management Software

The Contractor shall neatly train and organize all cables. No cables shall be installed with a radius less than the manufacturer's minimum recommended bending radius.

BOC Workstations

The Contractor shall install three (3) Workstations at the BOC in the locations as shown on the Drawings or as directed by the Engineer or a designated Department representative. The Contractor shall be responsible for coordinating with the Department or their designated representative to ensure installation of the Workstations is coordinated with the installation of other BOC equipment, furnishings, ancillaries, etc.

The Contractor shall connect the Workstation power supply cord to the designated power supply output receptacles.

The Contractor shall be responsible for proper configuration of Workstation equipment and connection of the Workstation to the Department's BOC LAN network.

The Workstations shall be connected to the Modular Chassis Switch using Cat 6 Copper Patch Cabling.

New Britain Workstation

The Contractor shall install one (1) Workstation at New Britain Station in the location as shown on the Drawings, or as directed by the Engineer or a designated Department representative.

The Contractor shall connect the Workstation power supply cord to the designated power supply output receptacles.

The Contractor shall be responsible for proper configuration of Workstation equipment and connection of the Workstation to the Busway communications network.

The Workstations shall be connected to the Gigabit Ethernet Switch installed at New Britain station using Cat 6 Copper Patch Cabling.

Security/Maintenance

All internal components, including all installed modules, shall be removable and replaceable by a single technician with basic hand tools.

Documentation and Training

The Workstation, and all associated equipment and cabling shall comply with the documentation and training requirements stated in Specification 100 – General Provisions and the Specification 300 – Training.

The Contractor shall provide all documentation required for verification that system components comply with the minimum technical requirements detailed in this document.

The Contractor shall provide all documentation detailing the installation and configuration of Workstation hardware and software.

Testing

The Workstation, and all associated equipment and cabling shall comply with the testing requirements stated in Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The Workstation shall be tested for, as a minimum, the following:

- Demonstration of the hardware components installed in the workstation, and their functioning.
- Verification of the software configuration and the associated licenses.
- Demonstration of simultaneous and independent display from two (2) installed Workstation Monitors through the Workstation.
- Demonstration of operation of all software installed on the Workstations.
- Demonstration of remote login to the Video Display Processor and operation of the Video Monitors through the Workstation.

METHOD OF MEASUREMENT

This work shall be measured for payment by the number of units of Workstations of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each Workstation shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the ITS and Communications Systems for CT***fastrak*** shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 551 – APC MANAGEMENT SOFTWARE

DESCRIPTION

This item shall consist of furnishing, installing, and testing the Automatic Passenger Counter (APC) Management Software, including all licences, for use by authorized users at the Busway Operations Center (BOC).

APC equipment installed on each transit vehicle will count and record passenger boardings and alightings, for periodic transmission to the APC Management Software via the Mobile Data Computer and the CAD/AVL Central Software. The APC Management Software will act as the central processing unit for the APC data received from all equipped transit vehicles.

References

The APC Management Software shall comply with all NTCIP specifications, including, but not limited to:

- NTCIP 1407 – Transit Communications Interface Profiles – Standard on Control Center (CC) Objects

The software shall be developed in accordance with recognized standards such as IEEE Software Engineering Standards.

MATERIALS

General

The APC Management Software shall be a module of the CAD/AVL Central Software or a separate stand-alone software package. It shall be made available to users in the BOC via a "desktop client" installed on BOC workstations.

The APC Management Software shall be interfaced with the CAD/AVL Central Software, to accept APC data from the on-board APC equipment via the on-board MDCs (refer to Specification 553 – CAD/AVL Central Software, Specification 564 – Mobile Data Computer, Specification 560 – Automatic Passenger Counter (1-doorway), Specification 561 – Automatic Passenger Counter (2-doorway) and Specification 562 – Automatic Passenger Counter (3-doorway)).

The work to establish the integration of software shall be accomplished as part of the Software Integration work (refer to Specification 206 – Software Integration).

Manufacturer Requirements

The Manufacturer shall, in the past 5 years, have successfully provided similar software for at least three (3) public transit agencies where the software monitors at least 50 vehicles in maximum service.

Functional Requirements

General

The APC Management Software shall support the processing, storage and reporting of APC data collected by on-board APC equipment.

The APC Management Software shall comply with the general software requirements in Specification 100 – General Provisions.

The hardware required to support the APC Management Software is specified in the following specifications: Specification 535 – Server and Specification 540 – Workstation. The APC Management Software shall be a module of the CAD/AVL Central Software or a separate stand-alone software package that interfaces with the CAD/AVL Central Software.

Logon and Logoff

The APC Management Software shall support a logon, logoff feature that is password protected and shall allow a user to logon to a specific user access level. Users shall logon to the APC Management Software using the same logon credentials as that entered in CAD/AVL Central Software. Users already logged on to the CAD/AVL Central Software shall be able to logon to the APC Management Software without re-entering logon credentials. Users logged off from the CAD/AVL Central Software shall be automatically logged off from the APC Management Software.

The APC Management Software shall allow users to logon to the system with varying privileges depending on their access level. Access levels may include, but are not limited to:

- BOC System Administrator
- BOC Dispatcher
- BOC Read-only dispatcher
- Busway Supervisor
- 'Home' Operating Company Dispatchers

The APC Management Software shall allow users logged in as system administrators to assign specific privileges to each access level; add, remove, or change access levels; assign access levels to each user; and add/remove users.

The APC Management Software shall support at least ten (10) concurrent users.

Graphical User Interface (GUI) Requirements

The APC Management Software shall incorporate a Graphical User Interface (GUI), to display information to users and accept user input in a clear, logical manner.

The GUI shall support concurrent display of multiple windows. At a minimum, the GUI shall support function key assignments, paging, scrolling, and shortcuts. The GUI shall support repositioning and resizing each window as desired to present the maximum amount of useable information.

CAD/AVL Central Software Integration

The APC Management Software shall accept APC data packages from the CAD/AVL Central Software at periodic intervals.

Data Processing, Storage, and Reporting Requirements

The APC Management Software shall store unprocessed APC data packages received from vehicles without alteration in database tables. The APC Management Software shall retain unprocessed APC data packages after post-processed APC data has been developed.

The APC Management Software shall initially flag in the unprocessed data (1) any “outlying” data; (2) instances where the calculated vehicle occupancy becomes negative; (3) instances where occupancy exceeds configurable thresholds; and (4) instances where the total number of boardings and alightings over the course of a block are not equal. The parameters controlling the automatic flagging of “outlying” data shall be agency configurable.

The APC Management Software shall automatically adjust the flagged unprocessed APC data during regular rollup by application of agency configurable adjustment factors. The adjustment factors shall be based on typical counting patterns of individual APC devices.

The APC Management Software shall automatically discard erroneous, questionable and incomplete unprocessed APC data during regular rollup by application of various agency configurable routines. The APC Management Software shall generate summary and detailed discard reports by discard reason and vehicle number.

The APC Management Software shall store the post-processed version of the APC data received from vehicles in a database table.

The APC Management Software GUI shall allow authorized users to physically enter manual ridecheck data for comparison/augmentation purposes.

The APC Management Software shall generate APC data reports, offering both tabular and graphical formats. The system shall also generate all specific reports required by the National Transit Database (NTD) program.

The APC Management Software GUI shall allow the user to select between unprocessed and post-processed data and apply filters comprising any combination of route, pattern, direction, stops, date/time period and day-of-week. The user shall be able to select to view data including boardings by stop, boardings not assigned to a stop, alightings by stop, alightings not assigned to a stop, on-board passenger load by stop, and stops for which boardings/alightings were not recorded.

The APC Management Software shall be capable of exporting select APC data using standard reporting tools (e.g., Crystal Reports or MS Access) and shall have the ability to export data into file formats that can be viewed and edited with standard office software (e.g., Microsoft Word and Excel).

Performance Requirements

The APC Management Software shall adhere to the performance requirements listed in the Specification 100 – General Provisions. In addition, the installed version of the APC Management Software application shall meet the following performance criteria under full system loading:

- All windows with non-paging data shall open and populate with data within three (3) seconds;
- All window with paging data shall open and populate with the initial data within three (3) seconds and thereafter page updates shall be retrieved within one (1) second;
- Database searches for a single record shall be completed within five (5) seconds;
- Mouse cursor movements shall be smooth;
- Dragging of the cursor bar for a scrollable list shall cause instantaneous redisplay of the list in time with the movement of the cursor bar.

Passenger Count Accuracy Requirements

The accuracy of the passenger counts as collected by the on-board APC equipment shall not be diminished by the APC Management Software post-processing.

Warranty Requirements

The Contractor shall develop, test, provide and install all applicable software “patches” or upgrades that become necessary to remedy system software faults or “bugs” identified during the warranty period.

The Contractor shall provide at no additional cost, all version updates, software patches and error corrections available for the system software provided.

The software manufacturer shall commit to continue to offer a maintenance/service agreement for the software for a minimum ten (10) year period. The maintenance/service agreement shall include providing patches, bus fixes, security upgrades, and ongoing technical support.

In addition, the Contractor shall satisfy all Warranty requirements listed in the Specification 400 – Technical Support and Warranty Services.

CONSTRUCTION METHODS

Installation

The Contractor shall install and configure the APC Management Software on the BOC Servers (specified in Specification 535 – Server).

The Contractor shall install and configure the APC Management Software desktop client on three (3) workstations at the BOC and one (1) workstation at the New Britain Station. The Contractor shall acquire all needed permits and licenses before software installation.

To the greatest extent possible, industry proven software packages shall be utilized to provide the functionalities specified in this document. Each such software package shall be identified in the proposal. The proposal shall state the purpose of the software package, where it will be used, and how it will be used. If one software package is required to interface with another software package, the interface shall be documented and supported by flowcharts or block diagrams as appropriate.

The APC Management Software shall be delivered in a ready-to-run form, including all necessary utility programs and documentation. Utilities for data storage allowing direct access, data archival and restore functions for older data shall be provided.

For software licensing, a minimum of ten (10) concurrent seat licenses or an enterprise site licensing solution shall be provided. The Contractor shall identify all necessary third-party software and associated licenses as part of their proposal.

The APC Management Software shall be capable of running in an active directory environment. System applications shall be capable of running concurrently with other Windows programs.

The Contractor shall be responsible for resolving any compatibility issues between software and any other existing Department software or systems. The Contractor shall confirm that software installation, including all third-party applications, will not negatively impact the operations of existing Department software applications available over the internal network.

Security/Maintenance

Security and Maintenance utilities shall be implemented to comply with the General Security and Maintenance Requirements stated in Specification 100 – General Provisions. Such utilities shall

be capable of monitoring the APC Management Software to identify security or maintenance issues such as unauthorized security breaches and software component failures.

Documentation and Training

The Contractor shall provide all necessary and appropriate technical and user documentation for the APC Management Software, which shall cover the functional features, technical information, training, help, and maintenance information, in conformance with the Software Documentation requirements in Specification 100 – General Provisions.

The Contractor shall provide all necessary and appropriate operational and maintenance training for the APC Management Software. The Contractor shall develop and submit a Training Plan, which shall cover the training for use and maintenance of the APC Management Software, in conformance with the Training requirements in Specification 300 – Training.

Testing

The APC Management Software shall comply with the testing requirements stated in Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 203 – On-board Equipment Pilot Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

METHOD OF MEASUREMENT

This work shall be measured for payment by the contract price for the APC Management Software as specified, installed, configured, completed, tested, and accepted in-place. The contract price of this item shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include providing, installing and configuring the APC Management Software, all materials, licenses, labor, testing, documentation, and other incidentals necessary to complete the work. This work shall not include labor associated with software integration tasks. Software integration should be accomplished as part of Specification 206 – Software Integration.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the ITS and Communications Systems for CT***fastrak*** shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 552 – BULK DATA GATEWAY SOFTWARE

DESCRIPTION

This item shall consist of furnishing, installing, and testing the Bulk Data Gateway Software, including all licenses, for use by authorized users at the Busway Operations Center (BOC).

The Bulk Data Gateway Software shall exchange bulk data files with the Vehicle Logic Unit (VLU) of the Mobile Data Computer (MDC), via the WLAN infrastructure and Mobile Communications Gateway and Router (MCGR) on vehicles when in range of bulk data transfer infrastructure (refer to Specification 563 – Mobile Communications Gateway and Router, and Specification 564 – Mobile Data Computer).

The Department will provide the required data connectivity and firewall for the connection between the Bulk Data Gateway Software and the WLAN infrastructure. It is anticipated that the WLAN infrastructure may not be available at the start of service. For the period that the WLAN infrastructure is not available, cellular data service shall also be used for exchange of bulk data. (Refer to Specification 555 – Cellular Data Communications Gateway Software).

References

The following standards shall apply for the following categories:

Transit Control Center Standards

- NTCIP 1407 – Transit Communications Interface Profiles – Standard on Control Center (CC) Objects

Software Development Standards

The software shall be developed in accordance with recognized standards such as:

- IEEE SA – 1455-1999 – IEEE Standard for Message Sets for Vehicle/Roadside Communications
- IEEE SA – 1488-2000 – IEEE Standard for Message Set Template for Intelligent Transportation Systems
- IEEE SA – 1489-1999 – IEEE Standard for Data Dictionaries for Intelligent Transportation Systems

MATERIALS

General

The Bulk Data Gateway Software shall be a module of the CAD/AVL Central Software or a stand-alone separate software that is interfaced with the CAD/AVL Central Software.

The Bulk Data Gateway Software shall interface with the VLU of the MDC via the on-board MCGR on transit vehicles and the WLAN to enable data exchange between the CAD/AVL Central Software and the vehicles (refer to Specification 553 – CAD/AVL Central Software, Specification 563 – Mobile Communications Gateway and Router, and Specification 564 – Mobile Data Computer).

The work to establish the integration of software shall be accomplished as part of the Software Integration work (refer to Specification 206 – Software Integration).

Manufacturer Requirements

The Manufacturer shall be regularly engaged in providing similar software for data communications to transportation agencies.

Functional Requirements

General

The Bulk Data Gateway Software shall comply with the general software requirements in Specification 100 – General Provisions.

The Bulk Data Gateway Software shall incorporate an integral firewall service to secure incoming and outgoing data.

Bulk data files shall be configurable via the CAD/AVL Central Software to be queued for download to:

- All transit vehicles;
- A selected group of transit vehicles; or
- A specific transit vehicle.

The time or frequency at which bulk data shall be available for download to vehicles shall be configurable via the CAD/AVL Central Software GUI.

The Bulk Data Gateway Software shall continue to attempt scheduled bulk data downloads to the VLU of the MDC on vehicles, until an acceptance receipt is received from the VLU.

The Bulk Data Gateway Software shall receive bulk data uploads and send an acknowledgement of receipt to the vehicle after receiving a bulk data upload.

CAD/AVL Central Software Integration

The Bulk Data Gateway Software shall be interfaced with the CAD/AVL Central Software to receive bulk data files to be downloaded to vehicles, and to send bulk data files uploaded from vehicles.

Once the Bulk Data Gateway Software receives a file from the CAD/AVL Central Software, it shall send an acknowledgement of receipt.

Once the Bulk Data Gateway Software receives an acknowledgement of receipt from the CAD/AVL Central Software after sending a file, it shall delete the file.

MDC and MCGR Integration

The Bulk Data Gateway Software shall be interfaced with the MDC via the MCGR to receive bulk data files uploaded from vehicles and to send bulk data files to be downloaded to vehicles.

Once the Bulk Data Gateway Software receives a file from the MDC, it shall send an acknowledgement of receipt.

Performance Specifications

The Bulk Data Gateway Software shall comply with the non-functional (performance) requirements in Specification 100 – General Provisions.

Warranty Requirements

The Contractor shall develop, test, provide and install all applicable software "patches" or upgrades that become necessary to remedy system software faults or "bugs" identified during the warranty period.

The Contractor shall provide at no additional cost, all version updates, software patches and error corrections available for the system software provided.

The software manufacturer shall commit to continue to offer a maintenance/service agreement for the software for a minimum ten (10) year period. The maintenance/service agreement shall include providing patches, bus fixes, security upgrades, and ongoing technical support.

In addition, the Contractor shall satisfy all Warranty requirements listed in Specification 400 – Technical Support and Warranty Services.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting the media containing the Bulk Data Gateway Software from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged media.

Installation

The Contractor shall install the Bulk Data Gateway Software on the BOC Servers (specified in Specification 535 – Server) and configure the software for immediate use. The Contractor shall acquire all needed permits and licenses before software installation.

The Bulk Data Gateway Software shall be delivered in a ready-to-run form, including all necessary utility programs and documentation.

The Bulk Data Gateway Software shall be capable of running in an active directory environment. System applications shall be capable of running concurrently with other installed programs.

The Contractor shall be responsible for resolving any compatibility issues between software and any other existing Department software or systems. The Contractor shall confirm that software installation, including all third-party applications, will not negatively impact the operations of existing Department software applications available over the internal network.

Security/Maintenance

Security and maintenance utilities shall be implemented to comply with the System Security Plan requirements stated in Specification 100 – General Provisions. Such utilities shall be capable of monitoring the Bulk Data Gateway Software to identify security or maintenance issues such as unauthorized security breaches, software component failures, etc.

Documentation and Training

The Contractor shall provide all necessary and appropriate technical and user documentation for the Bulk Data Gateway Software, which shall cover the functional features, technical information, training, help, and maintenance information, in conformance with the documentation requirements in Specification 100 – General Provisions.

The Contractor shall provide all necessary and appropriate operational and maintenance training for the Bulk Data Gateway Software, in compliance with the Training requirements in Specification 300 – Training. Training courses for the Bulk Data Gateway Software shall include, but not be limited to, maintenance training to systems administrators and IT staff.

Testing

The Bulk Data Gateway Software shall comply with the testing requirements stated in the Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 203 – On-board Equipment Pilot Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

METHOD OF MEASUREMENT

This work shall be measured for payment by the contract price for the Bulk Data Gateway Software as specified, installed, configured, completed, tested, and accepted in-place. The contract price of this item shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include providing, installing and configuring the Bulk Data Gateway Software, all materials, licenses, labor, testing, documentation, and other incidentals necessary to complete the work. This work shall not include labor associated with software integration tasks. Software integration should be accomplished as part of Specification 206 – Software Integration.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the ITS and Communications Systems for CT***fastrak*** shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 553 – CAD/AVL CENTRAL SOFTWARE

DESCRIPTION

This item shall consist of furnishing, installing, and testing the Computer-Aided Dispatch/Automatic Vehicle Location (CAD/AVL) Central Software, including all licences, for use by authorized users at the Busway Operations Center (BOC), and remote users.

The CAD/AVL Central Software will be the interface for busway administration, management, and dispatch staff to monitor and manage the operation of:

- all transit vehicles operating on busway routes; and
- all equipped non-revenue vehicles operating along the busway performing maintenance and supervisory functions.

References and Standards

The following standards shall apply for the following categories:

Transit Control Center Standards

- NTCIP 1405 – Transit Communications Interface Profiles – Standard on Spatial Representation (SP) Objects
- NTCIP 1407 – Transit Communications Interface Profiles – Standard on Control Center (CC) Objects

Software Development Standards

The software shall be developed in accordance with recognized standards such as:

- IEEE SA – 1455-1999 – IEEE Standard for Message Sets for Vehicle/Roadside Communications
- IEEE SA – 1488-2000 – IEEE Standard for Message Set Template for Intelligent Transportation Systems
- IEEE SA – 1489-1999 – IEEE Standard for Data Dictionaries for Intelligent Transportation Systems

MATERIALS

General

The CAD/AVL Central Software shall be made available for users in the BOC such as busway dispatchers or system administrators, users in the field such as supervisors, and users at a 'home' operating company's control center, via a user-friendly Graphical User Interface (GUI).

The CAD/AVL Central Software shall include all required application software (subject to approval by the Engineer) for a fully functioning CAD/AVL System.

A "desktop client" shall be provided to allow access to the CAD/AVL Central Software to users in the BOC. A "thin client" program shall be provided to allow remote access to the CAD/AVL Central Software to users outside of the BOC.

The CAD/AVL Central Software shall be interfaced with:

- The Mobile Data Computers (MDC) on busway vehicles via the Cellular and Bulk Data Gateways (refer to Specification 564 – Mobile Data Computers, Specification 555 – Cellular Data Communications Gateway Software, Specification 552 – Bulk Data Gateway Software),
- The On-board Processing Devices on non-revenue vehicles via the Cellular and Bulk Data Gateways (refer to Specification 566 – Non-Revenue Vehicle Equipment),
- The scheduling software (Trapeze FX – Version 11) at each "home" operating agency,
- The Automatic Passenger Counter (APC) Management Software (refer to Specification 551 – APC Management Software),
- The Traveler Information Software (refer to Specification 559 – Traveler Information Software), and
- The Automatic Voice Annunciation (AVA) and Trigger Location Software (refer to Specification 570 – AVA and Trigger Location Software).

The work to establish the integration of software shall be accomplished as part of the Software Integration work (refer to Specification 206 – Software Integration).

The hardware required to support the CAD/AVL Central Software is specified in the following specifications: Specification 535 – Server and Specification 540 – Workstation.

The CAD/AVL Central Software shall comply with the general software requirements in Specification 100 – General Provisions.

Manufacturer Requirements

The Manufacturer shall, in the past 5 years, have successfully provided similar software for at least three (3) public transit agencies where the software monitors at least fifty (50) vehicles in maximum service.

Functional Requirements

General

The CAD/AVL Central Software shall incorporate a core CAD/AVL application to perform the following functions:

- MDC Logon Verification for transit vehicles
- Location Tracking for transit and non-revenue vehicles
- Route and Schedule Adherence Tracking for revenue vehicles
- Location Playback for transit vehicles
- Text Messaging for transit vehicles
- Overt and Covert Alarm Handling for transit vehicles
- Event Reporting for transit vehicles
- Data Logging and Retrieval
- Reporting
- Vehicle Headsign Message Generation for transit vehicles

The CAD/AVL Central Software shall accommodate the Busway vehicle fleet, including all transit, as well as non-revenue vehicles (such as supervisory and maintenance vehicles), as specified in Specification 100 – General Provisions. The CAD/AVL Central Software shall be expandable to accommodate a minimum vehicle fleet of 500 vehicles. The CAD/AVL Central Software shall also have the ability to scale and expand to incorporate additional users and/or additional functionality in accordance with the provisions of the software licensing agreement.

The CAD/AVL Central Software shall incorporate a relational database manager (RDBM) software package. The RDBM software shall include the necessary tools to customize reports, customize queries, generate reports and integrate with other commonly used software packages. The RDBM software shall be used to configure all database tables, relationships, queries, reports, forms and automated data procedures. All necessary data dictionaries and database schema shall be provided.

Utilities shall be provided to support archive and restore functions for older data. The CAD/AVL Central Software shall provide a comprehensive purge capability that minimizes database storage requirements and purges archived records from online storage.

Graphical User Interface (GUI)

The CAD/AVL Central Software shall incorporate a Graphical User Interface (GUI) to display information to users and accept user input in a clear, logical manner.

The GUI shall support three types of display formats: map displays, schematic route displays, and tabular displays.

The GUI shall support concurrent display of multiple windows, including map display windows or tabular windows.

At a minimum, the GUI shall support function key assignments, paging, scrolling, and shortcuts.

The GUI shall support repositioning and resizing each window as desired to present the maximum amount of useable information.

Map Display

The CAD/AVL Central Software shall support a Geographical Information System (GIS)-based map display.

At a minimum, the map shall display the following major features and information along the busway service area and the surrounding New Britain-Hartford region:

- All operating agency garages, offices, and driver relief points in the service area.
- All street features (freeways, highways, major streets, and minor streets), as well as street names.
- Railroads and railroad stations.
- All major water features (rivers, lakes, etc.).
- Transit centers, bus stops, bus routes, time points, transfer points and paratransit service areas.
- Region and city boundaries.
- Major landmarks, including:
    - Hospitals
    - Malls/major shopping centers
    - Maintenance and operations facilities
    - Police and fire stations
    - Schools and universities

The CAD/AVL Central Software shall display agency configured map overlays such as trip/route patterns on the GIS base map.

The CAD/AVL Central Software shall support map import and conversion functions to allow for periodic updates of the maps from maintained GIS map sources available to the Department.

The CAD/AVL Central Software shall be capable of displaying all logged-in transit vehicles as icons on the map display, positioned to accurately indicate real-time vehicle location and direction of travel.

The CAD/AVL Central Software shall be capable of displaying all non-revenue vehicles as icons on the map display, positioned to accurately indicate real-time vehicle location.

The CAD/AVL Central Software shall define a minimum of eight (8) types of icons for specific groups of vehicles, i.e., fixed route, paratransit, special service/event, supervisor, maintenance, and administrative. Icons shall change color to indicate the status of the vehicles, emergency alerts, silent alarms, schedule status, and/or age or vehicle condition (last update), etc. Encoded symbols shall be used to facilitate user understanding.

The vehicle icons shall be updated with the latest reported vehicle locations. Distinct symbols or colors shall be used in the vehicle icons to indicate vehicle status. At a minimum the vehicle status shall be defined as: out of service; on-time; late; early; on-route; off-route; overt alarm; covert alarm. The CAD/AVL Central Software shall also allow a display of the 'trail' of where the vehicle has been when required.

Icon display parameters, symbols, colors, and vehicle trail persistence shall be agency configurable.

The CAD/AVL Central Software shall support the ability to click on a vehicle icon to display vehicle ID, operator ID, schedule adherence information, and time since the last location report was received. The user shall also be able to select a vehicle for subsequent action (such as sending a text message or creating an event) or to open its last location report.

The CAD/AVL Central Software shall support zooming the map display, as a minimum, to: overall coverage area, individual routes, center on a vehicle, or zoom to a desired magnification factor. The CAD/AVL Central Software shall allow the user to define zoom areas and activate them from an agency configurable list. The CAD/AVL Central Software shall allow a user to zoom the map display to a route by picking from a list of all active routes. The CAD/AVL Central Software shall allow a user to zoom the map display to and center on a vehicle by picking from a list of all logged in vehicles. The CAD/AVL Central Software shall be capable of automatically adjusting the level of detail to minimize cluttering the map display, when zoomed.

The CAD/AVL Central Software shall support activation of agency configurable filters, to control which information is displayed on the map.

The CAD/AVL Central Software shall allow the user to calculate the distance along a line drawn on the map as a sequence of straight lines between points.

Schematic Route Display

The CAD/AVL Central Software shall support a schematic representation of individual bus routes, with all logged in vehicles displayed as icons, positioned to indicate real-time vehicle location, and direction of travel. The vehicle icons shall be updated with the latest reported vehicle locations. Distinct symbols or colors shall be used in the vehicle icons to indicate vehicle status. At a minimum the vehicle status shall be defined as: out of service; on-time; late; early; on-route; off-route; overt alarm; covert alarm. The CAD/AVL Central Software shall also allow a display of the 'trail' of where the bus has been when required. Icon display parameters, symbols, colors, and vehicle trail persistence shall be agency configurable.

The CAD/AVL Central Software shall support the ability to click on a vehicle icon to display vehicle ID, operator ID, schedule adherence information, and time since the last location report was received. The user shall also be able to select a vehicle for subsequent action (such as sending a text message or creating an event) or to open its last location report.

Tabular Display

At a minimum, the CAD/AVL Central Software shall support tabular displays of the following information:

- Schedule assignments
- All vehicle pull-outs for the day from every garage. Pull-outs shall be automatically removed from the display once the vehicle has pulled out.
- All vehicle pull-ins for the day from every garage. Pull-ins shall be automatically added to the display once the vehicle has pulled in.
- Latest locations and status for all logged in vehicles
- Latest locations and status for all logged in vehicles on a particular route
- Events and Alarms
- Text messages
- Automatic passenger counts
- Reports

The CAD/AVL Central Software shall highlight vehicle IDs using distinct symbols, text styles, or colors to indicate vehicle status. At a minimum the vehicle status shall be defined as: out of service; on-time; late; early; on-route; off-route; overt alarm; covert alarm. Display parameters including symbols, text styles, and colors shall be agency configurable.

The CAD/AVL Central Software shall support sorting of all information in tabular format by any field.

The CAD/AVL Central Software shall support filtering of all information in tabular format by any field.

The CAD/AVL Central Software shall support the ability to select a vehicle ID from a table for subsequent action (such as sending a text message or creating and an event) or to open its last location report.

CAD/AVL Central Software Logon and Logoff

The CAD/AVL Central Software shall support a logon, logoff feature that is password protected and shall allow a user to logon to a specific user access level. The CAD/AVL Central Software shall allow users to log on to the system with varying privileges depending on their access level. Access levels may include, but are not limited to:

- BOC System Administrator
- BOC Dispatcher
- BOC Read-only dispatcher
- Busway Supervisor
- 'Home' Operating Company Dispatchers

The CAD/AVL Central Software shall allow users logged in as system administrators to assign specific privileges to each access level; add, remove, or change access levels; assign access levels to each user; and add/remove users.

Once a user is logged on to the CAD/AVL Central Software via a desktop client on a workstation, the CAD/AVL Central Software shall enable automatic logon to other software packages installed on that workstation, including the APC Management Software, Traveler Information Software, CCTV Camera Management Software, and the Emergency Callbox Management Software.

When a user logs off the CAD/AVL Central Software, the software shall automatically send a log off request to all software installed on that machine, that were automatically logged on when the user logged on to the CAD/AVL Central Software.

The CAD/AVL Central Software shall support at least thirty (30) concurrent users.

MDC Logon Verification

The CAD/AVL Central Software shall be capable of receiving and validating a logon request from an MDC, if the operator ID and run ID are valid and not already logged in on another MDC, and otherwise responding that it is an invalid login attempt.

The CAD/AVL Central Software shall receive and immediately process a logoff message from an MDC.

Location Tracking

The CAD/AVL Central Software shall receive location reports from the MDC on each transit vehicle whenever sent by the vehicle MDC.

The CAD/AVL Central Software shall receive location reports from the On-board Processing Device on each non-revenue vehicle whenever sent.

The CAD/AVL Central Software shall store and display location reports in a tabular format.

Based on the information received from the location reports, the CAD/AVL Central Software shall display real-time locations of both the transit vehicles and non-revenue vehicles on the map display and schematic route display. For this requirement, real-time shall be defined as a delay of less than one (1) second between of location reports and display of locations.

Route and Schedule Adherence Tracking

The CAD/AVL Central Software shall receive reported schedule adherence information from the latest reports from MDCs. Based on agency configurable thresholds, the system shall use the reported schedule adherence data to designate when vehicles are “early,” “late” or “on time.” Based on agency configurable thresholds, the system shall use the reported route adherence data to designate when vehicles are off-route.

The CAD/AVL Central Software shall display the schedule adherence and route adherence status of vehicles on map and tabular displays by highlighting vehicle icons or vehicle IDs using distinct symbols, text styles, or colors. Display parameters including symbols, text styles, and colors shall be agency configurable.

The CAD/AVL Central Software shall notify the user visually and audibly when a vehicle moves off route. Off-route alarms shall be self-extinguishing after an agency configurable time.

Location Playback

The CAD/AVL Central Software shall allow a user to replay and review the chronological sequence of reported locations for a selected vehicle over a selected time period from historical data on the map display or the schematic route display.

The CAD/AVL Central Software shall allow selection of any time period for the historical data. The CAD/AVL Central Software shall provide controls to view the entire sequence of reported locations from the beginning of the selected time period or to step through the sequence incrementally, forwards or backwards.

The CAD/AVL Central Software shall allow replay for a single vehicle, selected set of vehicles or all vehicles on the selected map display for selected time period.

The replay data shall include location reports, schedule adherence status and on-route status.

The CAD/AVL Central Software shall allow the ability to use playback without exiting from the current CAD/AVL operational view.

The CAD/AVL Central Software shall be able to be store a playback in a standard video format that can be exported for viewing on any computer equipped to view that video format.

Text Messaging

The CAD/AVL Central Software shall accept text messages sent from MDCs on vehicles.

The CAD/AVL Central Software shall allow a user to view received text messages in a tabular display that also indicates the vehicle ID and the time the message was sent. The CAD/AVL Central Software shall clearly indicate text messages that have not been viewed, and shall automatically mark them as read once a dispatcher views the text message. The CAD/AVL Central Software shall allow a dispatcher to mark a viewed text message as unread. The CAD/AVL Central Software shall allow users to archive viewed text messages. Unread text messages shall not be allowed to be archived until they are viewed.

The CAD/AVL Central Software shall allow users to reply to a received message, by sending a text message back to the MDC on the vehicle from which the message was received.

The CAD/AVL Central Software shall allow a user to send a text message to a MDC on a single vehicle, a predefined group of vehicles, all vehicles within an area selected on the map display, all vehicles operating on the same route, run or block, or an ad-hoc group of vehicles.

The CAD/AVL Central Software shall allow a user to create a text message, by selecting one of a set of agency configurable predefined messages or by manually entering text.

The CAD/AVL Central Software shall allow agency staff logged on with appropriate privileges to add, edit, delete, or reorder the listing of predefined text messages on the CAD/AVL Central Software.

The CAD/AVL Central Software shall allow for any message sent by a user to MDC(s) to be flagged as requiring vehicle operator acknowledgement or a Yes/No response and shall allow a user to view a list of such messages that have not yet been acknowledged or responded to.

Overt Alarm Handling

When an overt alarm message is received from an MDC on a vehicle, the CAD/AVL Central Software shall create an overt alarm event, display it in the event tracking table to all users, and notify them using agency configurable visual and audio alerting methods. Overt alarm alerts shall continue until acknowledged by the user. Once a user selects the overt alarm event, the CAD/AVL Central Software shall indicate this to that and all other users. The CAD/AVL Central Software shall allow the user to end the overt alarm event at any time.

The CAD/AVL Central Software shall send signals back to the MDC that generated the alarm when a user has selected the event and when the event has been ended.

The CAD/AVL Central Software shall allow a vehicle in overt alarm mode to send location reports more frequently. The frequency of reports shall be agency configurable.

The CAD/AVL Central Software shall display vehicles in overt alarm mode using a distinctly identifiable agency configurable symbol or color in the selected map display.

Covert Alarm Handling

When a covert alarm message is received from an MDC on a vehicle, the CAD/AVL Central Software shall create a covert alarm event, display it in the event tracking table to all users, and notify them using agency configurable visual and audio alerting methods. Covert alarm alerts shall continue until acknowledged by a user. Once one of the users selects the covert alarm event, the CAD/AVL Central Software shall indicate this to that and all other users. The CAD/AVL Central Software shall allow the user to end the covert alarm event at any time.

The CAD/AVL Central Software shall send signals back to the MDC that generated the alarm when a user has selected the event and when the event has been ended.

During a covert alarm event, the CAD/AVL Central Software shall not allow users to send text messages to the MDC that generated the alarm, but all other location reporting and schedule/route adherence monitoring abilities shall remain operational.

The CAD/AVL Central Software shall allow a vehicle in covert alarm mode to send location reports more frequently. The required frequency of such reports shall be agency configurable.

The CAD/AVL Central Software shall display vehicles in covert alarm mode using a distinctly identifiable agency configurable symbol or color in the selected map display.

Event Reporting

The CAD/AVL Central Software shall allow authorized users to select an event to form the basis for an event report, with the event report form auto-populated with all information already known in the system about the event. Event information shall include as a minimum: event type; location; closure impacts; injuries; who declared it, and times of event. Information contained in an event report shall be agency configurable. Types of events may include:

- Accident involving the bus
- Accident affecting traffic flow
- Mechanical interference
- Maintenance alerts
- Overt alarm message
- Covert alarm message

- Passenger medical emergency

Certain types of events shall be graphically displayed with a distinctly identifiable agency configurable symbol or color on the map.

The CAD/AVL Central Software shall be capable of transmitting event information to on-board MDCs of vehicles that will be affected by the event. The type of information sent to on-board MDCs during different types of events shall be agency configurable.

The CAD/AVL Central Software shall make one central event report accessible from the server so everyone sees the same current report information, but only one instance of the report shall be available for modification at a time.

The CAD/AVL Central Software shall allow authorized users to modify an active event report, with other system users limited to read-only access.

The CAD/AVL Central Software shall allow the user to view a list of currently active event reports in an event tracking table that can be sorted by date/time, event type, or initiating user. The active event report shall be able to be repeatedly accessed and modified, until it is marked closed after which further modifications shall not be possible.

The CAD/AVL Central Software shall allow the selected event report to appear in a separate window and be available for editing.

The CAD/AVL Central Software shall track the user and date/time when the event report is created, modified or closed.

The CAD/AVL Central Software shall allow authorized users to close an active event report. The user shall be able to select from a list of currently active event reports, which can be sorted by date/time, event type, or initiating user. The user shall be asked to confirm the selected event report before the event is closed.

The event tracking table shall indicate, for each event report, the date/time of creating the report, the event type, the initial event text, the initiating user, the date/time of each subsequent modification, each modified version of the text, the modifying user, the date/time the event was closed, and the closing user.

<u>Data Logging and Retrieval</u>

The CAD/AVL Central Software shall support the storage and archiving of the following information in a historical database:

- All information exchanged with MDCs on vehicles including location data, route/schedule adherence data, logon/logoff data, overt alarms, covert alarms, text messages, and APC data.
- All information exchanged with Non-Revenue Vehicle Equipment on non-revenue vehicles including location data and diagnostic data.

- All information generated by the CAD/AVL Central Software including user logons and logoffs, messages, events.

The system shall store CAD/AVL time-related data with a resolution of seconds, but enable its display in hours and minutes format.

The information contained in the historical database shall be made available for retrieval, analysis, display, and printing. The information shall be stored in a manner that allows direct access by the software for at least ninety (90) days.

The CAD/AVL Central Software shall stamp stored data with the time and date, and include sufficient information to enable selective sorting and retrieval based on user specified selection criteria. At a minimum, the following sorting and selection criteria shall be supported for accessing the historical data from both the online and archived storage: date and time, GPS latitude/longitude, vehicle ID, run ID, block ID, operator ID, user ID, stop ID, APC data, and event type (where needed).

The CAD/AVL Central Software shall allow data items in the historical database to be read-only with modification only permitted to individual pre-defined fields.

The CAD/AVL Central Software shall include a means of archiving transaction data, or restoring data from an archive, while the system is in operation. It shall not be necessary to shut down the database to perform a successful backup or restore operation.

Reporting

At a minimum, the CAD/AVL Central Software shall allow the following standard reports to be created based on the CAD/AVL data:

- National Transit Database (NTD) annual reports in accordance with Federal Transit Administration (FTA) rules
- On time performance
- Active fleet (weekday and weekend)
- Productivity
- Number of events/accidents
- Lost service time, by event type

The CAD/AVL Central Software shall also allow reporting of actual revenue-hours, revenue-miles, layover-hours, deadhead-hours, deadhead-miles, actual-hours, and actual-miles. Deadhead should be broken down between to/from garage and interline types.

The CAD/AVL Central Software shall allow authorized users to configure the information contained in the standard reports and their format.

The CAD/AVL Central Software shall have the capability to generate reports based on exceptions in accordance with agency configurable thresholds for various CAD/AVL components.

The CAD/AVL Central Software shall have the capability to generate ad-hoc reports based on stored CAD/AVL data.

The CAD/AVL Central Software shall use standard reporting tools (e.g. Crystal Reports or MS Access) and shall have the ability to export data into file formats that can be viewed and edited with standard office software (e.g. Microsoft Word and Excel).

Vehicle Headsign Message Generation

The CAD/AVL Central Software shall support the generation of text messages for display on vehicle headsigns. A text message generation screen shall provide the option of selecting a message from a list of canned messages or entering a free-form message manually.

The CAD/AVL Central Software shall maintain an agency configurable library of predefined text messages. Predefined messages could include route number, route name, “OUT OF SERVICE”, “FROM GARAGE”, and “IN TRAINING”. These messages may also include: public information, safety information and general transit information. The CAD/AVL Central Software shall ensure that a user is not allowed to enter a free-form message or configure a predefined message that exceeds a configurable character limit.

The CAD/AVL Central Software shall allow the user to assign a message to a specific vehicle, set of vehicles, trip, route, and/or run.

The CAD/AVL Central Software shall allow users to assign different messages to a revenue trip on run, a deadhead trip from the garage, a deadhead trip to the garage, and interlining between revenue trips.

Bulk Data Files

The CAD/AVL Central Software shall prepare bulk data files (including schedule data, headsign display messages, or firmware updates when required) for download to on-board MDCs periodically, as controlled by users.

The CAD/AVL Central Software shall download bulk data files to on-board MDCs automatically at certain dates or times or when instructed by a user, using the Bulk Data Gateway software.

The CAD/AVL Central Software shall allow bulk data files from on-board MDCs to be uploaded as and when required, using the Bulk Data Gateway software.

The CAD/AVL Central Software shall prepare bulk data files (including firmware updates when required) for download to On-board Processing Devices periodically, as controlled by users.

The CAD/AVL Central Software shall download bulk data files to On-board Processing Devices automatically at certain dates or times or when instructed by a user, using the Bulk Data Gateway software.

The CAD/AVL Central Software shall allow bulk data files from On-board Processing Devices to be uploaded as and when required, using the Bulk Data Gateway software.

Cellular Data Communications Gateway Integration

The CAD/AVL Central Software shall be interfaced with the Cellular Data Communications Gateway to enable transmission of all real-time incoming and outgoing messages (including logon/logoff requests, passenger counts, location information, schedule adherence information, route adherence information, text messages, alarm messages, and event messages) and bulk data files between the CAD/AVL Central Software and the MDCs via the cellular data communication networks.

The CAD/AVL Central Software shall be interfaced with the Cellular Data Communications Gateway to enable transmission of all real-time incoming and outgoing messages (including location reports) and bulk data files between the CAD/AVL Central Software and the On-board Processing Devices via the cellular data communication networks.

The CAD/AVL Central Software shall be interfaced with the Cellular Data Communications Gateway to enable transmission of bulk data files between the CAD/AVL Central Software and the On-board Processing Devices.

Bulk Data Gateway Integration

The CAD/AVL Central Software shall be interfaced with the Bulk Data Gateway to enable transmission of bulk data files between the CAD/AVL Central Software and the MDCs via the WLAN.

It is anticipated that the WLAN network may not be available at the start of service. For the period that the WLAN network is not available, the cellular network shall be used for exchange of bulk data.

Scheduling Software Integration

The CAD/AVL Central Software shall support entering schedule information both manually and automatically through a download from another computer, through a LAN, or through removable media.

The CAD/AVL Central Software shall support the file formats in which the schedules are made available by the Trapeze FX - Version 11 scheduling software at each “home” operating agency.

The CAD/AVL Central Software shall be interfaced with the scheduling software (Trapeze FX - Version 11) at each “home” operating agency to:

- Automatically update schedules in the CAD/AVL Central Software after they are changed in the scheduling software.
- Automatically update the vehicle/block assignments in the CAD/AVL Central Software as they made by the home agency in the scheduling software.
- Automatically update operator run assignments and background information as they are made by the home agency in the scheduling software.

The CAD/AVL Central Software shall allow updates to the schedule from the scheduling software to be downloaded periodically, as controlled by users.

MDC Integration

The CAD/AVL Central Software shall be capable of sending and receiving various message types from the MDC including logon/logoff requests, vehicle headsign display messages, passenger counts, location information, schedule adherence information, route adherence information, text messages, alarm messages, and event messages.

The CAD/AVL Central Software shall allow agency staff logged on with appropriate privileges to configure, add, edit, delete, or reorder the listing of predefined text messages on MDCs.

The CAD/AVL Central Software shall allow agency staff logged on with appropriate privileges to remotely logon to any vehicle MDC.

Non-Revenue Vehicle Equipment Integration

The CAD/AVL Central Software shall be capable of receiving location and diagnostic data from the On-board Processing Devices.

The CAD/AVL Central Software shall be capable of sending firmware updates to the On-board Processing Devices.

APC Management Software Integration

The CAD/AVL Central Software shall receive and store APC data package from the MDCs.

The CAD/AVL Central Software shall accumulate incoming APC data packages from the vehicles over an agency configurable period of time before they are forwarded to the APC Management Software.

Traveler Information Software Integration

The CAD/AVL Central Software shall periodically provide vehicle route/trip assignments and schedule updates to the Traveler Information Software.

The CAD/AVL Central Software shall provide a real-time output of the current location and route/schedule adherence for all vehicles, for use by the Traveler Information Software.

AVA and Trigger Location Software Integration

The CAD/AVL Central Software shall periodically provide vehicle route/trip assignments and schedule updates to the AVA and Trigger Location Software.

XML Data Feed Acceptance

The CAD/AVL Central Software shall be capable of accepting an XML data feed of vehicle locations from other systems in real-time. The format of this incoming data feed shall be finalized by the Contractor in discussion with Department during Design Review. The CAD/AVL Central Software shall be capable of displaying vehicle location from the data feed in schematic route display, map display or tabular display in real-time. For this requirement, real-time shall be defined as a delay of less than one (1) second between receipt of XML data feed from external source and display of data.

Performance Requirements

The CAD/AVL Central Software shall comply with the non-functional (performance) requirements in Specification 100 – General Provisions. In addition, the installed versions of the CAD/AVL Central Software application shall meet the following performance criteria under full system loading:

- All windows with non-paging data shall open and populate with data within three (3) seconds;
- All windows with paging data shall open and populate with the initial data within three (3) seconds and thereafter page updates shall be retrieved within one (1) second;
- Database searches for a single record shall be completed within five (5) seconds;
- Mouse cursor movements shall be smooth;
- Dragging of the cursor bar for a scrollable list shall cause instantaneous redisplay of the list in time with the movement of the cursor bar.
- The system shall provide the ability to recall and redraw maps (maps that are configured and exist on a screen, although covered by another window) in no more than two (2) seconds.
- The system shall incorporate latency parameters for each type of message inbound and outbound dependent on message priority. For example some latency parameters could be:
    a) Emergency Activation – five (5) seconds
    b) Text Message – twenty (20) seconds
    c) Vehicle Overt Alarm – twenty (20) seconds

d) Vehicle Schedule Adherence Notification – ten (10) seconds

e) Outbound Advisory Message – ten (10) seconds

f) Vehicle Symbol Update on Map – three (3) seconds

Warranty Requirements:

The Contractor shall develop, test, provide and install all applicable software "patches" or upgrades that become necessary to remedy system software faults or "bugs" identified during the warranty period.

The Contractor shall provide at no additional cost, all version updates, software patches and error corrections available for the system software provided.

The software manufacturer shall commit to continue to offer a maintenance/service agreement for the software for a minimum ten (10) year period. The maintenance/service agreement shall include providing patches, bus fixes, security upgrades, and ongoing technical support.

In addition, the Contractor shall satisfy all Warranty requirements listed in the Specification 400 – Technical Support and Warranty Services.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting the media containing the CAD/AVL Central Software from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged media.

Installation

The Contractor shall install the CAD/AVL Central Software on the BOC Servers. The Contractor shall acquire all needed permits and licenses before software installation.

The Contractor shall install the desktop clients on a minimum of three (3) dispatch workstations at the BOC. The Contractor shall configure the desktop clients for immediate use by at least two (2) system administrators and six (6) dispatchers.

The Contractor shall install and configure the thin client for immediate use by at least two (2) system administrators and four (4) additional users through a remote workstation, laptop or tablet.

The Contractor shall install and configure the thin client for immediate use by at least two (2) users through the Workstation installed at the New Britain Station.

The CAD/AVL Central Software shall be delivered in a ready-to-run form, including all necessary utility programs and documentation. Utilities for data storage allowing direct access, data archival and restore functions for older data shall be provided.

To the greatest extent possible, industry proven software packages shall be utilized to provide the functionalities specified in this document. Each such software package shall be identified in the proposal. The proposal shall state the purpose of the software package, where it will be used, and how it will be used. If one software package is required to interface with another software package, the interface shall be documented and supported by flowcharts or block diagrams as appropriate.

For software licensing, a minimum of thirty (30) concurrent seat licenses or an enterprise site licensing solution shall be provided. The Contractor shall identify all necessary third-party software and associated licenses as part of their proposal.

Upon installation and configuration, the CAD/AVL Central Software shall be capable of being accessed from anywhere within the BOC's internal computer network by authorized system users using the desktop client or the thin client.

The CAD/AVL Central Software shall be capable of running in an active directory environment. System applications shall be capable of running concurrently with other installed programs.

The Contractor shall be responsible for resolving any compatibility issues between software and any other existing Department software or systems. The Contractor shall confirm that software installation, including all third-party applications, will not negatively impact the operations of existing Department software applications available over the internal network.

Security/Maintenance

Security and maintenance utilities shall be implemented to comply with the System Security Plan Requirements stated in Specification 100 – General Provisions. Such utilities shall be capable of monitoring the CAD/AVL Central Software to identify security or maintenance issues such as unauthorized security breaches and software component failures.

Documentation and Training

The Contractor shall provide all necessary and appropriate technical and user documentation for the CAD/AVL Central Software, which shall cover the functional features, technical information, training, help, and maintenance information, in compliance with the documentation requirements in Specification 100 – General Provisions.

The Contractor shall provide all necessary and appropriate operational and maintenance training for the CAD/AVL Central Software in compliance with the Training requirements in Specification 300 – Training.

Training courses for the CAD/AVL Central Software shall include but are not limited to the following:

- Computer Aided Dispatch Training
- System Administration Training
- Remote User Training
- Data Analysis and Report Generation Training
- Maintenance Training

Testing

The CAD/AVL Central Software shall comply with the testing requirements stated in Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 203 – On-board Equipment Pilot Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The Contractor shall be responsible for all testing that may be required to establish approval and acceptance of the CAD/AVL Central Software.

METHOD OF MEASUREMENT

This work shall be measured for payment by the contract price for the CAD/AVL Central Software as specified, installed, configured, completed, tested, and accepted in-place. The contract price of this item shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include providing, installing and configuring the CAD/AVL Central Software, all materials, licenses, labor, testing, documentation, and other incidentals necessary to complete the work. This work shall not include labor associated with software integration tasks. Software integration should be accomplished as part of Specification 206 – Software Integration.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the ITS and Communications Systems for CT***fastrak*** shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 554 – CCTV CAMERA MANAGEMENT SOFTWARE

DESCRIPTION

General

This item shall consist of furnishing, installing, integrating and testing the CCTV Camera Management Software, including all licenses, for use by authorized users at the Busway Operations Center (BOC).

The CCTV Camera Management Software will provide access to all the video data stored on the Network Video Recorder (NVR).

The Camera management software shall configure camera video into channels recorded onto the NVRs.

The Camera Management Software shall organize camera channels from the network into views for monitoring at the BOC through the Video Display Processor.

References and Standards

The following standards shall apply for the following categories:

Transit Control Center Standards

- NTCIP 1407 – Transit Communications Interface Profiles – Standard on Control Center (CC) Objects

Software Development Standards

The software shall be developed in accordance with recognized standards such as:

- IEEE SA – 1455-1999 – IEEE Standard for Message Sets for Vehicle/Roadside Communications
- IEEE SA – 1488-2000 – IEEE Standard for Message Set Template for Intelligent Transportation Systems
- IEEE SA – 1489-1999 – IEEE Standard for Data Dictionaries for Intelligent Transportation Systems

MATERIALS

General

The CCTV Camera Management Software shall be a separate stand-alone software package. It shall be made available to users in the BOC via a "desktop client" installed on workstations.

The CCTV Camera Management Software shall be interfaced with the NVRs (refer to Specification 534 – Network Video Recorder).

The CCTV Camera Management Software shall comply with the general software requirements in Specification 100 – General Provisions.

The work to establish the integration of software shall be accomplished as part of the Software Integration work (refer to Specification 206 – Software Integration).

Manufacturer Requirements

The Manufacturer shall have implemented a CCTV Camera Management Software with similar functionality for at least three (3) projects equipped with at least fifty (50) CCTV cameras, in the past five (5) years.

Functional Requirements

General

The hardware required to support the CCTV Camera Management Software is specified in Specification 535 – Server and Specification 540 – Workstation. The CCTV Camera Management Software shall be a separate stand-alone software package.

Logon and Logoff Requirements

The CCTV Camera Management Software shall support a logon feature that is password protected and shall allow a user to logon with a specific user access level. Users shall log on to the CCTV Camera Management Software using the same logon credentials as those entered for the CAD/AVL Central Software. Users already logged on to the CAD/AVL Central Software shall be able to log on to the CCTV Camera Management Software without re-entering logon credentials. Users logged off from the CAD/AVL Central Software shall be automatically logged off from the CCTV Camera Management Software.

The CCTV Camera Management Software shall allow users to log on to the system with varying privileges depending on their access level. Access levels shall include, but are not limited to:

- BOC System Administrator
- BOC Dispatcher

- BOC Read-only dispatcher
- Busway Supervisor
- Technician
- Municipal
- Regional
- Maintenance

The CCTV Camera Management Software shall allow users logged in as system administrators to assign specific privileges to each access level; add, remove, or change access levels; assign access levels to each user; and add/remove users.

The CCTV Camera Management Software shall support at least ten (10) concurrent users.

The CCTV Camera Management Software shall support logoff functionality.

Graphical User Interface (GUI) Requirements

The CCTV Camera Management Software shall incorporate a Graphical User Interface (GUI), to display information to users and accept user input in a clear, logical manner.

The GUI shall support concurrent display of multiple windows. At a minimum, the GUI shall support function key assignments, paging, scrolling, and shortcuts. The GUI shall support repositioning and resizing each window as desired to present the maximum amount of useable information.

NVR Integration Requirements

The CCTV Camera Management Software shall interface with the cameras to provide monitoring access to all live video feeds from cameras, and with the NVRs to provide management of all video data stored on the NVR.

Camera Viewing Interface Requirements

The CCTV Camera Management Software shall support the following camera views at a minimum:

- Single camera full window view
- Four-camera tiled view
- Nine-camera tiled view
- Sixteen-camera tiled view

The CCTV Camera Management Software shall display configurable labels, including camera name, unique ID and location information, under each video view.

The CCTV Camera Management Software shall support a navigation bar (navbar) with names of each camera.

The CCTV Camera Management Software shall allow designated users to give descriptive names to cameras.

The CCTV Camera Management Software shall allow users to obtain a full window view by double clicking on a camera name.

The CCTV Camera Management Software shall allow designated users to give descriptive names to views with groups of cameras, and to save that multiple camera view for future retrieval under that name using the navbar.

The CCTV Camera Management Software shall allow users to drag and drop a camera from the navbar onto a camera in an existing view to replace that camera with the new camera in that view. When the cameras composition in a previously saved multiple cameras view has been so adjusted, if replacing the view the software shall offer the option to save this adjustment as a permanent change to the composition of that saved view.

The CCTV Camera Management Software shall allow users to control the pan/tilt/zoom functions of one camera at a time by clicking on that camera's video feed to obtain control and then clicking on on-screen buttons for zoom in, zoom out, pan left, pan right, tilt clockwise, tilt counterclockwise.

The CCTV Camera Management Software shall allow users to configure and save pan/tilt/zoom stops (maximums) for individual cameras.

The CCTV Camera Management Software shall allow users to play back any and all video data stored on the NVR by specifying the date, time and camera for the beginning of video footage they would like to view.

The CCTV Camera Management Software shall support replay of recorded video with 0.25x, 0.5x, 1x, 2x, 4x, 8x, 16x and 32x speeds both forwards and backwards, as well as enabling pause/restart and frame by frame step forwards and backwards functionality.

<u>NVR Storage Management Requirements</u>

The CCTV Camera Management Software shall allow users to flag video segments for long term archival by specifying the beginning and ending date and time and camera to which the video segment belongs.

The CCTV Camera Management Software shall store all video segments flagged for long term archival storage with a username and description referring to the start timestamp and camera.

The CCTV Camera Management Software shall store all video segments flagged for long term archival in a separate space on the NVR where they shall not be overwritten until archived.

The CCTV Camera Management Software shall raise an alert to administrators when utilization of the NVR storage space used for long term archival of flagged videos reaches 90% of capacity.

Once video segments flagged for long term archival storage have been transferred to separate data storage unit separate from the NVR, the CCTV Camera Management Software shall allow flagged video data on the NVR to be overwritten.

The CCTV Camera Management Software shall allow users to store a descriptive name for video segments stored in long term archival storage.

The CCTV Camera Management Software shall allow users to export any recorded video segment stored on the NVR, including long term archival video, to external media such as a DVD±RW optical drive, USB drive, or other approved means.

The CCTV Camera Management Software shall allow users to flag a video segment for forensic storage.

The CCTV Camera Management Software shall immediately encrypt any videos flagged for forensic storage so that they cannot be altered, apply an immutable timestamp and location stamp and export the videos to protected storage.

The CCTV Camera Management Software shall provide a drag-and-drop interface to provide users with control over wall-mounted video monitors. Users shall be able to use the CCTV Camera Management Software to configure camera views on wall-mounted monitors, configuring both the views displayed as well as the size and display duration for each view using the monitor control interface.

The monitor control interface shall show each of the monitors and a list of camera views currently being displayed on each monitor. The interface shall allow users to add (by drag-and-drop), re-size, or remove views from each monitor.

Performance Requirements

The CCTV Camera Management Software desktop client shall meet the following performance criteria under full system loading:

- All windows with non-paging data shall open and populate with data within three (3) seconds;
- All window with paging data shall open and populate with the initial data within three (3) seconds and thereafter page updates shall be retrieved within one (1) second;
- Searches for a single video shall be completed within five (5) seconds;

- Mouse cursor movements shall be smooth;
- Dragging of the cursor bar for a scrollable list shall cause instantaneous redisplay of the list in time with the movement of the cursor bar.

The CCTV Camera Management Software shall be capable of running in the background or foreground concurrently with CAD/AVL software without degradation of performance for either software.

The CCTV Camera Management Software coders/decoders (CODECs) shall be compatible with the CCTV cameras and the NVR.

Warranty Requirements

The CCTV Camera Management Software, and all associated utilities shall comply with the warranty requirements stated in the Specification 400 – Technical Support and Warranty Services.

The Contractor shall develop, test, provide and install all applicable software "patches" or upgrades that become necessary to remedy system software faults or "bugs" identified during the integration, testing, commissioning, or warranty periods.

The software manufacturer shall commit to continue to offer a maintenance/service agreement for the software for a minimum ten (10) year period. The maintenance/service agreement shall include providing patches, bus fixes, security upgrades, and ongoing technical support.

The Contractor shall provide at no additional cost, all version updates, software patches and error corrections available for any software or firmware provided.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting the media containing the CCTV Camera Management Software from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged media.

Installation

The Contractor shall install the CCTV Camera Management Software on the BOC servers (specified in Specification 535 – Server). The Contractor shall acquire all needed permits and licenses before software installation.

The Contractor shall install the CCTV Camera Management Software desktop client on a minimum of three (3) workstations at the BOC and one (1) workstation at the New Britain

Station. The Contractor shall configure the desktop clients for immediate use by at least two (2) system administrators and eight (8) additional users.

The CCTV Camera Management Software shall be delivered in a ready-to-run form, including all necessary utility programs and documentation. Utilities for data storage allowing direct access, data archival and restore functions for older data shall be provided.

To the greatest extent possible, industry proven software packages shall be utilized to provide the functionalities specified in this document. Each such software package shall be identified in the proposal. The proposal shall state the purpose of the software package, where it will be used, and how it will be used.

For software licensing, a minimum of ten (10) concurrent seat licenses or an enterprise site licensing solution shall be provided. The Contractor shall identify all necessary third-party software and associated licenses as part of their proposal.

The CCTV Camera Management Software shall be capable of running in an active directory environment. System applications shall be capable of running concurrently with other installed programs.

The Contractor shall be responsible for seeking out and resolving any compatibility issues between software and any other existing Department software or systems. The Contractor shall confirm that software installation, including all third-party applications, will not negatively impact the operations of existing Department software applications available over the internal network.

Security/Maintenance

Security and maintenance utilities shall be implemented to comply with the System Security Plan Requirements stated in Specification 100 – General Provisions. Such utilities shall be capable of monitoring the CCTV Camera Management Software to identify security or maintenance issues such as unauthorized access or configuration changes, security breaches and software component failures.

Documentation and Training

The Contractor shall provide all necessary and appropriate technical and user documentation for the CCTV Camera Management Software, which shall cover the functional features, technical information, training, help, and maintenance information, in compliance with the documentation requirements in Specification 100 – General Provisions.

The Contractor shall provide all necessary and appropriate operational and maintenance training for the CCTV Camera Management Software in compliance with the training requirements in Specification 300 – Training.

Training courses for the CCTV Camera Management Software shall include but are not limited to the following:

- User Training
- System Administration Training
- Maintenance Training

Testing Requirements

The CCTV Camera Management Software shall comply with the testing requirements stated in Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The Contractor shall be responsible for all testing that may be required to establish acceptance of the CCTV Camera Management Software.

METHOD OF MEASUREMENT

This work shall be measured for payment by the contract price for the CCTV Camera Management Software as specified, installed, configured, completed, tested, and accepted in-place. The contract price of this item shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include providing, installing and configuring the CCTV Camera Management Software, all materials, licenses, labor, testing, documentation, and other incidentals necessary to complete the work. This work shall not include labor associated with software integration tasks. Software integration should be accomplished as part of Specification 206 – Software Integration.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the ITS and Communications Systems for CT***fastrak*** shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 555 – CELLULAR DATA COMMUNICATION GATEWAY SOFTWARE

DESCRIPTION

This item shall consist of furnishing, installing, and testing the Cellular Data Communications Gateway Software, including all licenses, for use by authorized users at the Busway Operations Center (BOC).

A Cellular Data Communications Gateway shall be established with the cellular data carrier selected by the Department, to enable the CAD/AVL Central Software to exchange real-time data messages and bulk data over the leased cellular accounts with the Mobile Communications Gateway and Router (MCGR) on transit vehicles, and with the Non Revenue Vehicle Equipment on non-revenue vehicles.

The Department will provide the required data connectivity and firewall for the connection to the cellular data provider.

References and Standards

The following standards shall apply for the following categories:

Transit Control Center Standards

- NTCIP 1407 – Transit Communications Interface Profiles – Standard on Control Center (CC) Objects

Software Development Standards

The software shall be developed in accordance with recognized standards such as:

- IEEE SA – 1455-1999 – IEEE Standard for Message Sets for Vehicle/Roadside Communications
- IEEE SA – 1488-2000 – IEEE Standard for Message Set Template for Intelligent Transportation Systems
- IEEE SA – 1489-1999 – IEEE Standard for Data Dictionaries for Intelligent Transportation Systems

MATERIALS

General

A Cellular Data Communications Gateway Software shall be a module of the CAD/AVL Central Software or a stand-alone separate software that is interfaced with the CAD/AVL Central Software.

The Cellular Data Communications Gateway Software shall interface with the VLU of the MDC via the on-board MCGR on transit vehicles to enable data exchange between the CAD/AVL Central Software and the on-board Mobile Data Computers (refer to Specification 553 – CAD/AVL Central Software, Specification 563 – Mobile Communications Gateway and Router, and Specification 564 – Mobile Data Computer).

The Cellular Data Communications Gateway Software shall interface with the On-board Processing Device of the Non-Revenue Vehicle Equipment on non-revenue vehicles to enable data exchange between the CAD/AVL Central Software and the On-board Processing Devices (refer to Specification 553 – CAD/AVL Central Software, and Specification 566 – Non-Revenue Vehicle Equipment).

The work to establish the integration of software shall be accomplished as part of the Software Integration work (refer to Specification 206 – Software Integration).

The Cellular Data Communications Gateway Software shall comply with the general software requirements in Specification 100 – General Provisions.

Manufacturer Requirements

The Manufacturer shall, in the past five (5) years, have successfully provided similar software for at least three (3) public transit agencies where the software communicates with at least fifty (50) vehicles in maximum service.

Functional Requirements

General

The Cellular Data Communications Gateway Software shall enable the CAD/AVL Central Software to exchange real-time data messages and bulk data over the leased cellular data network with transit and non-revenue vehicles.

The Cellular Data Communications Gateway Software shall be interfaced with the cellular provider network via the Modular Chassis Switch using IP addresses, VPN or similar proven and established methods. The specific methods shall be proposed by the Contractor for approval after discussions with the Department as well as the selected Cellular Data Network Provider.

The Cellular Data Communications Gateway Software shall incorporate an integral firewall to secure incoming and outgoing data exchanged with the cellular provider network.

CAD/AVL Central Software Integration:

The Cellular Data Communications Gateway Software shall process data messages received from the MCGR on transit vehicles and pass these to the CAD/AVL Central Software, in real-time.

The Cellular Data Communications Gateway Software shall process data messages received from the Non-Revenue Vehicle Equipment on non-revenue vehicles and pass these to the CAD/AVL Central Software, in real-time.

The Cellular Data Communications Gateway software shall process data messages received from the CAD/AVL Central Software and pass these to the MCGR on transit vehicles, in real-time.

Outgoing real-time messages shall be configurable via the CAD/AVL Central Software GUI to download to:

- All transit vehicles;
- A specific selected group of transit vehicles; or
- A specific transit vehicle.

Performance Requirements

The Cellular Data Communications Gateway Software shall comply with the non-functional (performance) requirements in Specification 100 – General Provisions.

Warranty Requirements

The Contractor shall develop, test, provide and install all applicable software "patches" or upgrades that become necessary to remedy system software faults or "bugs" identified during the warranty period.

The Contractor shall provide at no additional cost, all version updates, software patches and error corrections available for the system software provided.

The software manufacturer shall commit to continue to offer a maintenance/service agreement for the software for a minimum ten (10) year period. The maintenance/service agreement shall include providing patches, bus fixes, security upgrades, and ongoing technical support.

In addition, the Contractor shall satisfy all Warranty requirements listed in the Specification 400 – Technical Support and Warranty Services.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting the media containing the Cellular Data Communications Gateway Software from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged media.

Installation

The Contractor shall install the Cellular Data Communications Gateway Software on the BOC Servers (specified in Specification 535 – Server) and configure the software for immediate use. The Contractor shall acquire all needed permits and licenses before software installation.

The Cellular Data Communications Gateway Software shall be delivered in a ready-to-run form, including all necessary utility programs and documentation.

The Cellular Data Communications Gateway Software shall be capable of running in an active directory environment. System applications shall be capable of running concurrently with other installed programs.

The Contractor shall be responsible for resolving any compatibility issues between software and any other existing Department software or systems. The Contractor shall confirm that software installation, including all third-party applications, will not negatively impact the operations of existing Department software applications available over the internal network.

Security/Maintenance

Security and maintenance utilities shall be implemented to comply with the System Security Plan requirements stated in Specification 100 – General Provisions. Such utilities shall be capable of monitoring the Cellular Data Communications Gateway Software to identify security or maintenance issues such as unauthorized security breaches, software component failures, etc.

Documentation and Training

The Contractor shall provide all necessary and appropriate technical and user documentation for the Cellular Data Communications Gateway Software, which shall cover the functional features, technical information, training, help, and maintenance information, in compliance with the documentation requirements in Specification 100 – General Provisions.

The Contractor shall provide all necessary and appropriate operational and maintenance training for the Cellular Data Communications Gateway Software, in compliance with the Training requirements in Specification 300 – Training.

Training courses for the Cellular Data Communications Gateway Software shall include but are not limited to the following:

- Maintenance Training

Testing

The Cellular Data Communications Gateway Software, and all associated equipment and cabling shall comply with the testing requirements stated in the Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 203 – On-board Equipment Pilot Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The Contractor shall be responsible for all testing that may be required to establish approval and acceptance of the Cellular Data Communications Gateway Software.

METHOD OF MEASUREMENT

This work shall be measured for payment by the contract price for the Cellular Data Communication Gateway Software as specified, installed, configured, completed, tested, and accepted in-place. The contract price of this item shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include providing, installing and configuring the Cellular Data Communication Gateway Software, all materials, licenses, labor, testing, documentation, and other incidentals necessary to complete the work. This work shall not include labor associated with software integration tasks. Software integration should be accomplished as part of Specification 206 – Software Integration.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the ITS and Communications Systems for CT***fastrak*** shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 556 – EMERGENCY CALLBOX (ECB) MANAGEMENT SOFTWARE

DESCRIPTION

General

This item shall consist of furnishing, installing, integrating and testing the Emergency Call Box (ECB) Management Software, including all licenses, for use by authorized users at the Busway Operations Center (BOC).

The ECB Management Software shall support the configuration and monitoring of ECB devices, and the storage and reporting of data received from field ECB devices.

References and Standards

The following standards shall apply for the following categories:

Transit Control Center Standards

- NTCIP 1407 – Transit Communications Interface Profiles – Standard on Control Center (CC) Objects

Software Development Standards

The software shall be developed in accordance with recognized standards such as:

- IEEE SA – 1455-1999 – IEEE Standard for Message Sets for Vehicle/Roadside Communications
- IEEE SA – 1488-2000 – IEEE Standard for Message Set Template for Intelligent Transportation Systems
- IEEE SA – 1489-1999 – IEEE Standard for Data Dictionaries for Intelligent Transportation Systems

MATERIALS

General

The ECB Management Software shall be a separate stand-alone software package. It shall be made available to users in the BOC via a “desktop client” installed on BOC workstations.

The work to establish the integration of software shall be accomplished as part of the Software Integration work (refer to Specification 206 – Software Integration).

The ECB Management Software shall be interfaced with the field ECB devices (refer to Specification 513 – Emergency Callbox).

The ECB Management Software shall comply with the general software requirements in Specification 100 – General Provisions.

Manufacturer Requirements

The Manufacturer shall have implemented software with similar functionality for at least three (3) different clients in the past three (3) years.

Functional Requirements

General

The ECB Management Software shall support the configuration of ECB devices, and the storage and reporting of indications received from field ECB devices.

Logon and Logoff Requirements

The ECB Management Software shall support a logon feature that is password protected and shall allow a user to logon to a specific user access level. Users shall log on to the ECB Management Software using the same logon credentials as that entered in CAD/AVL Central Software. Users already logged on to the CAD/AVL Central Software shall be able to log on to the ECB Management Software without re-entering logon credentials. Users logged off from the CAD/AVL Central Software shall be automatically logged off from the ECB Management Software.

The ECB Management Software shall allow users to log on to the system with varying privileges depending on their access level. Access levels may include, but are not limited to:

- System Administrator
- User
- Read-only User

The ECB Management Software shall allow users logged in as system administrators to assign specific privileges to each access level; add, remove, or change access levels; assign access levels to each user; and add/remove users.

The ECB Management Software shall support at least ten (10) concurrent users.

The ECB Management Software shall support logoff functionality.

Graphical User Interface (GUI) Requirements

The ECB Management Software shall incorporate a Graphical User Interface (GUI), to display information to users and to accept user input in a clear, logical manner.

The GUI shall support concurrent display of multiple windows. At a minimum, the GUI shall support function key assignments, paging, scrolling, and shortcuts. The GUI shall support repositioning and resizing each window as desired to present the maximum amount of useable information.

ECB Configuration Requirements

The ECB Management Software shall allow users with appropriate privileges to configure individual ECB field devices, including but not limited to the stored emergency numbers, speakerphone and microphone volumes, and resetting ECB activation.

Data Storage and Reporting Requirements

The ECB Management Software shall accept and store notifications of activation from the field ECB devices. With each notification of activation, the ECB management software will record the location of the activated ECB.

The ECB Management Software shall accept indications of fault detection from field ECB devices. With each indication, the ECB Management Software will record the location of the faulty ECB device. Field device faults detected shall include at a minimum, loss of power, loss of telephony connections, and loss of communications with the BOC.

The ECB Management Software shall be capable of issuing visual and audio alerts to BOC users when an ECB field device is activated and when a fault is detected with an ECB field device.

The ECB Management Software shall alert a user via the GUI if communication with an ECB device has been lost.

These alerts shall be configurable to enable the system to require users to acknowledge the alert prior to alert being disengaged. The system shall be configurable to send an e-mail or an SMS text when a fault is detected.

The ECB Management Software shall be capable of exporting select notifications and fault data using standard reporting tools (e.g. Crystal Reports or MS Access) and shall have the ability to export data into file formats that can be viewed and edited with standard office software (e.g., Microsoft Word and Excel).

ECB Device Integration

The ECB Management Software shall send configuration data to all ECB field devices via the CT***fastrak*** communication system.

The ECB Management Software shall accept notifications and fault indications from all ECB field devices via the CT***fastrak*** communication system.

Performance Requirements

The ECB Management Software desktop client shall meet the following performance criteria:

- All windows with non-paging data shall open and populate with data within three (3) seconds;
- All window with paging data shall open and populate with the initial data within three (3) seconds and thereafter page updates shall be retrieved within one (1) second;
- Database searches for a single record shall be completed within five (5) seconds;
- Mouse cursor movements shall be smooth;
- Dragging of the cursor bar for a scrollable list shall cause instantaneous redisplay of the list in time with the movement of the cursor bar.

Warranty Requirements

The ECB Management Software, and all associated utilities shall comply with the warranty requirements in the Specification 400 – Technical Support and Warranty Services.

The Contractor shall develop, test, provide and install all applicable software “patches” or upgrades that become necessary to remedy system software faults or “bugs” identified during the warranty period. This provision includes operating system and security utilities and firmware.

The software manufacturer shall commit to continue to offer a maintenance/service agreement for the software for a minimum ten (10) year period. The maintenance/service agreement shall include providing patches, bus fixes, security upgrades, and ongoing technical support.

The Contractor shall provide at no additional cost, all version updates, software patches and error corrections available for the system software provided.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting the media containing the ECB Management Software from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged media.

Installation

The Contractor shall install the ECB Management Software on the BOC servers (specified in Specification 535 – Server). The Contractor shall acquire all needed permits and licenses before software installation.

The Contractor shall install the ECB Management Software desktop client on a minimum of three (3) workstations at the BOC. The Contractor shall configure the desktop clients for immediate use.

The ECB Management Software shall be delivered in a ready-to-run form, including all necessary utility programs and documentation. Utilities for data storage allowing direct access, data archiving and restore functions for older data shall be provided.

To the greatest extent possible, industry proven software packages shall be utilized to provide the functionality specified in this document. Each such software package shall be identified in the proposal. The proposal shall state the purpose of the software package, where it will be used, and how it will be used.

For software licensing, a minimum of ten (10) concurrent seat licenses or an enterprise site licensing solution shall be provided. The Contractor shall identify all necessary third-party software and associated licenses as part of their proposal.

The ECB Management Software shall be capable of running in an active directory environment. System applications shall be capable of running concurrently with other installed programs.

The Contractor shall be responsible for resolving any compatibility issues between software and any other existing Department software or systems. The Contractor shall confirm that software installation, including all third-party applications, will not negatively impact the operations of existing Department software applications available over the internal network.

Security/Maintenance

Security and Maintenance utilities shall be implemented to comply with the System Security Plan requirements stated in Specification 100 – General Provisions. Such utilities shall be capable of monitoring the ECB Management Software to identify security or maintenance issues such as unauthorized access, security breach, software component failures, etc.

Documentation and Training

The Contractor shall provide all necessary and appropriate technical and user documentation for the ECB Management Software, which shall cover the functional features, technical information,

training, help, and maintenance information, in compliance with the documentation requirements in Specification 100 – General Provisions.

The Contractor shall provide all necessary and appropriate operational and maintenance training for the ECB Management Software in compliance with the training requirements in Specification 300 – Training.

Training courses for the ECB Management Software shall include but are not limited to the following:

- User Training
- System Administration Training
- Maintenance Training

Testing Requirements

The Contractor shall fulfill the testing requirements in Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 203 – On-board Equipment Pilot Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test, to gain system acceptance for the ECB Management Software.

METHOD OF MEASUREMENT

This work shall be measured for payment by the contract price for the ECB Management Software as specified, installed, configured, completed, tested, and accepted in-place. The contract price of this item shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include providing, installing and configuring the ECB Management Software, all materials, licenses, labor, testing, documentation, and other incidentals necessary to complete the work. This work shall not include labor associated with software integration tasks. Software integration should be accomplished as part of Specification 206 – Software Integration.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the ITS and Communications Systems for CT***fastrak*** shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 558 – NETWORK MANAGEMENT SYSTEM

DESCRIPTION

This item shall consist of furnishing, installing, integrating, and testing a Network Management System (NMS), including all licenses, for use by authorized users at the Busway Operations Center (BOC), and remote users.

The NMS shall consist of software to manage the communications network and its components and shall be installed on a Server. The system shall facilitate the retrieval, storage, analysis and display of status information from all network devices attached to the system that are Simple Network Management Protocol (SNMP) and/or Internet Control Message Protocol (ICMP) capable and shall facilitate remote monitoring and configuration of these devices.

References

Internet Engineering Task Force (IETF) – Request for Comments (RFC) 3411 through 3418

MATERIALS

General

The NMS shall be installed and hosted on a Server (refer to Specification 535 – Server) connected to the Modular Chassis Switch (refer to Specification 533 – Modular Chassis Switch) in the Busway Operations Center (BOC). The NMS shall be interfaced with the Busway ITS equipment through the busway communications network.

The work to establish the integration of software shall be accomplished as part of the Software Integration work (refer to Specification 206 – Software Integration).

Manufacturer Requirements

The manufacturer shall be regularly engaged in the development, production and support of Network Management Systems used in telecommunications network operations centers, transportation operations centers and other high-reliability, critical systems.

Functional Requirements

General

The NMS shall monitor the operational status of all the ITS and communications components on the system in real-time.

The NMS deployed shall be capable of managing any SNMP compliant device from any vendor.

The NMS shall support SNMPV1, SNMPV2C and SNMPV3 and shall automatically discover and poll SNMP and ICMP devices.

The NMS shall be locally accessible at the BOC and remotely accessible through a secured VPN access.

The NMS shall support at least ten (10) concurrent users.

GUI

The NMS shall be capable of automatically displaying the layout of each network map as a tree, ring or bus topology. Each map object shall use a device specific or user selected icon and the object color shall indicate the device status.

The NMS shall support direct selection of objects. The system shall provide a navigation tree to display the current alarm status of each subnet. The NMS shall support PAN/ZOOM feature and shall provide a view of all the devices attached to the network in one window.

Log on and Log off

The NMS shall support a logon, logoff feature that is password protected and shall allow a user to logon to a specific user access level.

The NMS shall allow users to log on to the system with varying privileges depending on their access level. Access levels may include, but are not limited to:

- BOC System Administrator
- BOC Network Management System Administrator
- BOC Network Management System Personnel
- Busway Supervisor
- Field Network Management Personnel

The NMS shall allow users logged in as system administrators or BOC Network Management System Administrator to assign specific privileges to each access level; add, remove, or change access levels; assign access levels to each user; and add/remove users.

The NMS shall allow users logged in as BOC System Administrator(s) or BOC Network Management System Administrator(s) to assign the following for the communications and ITS

components: specific privileges to each access level; add, remove, or change access levels; assign access levels to each user; and add/remove users.

Graphical User Interface (GUI)

The NMS shall incorporate a Graphical User Interface (GUI), to display information to users and accept user input in a clear, logical manner.

The NMS shall allow the user to filter the information for display by alert type, time of alert, station location, busway location, communication component, and by ITS component.

The GUI shall support concurrent display of multiple windows.

At a minimum, the GUI shall support function key assignments, paging, scrolling, and shortcuts. The GUI shall support repositioning and resizing each window as desired to present the maximum amount of useable information.

Automatic Control of Communication and ITS Components

As part of the NMS, a database of all components of the communication system shall be maintained at the BOC.

The NMS shall provide polling agents to upload status, configuration changes or alerts from Ethernet connected devices.

The NMS automatic control functionality shall be configurable by users designated by BOC System Administrators and BOC network Management System Administrators.

The NMS shall allow a designated operator to remotely access and control any of the ITS and communications components on the communications network.

The NMS shall have configurable functionality for remote access and control of any of the ITS and communication system components on the network. The NMS shall facilitate this remote access and control of the components in the network through a secure encrypted channel.

Alerts

The NMS shall alert the BOC controller when communications system and ITS components are non-responsive, outside of their normal operating range or when there is a loss of a communication link on the network.

The NMS shall provide operator alerts when any element(s) of the communications system or ITS component(s) under observation are operating outside of their normal operating range.

The NMS shall provide alerts via:

- Audio file
- Pop-up Alarm

The NMS shall allow provision of alerts via:

- Email
- Pager
- SMS (text message)

The NMS shall include a configurable ranking scale to communicate the severity of the component alert.

The NMS shall alert the BOC operator of scheduled maintenance. The NMS scheduled maintenance alerts shall have configurable due-date arrival time in order to arrange a suitable response in a timely fashion.

Reports

The NMS shall be capable of automatically generating reports on a daily, weekly or monthly basis in formats including graphs, bar charts, table, or spreadsheet format. The system shall be capable of exporting the reports to printers, files or web servers.

The NMS shall provide routine reports of the operational status of the communications system and ITS components interfaced to the communications system.

The NMS shall act as a central repository for all maintenance reports of the communication system and ITS components.

Warranty Requirements

The Network Management System, and all associated equipment and cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services.

CONSTRUCTION METHODS

Installation

The Contractor shall install and configure the NMS in accordance with the manufacturer's recommended installation procedure, and in accordance with the design drawings and specifications

The Contractor shall install the NMS on the Servers and assign IP address(es) to the same, in accordance with the Contractor-developed IP Address Coordination Plan approved by the Engineer.

The NMS shall be configured to monitor each necessary Ethernet network without creating bridges between them.

Security/Maintenance

Security and Maintenance utilities shall be implemented to comply with the System Security Plan Requirements stated in Specification 100 – General Provisions.

Documentation and Training

The Contractor shall provide all necessary and appropriate technical and user documentation for the Network Management System, which shall cover the functional features, technical information, training, help, and maintenance information, in compliance with the Software Documentation requirements in Specification 100 – General Provisions.

The Contractor shall provide documentation and training on all the installation, configuration, operating features, management functions, and maintenance procedures for the Network Management System. The Contractor shall develop and submit a Training Plan, which shall cover the training for use and maintenance of the Network Management System, in compliance with the Training requirements in Specification 300 – Training.

Testing

The Contractor shall test the NMS, and all associated equipment and cabling in accordance with the testing requirements stated in Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 203 – On-board Equipment Pilot Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The Contractor shall demonstrate compliance with all of the functional, operational and performance requirements specified above.

The Contractor shall verify the operation of the NMS while the Ethernet network utilization is below 50% of capacity.

METHOD OF MEASUREMENT

This work shall be measured for payment by the contract price for the Network Management System as specified, installed, configured, completed, tested, and accepted in-place. The contract price of this item shall be as indicated by the Contractor in the negotiated contract Price proposal, and shall include providing, installing and configuring the Network Management System, all

materials, licenses, labor, testing, documentation, and other incidentals necessary to complete the work. This work shall not include labor associated with software integration tasks. Software integration should be accomplished as part of Specification 206 – Software Integration.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the CT***fastrak*** ITS and Communications Systems shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 559 – TRAVELER INFORMATION SOFTWARE

DESCRIPTION

This item shall consist of furnishing, installing, and testing the Traveler Information Software, including all licenses, for use by authorized users at the Busway Operations Center (BOC).

The Traveler Information Software shall be used to allow users to provide busway passengers with information about schedules, real-time vehicle locations, and expected arrival times of transit vehicles at busway stations in real-time. Traveler information shall be provided through a number of Department-operated dissemination methods at the stops and terminals, and potentially, in the future, through customer personal devices over the internet.

References

The Traveler Information Software shall comply with all NTCIP specifications, including, but not limited to:

- NTCIP 1403 – Transit Communications Interface Profiles – Standard on Passenger Information (PI) Objects
- NTCIP 1405 – Transit Communications Interface Profiles – Standard on Spatial Representation (SP) Objects
- NTCIP 1407 – Transit Communications Interface Profiles – Standard on Control Center (CC) Objects

The software shall be developed in accordance with recognized standards such as IEEE Software Engineering Standards.

MATERIALS

General

The Traveler Information Software shall be a module of the CAD/AVL Central Software or a separate stand-alone software package that interfaces with the CAD/AVL Central Software. It shall be made available to users in the BOC via a “desktop client” installed on BOC workstations.

The Traveler Information Software shall be interfaced with the CAD/AVL Central Software and the Traveler Information System (TIS) Controllers at the stations (refer to specifications: Specification 553 – CAD/AVL Central Software, Specification 518 – TIS Controller).

The work to establish the integration of software shall be accomplished as part of the Software Integration work (refer to Specification 206 – Software Integration).

Manufacturer Requirements

The Manufacturer shall, in the past 5 years, have successfully provided similar software for at least three (3) public transit agencies where the software supports arrival time prediction for at least 50 vehicles in maximum service and information dissemination to at least 10 different locations.

Functional Requirements

General

The Traveler Information Software shall accept real-time vehicle location information from the CAD/AVL Central Software to provide a real-time feed that supports other dissemination methods (such as smart phone applications). The Traveler Information Software shall generate vehicle arrival time predictions for each vehicle and for each station, for transmission to the station TIS Controllers to enable Variable Message Signs (VMSs) displays and PA announcements, and to provide a real-time feed that supports other dissemination methods. The Traveler Information Software shall generate sign message content data for transmission to station TIS Controllers for display on Variable Message Signs (VMSs), and audio announcements on PA System speakers. (Refer to Specification 553 – CAD/AVL Central Software, Specification 518 – TIS Controller, Specification 520 – Variable Message Sign (Double-sided), Specification 521 – Variable Message Sign (Single-sided, Pole-Mounted), and Specification 522 – Variable Message Sign (Single-sided, Cantilever Mounted), and Specification 515 – PA System).

The Traveler Information Software shall comply with the general software requirements in Specification 100 – General Provisions.

The hardware required to support the Traveler Information Software is specified in the following specifications: Specification 535 – Servers, Specification 540 – Workstations. The Traveler Information Software shall be a module of the CAD/AVL Central Software or a separate stand-alone software package.

Logon and Logoff Requirements

The Traveler Information Software shall support a logon, logoff feature that is password protected and shall allows a user to logon to a specific user access level. Users shall logon to the Traveler Information Software using the same logon credentials as entered for the CAD/AVL Central Software. Users already logged on to the CAD/AVL Central Software shall be able to logon to the Traveler Information Software without re-entering logon credentials. Users logged off from the CAD/AVL Central Software shall be automatically logged off from the Traveler Information Software.

The Traveler Information Software shall allow users to logon to the system with varying privileges depending on their access level. Access levels may include, but are not limited to:

- BOC System Administrator
- BOC Dispatcher
- BOC Read-only dispatcher
- Busway Supervisor
- 'Home' Operating Company Dispatchers

The Traveler Information Software shall allow users logged in as system administrators to assign specific privileges for users logging in to each access level for the Traveler Information Software or station TIS Controller workstations; add, remove, or change access levels; assign access levels to each user; and add/remove users.

The Traveler Information Software shall support at least ten (10) concurrent users.

Graphical User Interface (GUI) Requirements

The Traveler Information Software shall incorporate a Graphical User Interface (GUI), to display information to users and accept user input in a clear, logical manner.

The GUI shall display in a tabular format the information being sent to station TIS Controllers for VMS display and PA System announcement, the information being currently displayed by VMSs and most recently announced on the PA System.

The GUI shall also provide interactive user interfaces to enable authorized users to generate the messages to be displayed on station VMSs and record announcements to be played on the station PA System speakers.

The GUI shall display in a tabular format alerts received from the field, either due to TIS Controller faults/failures or loss of communication to TIS Controllers.

The GUI shall support the concurrent display of multiple windows. The GUI shall allow the user to filter the information for display by station platform, direction, and by individual VMSs. At a minimum, the GUI shall support function key assignments, paging, scrolling, and shortcuts. The GUI shall support repositioning and resizing each window as desired to present the maximum amount of useable information.

CAD/AVL Central Software Integration

The Traveler Information Software shall accept vehicle route/trip assignment, location updates, and schedule adherence updates from the CAD/AVL Central Software as soon as such updates are available.

Arrival Prediction Generation

The Traveler Information Software shall employ a prediction algorithm to generate arrival time predictions to the nearest second, throughout the operational day, for all vehicles, routes, and stations on the busway.

The Traveler Information Software shall have the ability to align real-time vehicle locations with schedules to be able to automatically assign the vehicle to a block or trip being operated when needed. If reported vehicle locations cannot be aligned with a specific unassigned block, the vehicle shall be assigned to the nearest unassigned scheduled trip on the same route in the same direction, in terms of clock time in the schedule.

The Traveler Information Software shall use latest reported vehicle locations, and may also use other information such as schedule adherence or archived segment travel time data, to accurately maintain current vehicle arrival time predictions for all stations on the busway.

The Traveler Information Software shall account for the time lag in the vehicle location updates before they reach the prediction algorithm, making predictions based on the timestamp attached at the vehicle rather than the time at which the data was received.

The Traveler Information Software shall allow configuration of 'early' and 'late' thresholds for a vehicle in operation based on the arrival predictions.

The Traveler Information Software shall stop generating predictions when a vehicle departs its last station on the busway, is indicated as being off-route, is taken out of service by users, or an agency configurable time has elapsed since the last location update.

The Traveler Information Software shall resume generating predictions when a vehicle is reported on-route and still 'upstream' of the last busway station for its current trip, when it was previously off-route or a location update is received following suspension of updating due to elapsed time since the previous update.

For each station, the Traveler Information Software shall generate vehicle arrival predictions for at least the next three (3) vehicles serving that station.

The Traveler Information Software shall send vehicle arrival prediction information to TIS Controllers in a format appropriate for enabling display on station VMSs, and conversion to announcements via text-to-speech engine. For each station platform and direction, the vehicle arrival prediction information sent to the TIS Controller shall include a time stamp in accordance with the centralized system clock, and the following for the next three (3) expected vehicles: a route designation, the trip destination or an abbreviation thereof, and either the integer number of minutes until expected arrival or a status designation of up to four (4) characters, such as 'NEXT' or 'LATE'.

The Traveler Information Software shall reduce the length of the prediction information message data sent to the TIS Controllers, such that the messages fit the available VMS width without scrolling. The VMS will provide four-lines with display matrices supporting at least twenty-four (24) fixed width font characters per line.

The format for how the information shall be displayed on the four lines of a station VMSs is shown below:

<Route> <Dest> <XMIN/LATE/NEXT>
<Route> <Dest> <XMIN/LATE/NEXT>
<Route> <Dest> <XMIN/LATE/NEXT>
<Emergency/Public Information>{scrolling}

The Traveler Information Software shall allow the automatic delivery of vehicle arrival prediction information updates to be at Department-programmed frequency, by destination station platforms and by direction. At a minimum, the Traveler Information Software shall allow automatic delivery of prediction information over the range of every ten (10) seconds to every sixty (60) seconds.

Real-Time Data Feed

The Traveler Information Software shall provide a data feed containing real-time vehicle locations and predicted vehicle arrival times at each station in one or more machine-readable formats (such as XML, JSON, TXT) for Department use to enable posting information on its website, access via an automated telephone system publishing to third parties, or any other purposes designated by Department.

The Traveler Information Software shall provide a GTFS-realtime feed containing real-time vehicle locations and predicted vehicle arrival times at each station for Department use to enable posting information on Google Maps. For more information regarding GTFS-realtime refer to https://developers.google.com/transit/gtfs-realtime/. The ITS Contractor shall coordinate with the Department to ensure that the GTFS-realtime feed is consistent with the Department's GTFS files for CT***fastrak***.

Sign Message Generation

The Traveler Information Software shall support the generation of ad-hoc text messages for display on station VMSs. A text message generation screen shall provide the option of selecting a message from a list of canned messages or entering a free-form message manually.

The Traveler Information Software shall maintain an agency configurable library of predefined text messages. These messages may include: weather information, incident information, public safety information, and general transit information. The Traveler Information Software shall ensure that a user is not allowed to enter a free-form message or configure a predefined message that exceeds a configurable character limit.

The Traveler Information Software shall allow the user to assign a message as being either the public information or emergency type. The Traveler Information Software shall allow the user to

assign a specific single platform or a set of destination platforms and directions to the selected message.

The Traveler Information Software shall allow the pre-scheduled automatic delivery of text messages to be programmed in terms of frequency, specific times of day, day of week, and destination station platforms and direction.

The Traveler Information Software shall allow the user to manually select a text message for immediate delivery to the assigned station platforms and direction, or to be programmed in terms of pre-scheduled frequency and destination station platforms and direction.

Announcement Generation

The Traveler Information Software shall support the recording of announcements for playing on the PA System using available microphone equipment on the workstation. An announcement generation screen shall provide the option of selecting from a list of pre-recorded announcements or recording a freeform announcement. The Traveler Information Software shall maintain a library of pre-recorded announcements that shall be agency configurable. These messages may include: weather information, incident information, public safety information, and general transit information. The Traveler Information Software shall be capable of ensuring that a user is not allowed to record a message longer than a configurable number of seconds.

The Traveler Information Software shall allow the user to assign an announcement as being either the public information or emergency type. The Traveler Information Software shall allow the user to assign a specific single platform or a set of destination stations to the selected announcement.

The Traveler Information Software shall allow the pre-scheduled automatic delivery of announcements to be programmed in terms of frequency, specific times of day, day of week, and destination stations.

The Traveler Information Software shall allow the user to manually select an announcement for immediate playing at the assigned stations, or to be programmed in terms of pre-scheduled frequency and destination stations.

Traveler Information System (TIS) Controller Integration

The Traveler Information Software shall send vehicle arrival prediction information messages to the appropriate TIS Controller(s) based on the assigned destination station platforms and directions. The Traveler Information Software shall send public information and emergency text messages to the appropriate TIS Controller(s) based on the assigned destination station platforms and directions. The Traveler Information Software shall send announcements to the appropriate TIS Controller(s) based on the assigned destination stations.

The Traveler Information Software shall be able to periodically request that a TIS Controller respond with the information currently being displayed on the VMS and most recently announced through the PA System speakers, and store the information in a database. The frequency of

requests to a TIS Controller shall be agency configurable. The Traveler Information Software shall be able to query any TIS Controller for the current messages displayed on any or all VMS signs it controls, and most recently announced through the PA System speakers.

The Traveler Information Software shall be capable of managing and configuring logon/logoff functionality at TIS Controllers.

The Traveler Information Software shall receive fault/failure alerts from the TIS Controllers. Loss of communication with the TIS Controllers shall also trigger an alert in the Traveler Information Software.

Alert Management

The Traveler Information Software shall support an alert management function. This function shall enable an authorized user to view alerts received from the field. Alerts include, but are not limited to, fault/failure alerts from TIS Controllers, and indication of loss of communication with TIS Controllers.

The Traveler Information Software shall allow an authorized user to mark the alert as high or low priority. An authorized user shall also be able to archive or delete alerts.

XML Data Feed

The Traveler Information Software shall be capable of outputting an XML data feed in real-time. The data feed shall include, at a minimum, locations for all vehicles in service and predictions of vehicle arrival times at stations. The details of the data feed shall be finalized by the Contractor in discussion with the Department during Design Review. The Contractor shall provide the Department with an Application Programming Interface (API) document detailing the requirements for this data feed output interface. For this requirement, real-time shall be defined as a delay of less than one (1) second between receipt of data from buses and output of formatted XML data.

Performance Requirements

The Traveler Information Software shall adhere to the performance requirements listed in Specification 100 – General Provisions.

In addition, the Traveler Information Software desktop client shall meet the following performance criteria under full system loading:

- All windows with non-paging data shall open and populate with data within three (3) seconds;
- All window with paging data shall open and populate with the initial data within three (3) seconds and thereafter page updates shall be retrieved within one (1) second;

- Messages shall be displayed on signs within twenty (20) seconds of implementing a plan or selecting and implementing a predefined message;
- Database searches for a single record shall be completed within five (5) seconds;
- Mouse cursor movements shall be smooth;
- Dragging of the cursor bar for a scrollable list shall cause instantaneous redisplay of the list in time with the movement of the cursor bar.

Prediction Accuracy Requirements

When valid input data are being provided, the predictions for vehicle arrivals shall comply with the following minimal accuracy requirements:

- At least 90% of all predictions made less than three (3) minutes in advance of an actual arrival time shall be within one minute of the actual arrival time.
- At least 90% of all predictions made less than five (5) minutes in advance of an actual arrival time shall be within two minutes of the actual arrival time.
- At least 90% of all predictions made less than ten (10) minutes in advance of an actual arrival time shall be within three minutes of the actual arrival time.

Warranty Requirements

The Contractor shall develop, test, provide and install all applicable software "patches" or upgrades that become necessary to remedy system software faults or "bugs" identified during the warranty period.

The Contractor shall provide at no additional cost, all version updates, software patches and error corrections available for the system software provided.

The software manufacturer shall commit to continue to offer a maintenance/service agreement for the software for a minimum ten (10) year period. The maintenance/service agreement shall include providing patches, bus fixes, security upgrades, and ongoing technical support.

In addition, the Contractor shall satisfy all Warranty requirements listed in Specification 400 – Technical Support and Warranty Services.

CONSTRUCTION METHODS

Installation

The Contractor shall install the Traveler Information Software on the BOC Servers (specified in Specification 535 – Server).

The Contractor shall install the Traveler Information Software desktop client on three (3) workstations at the BOC. The Contractor shall acquire all needed permits and licenses before software installation.

To the greatest extent possible, industry proven software packages shall be utilized to provide the functionalities specified in this document. Each such software package shall be identified in the proposal. The proposal shall state the purpose of the software package, where it will be used, and how it will be used. If one software package is required to interface with another software package, the interface shall be documented and supported by flowcharts or block diagrams as appropriate.

The Traveler Information Software shall be delivered in a ready-to-run form, including all necessary utility programs and documentation. Utilities for data storage allowing direct access, data archival and restore functions for older data shall be provided.

For software licensing, a minimum of ten (10) concurrent seat licenses or an enterprise site licensing solution shall be provided. The Contractor shall identify all necessary third-party software and associated licenses as part of their proposal.

The Traveler Information Software shall be capable of running in an active directory environment. System applications shall be capable of running concurrently with other Windows programs.

The Contractor shall be responsible for resolving any compatibility issues between software and any other existing Department software or systems. The Contractor shall confirm that software installation, including all third-party applications, will not negatively impact the operations of existing Department software applications available over the internal network.

Security/Maintenance

Security and Maintenance utilities shall be implemented to comply with the General Security and Maintenance Requirements stated in the Specification 100 – General Provisions. Such utilities shall be capable of monitoring the Traveler Information Software to identify security or maintenance issues such as unauthorized security breaches, software component failures, etc.

Documentation and Training

The Contractor shall provide all necessary and appropriate technical and user documentation for the Traveler Information Software, which shall cover the functional features, technical information, training, help, and maintenance information, in compliance with the Software Documentation requirements in the Specification 100 – General Provisions.

The Contractor shall provide all necessary and appropriate operational and maintenance training for the Traveler Information Software. The Contractor shall develop and submit a Training Plan,

which shall cover the training for use and maintenance of the Traveler Information Software, in compliance with the Training requirements in Specification 300 – Training.

Testing Requirements

The Traveler Information Software shall comply with the testing requirements stated in Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

For measuring the accuracy of predictions during Acceptance Testing, the Contractor shall provide the Department with Accuracy Testing Procedures for the Traveler Information Software as part of the Acceptance Test Plan.

For system acceptance, the Contractor shall provide archived raw prediction records (indicating the vehicle, route, direction, stop, time of prediction, and predicted times) and archived times for vehicle arrivals at stations sufficient to conduct the Accuracy Testing Procedures, and to allow Department to define periodic extracts of these data in terms of the range of vehicle, routes, and stops included and the overall number of prediction records.

After Final Acceptance is issued and for the duration of the warranty, the Contractor shall provide monthly performance reports, describing the average accuracy of the bus arrival prediction algorithm over the period at stations identified by the Department relative to the criteria defined above for varying number of minutes in advance of actual arrival times.

METHOD OF MEASUREMENT

This work shall be measured for payment by the contract price for the Traveler Information Software as specified, installed, configured, completed, tested, and accepted in-place. The contract price of this item shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include providing, installing and configuring the Traveler Information Software, all materials, licenses, labor, testing, documentation, and other incidentals necessary to complete the work. This work shall not include labor associated with software integration tasks. Software integration should be accomplished as part of Specification 206 – Software Integration.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the CT***fastrak*** ITS and

Communications Systems shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 560 – AUTOMATIC PASSENGER COUNTER (1-DOORWAY)

SPECIFICATION 561 – AUTOMATIC PASSENGER COUNTER (2-DOORWAY)

SPECIFICATION 562 – AUTOMATIC PASSENGER COUNTER (3-DOORWAY)

DESCRIPTION

Summary

Specification 560 – Automatic Passenger Counter (1-doorway)

This item shall consist of furnishing, installing, and testing an on-board Automatic Passenger Counter (APC) system, all needed components and accessories required for a full and complete installation, including all associated equipment and cabling for transit vehicles with one (1) doorway.

Specification 561 – Automatic Passenger Counter (2-doorway)

This item shall consist of furnishing, installing, and testing an on-board Automatic Passenger Counter (APC) system, all needed components and accessories required for a full and complete installation, including all associated equipment and cabling for transit vehicles with two (2) doorways.

Specification 562 – Automatic Passenger Counter (3-doorway)

This item shall consist of furnishing, installing, and testing an on-board Automatic Passenger Counter (APC) system, all needed components and accessories required for a full and complete installation, including all associated equipment and cabling for transit vehicles with three (3) doorways.

For each type of bus, the APC system shall consist of APC sensors installed to monitor each doorway completely, integrated with one or more APC Controller devices, and including any necessary communication interfaces. The APC sensors shall count passenger boardings and alightings at every doorway. The APC controller(s) shall process information received from the APC sensors and send it for storage on the Vehicle Logic Unit (VLU) of the Mobile Data Computer (MDC) (refer to Specification 564 – Mobile Data Computer) for subsequent upload to the Busway Operations Center (BOC).

References and Standards

Environmental and Enclosure

- SAE J1455 – Recommended Environmental Practices for Electronic Equipment Design in Heavy-Duty Vehicle Applications
- SAE J1113/13 – Electromagnetic Compatibility Measurement Procedure for Vehicle Components--Part 13: Immunity to Electrostatic Discharge
- MIL-STD-810 – Department of Defense Test Method Standard for Environmental Engineering Considerations and Laboratory Tests
- International Electrotechnical Commission (IEC) Standard 60529 – Degrees of Protection provided by Enclosures
- European Norm (EN) 50155: Railways Applications Electronic Equipment Used on Rolling Stock
- Federal Communications Commission (FCC) Code of Federal Regulations 47 Part 15 Class A

Communications

- SAE J1708 – Serial Data Communications between Microcomputer Systems in Heavy-Duty Vehicle Applications
- SAE J1939 – Recommended Practice for a Serial Control and Communications Vehicle Network

Product Safety

- Underwriters Laboratory (UL) 60950: Information technology equipment – safety, International Electrotechnical Commission (IEC) 60950: Safety of information technology equipment, European Norm (EN) 60950: Safety of information technology equipment, Canadian Standards Association (CSA) 60950-95: Safety of Information Technology Equipment, or similar

MATERIALS

General

On each transit vehicle, the Contractor shall equip all doorways with a sufficient number of APC sensors to meet the performance requirements, and install one or more APC controllers. The Contractor shall determine the number of APC sensors and controllers for each type of bus, in coordination with the Department. The Contractor shall also install any communications required

between the sensors and the controller(s) and between the controller(s) and the VLU of the MDC.

The APC Controller(s) shall be connected to the VLU of the MDC using cabling and other communication hardware complying with SAE J1708, SAE J1939 or approved equivalent to facilitate transmission of boarding and alighting counts to the MDC (refer to Specification 564 – Mobile Data Computer).

The APC shall comply with the safety standards referenced in References and Standards.

The APC and all associated equipment and cabling shall comply with the Materials requirements stated in Specification 100 – General Provisions. If conflicts exist, this Item specification shall govern.

Manufacturer Requirements

The APC Manufacturer shall, in the past 5 years, have successfully installed similar equipment for at least three (3) public transit agencies where the equipment is installed on a fleet of at least fifty (50) vehicles.

Physical Requirements

APC sensors shall be rugged devices which can be safely and securely installed. The devices shall have an indistinctive exterior color similar to bus interiors, so as to not draw undue attention from passengers.

APC controller(s) shall be designed for placement in protected areas or enclosures. Further details about the enclosure dimensions shall be decided by the Department in conjunction with the Contractor.

The APC controller(s) shall have a USB or RS-232 serial connection port for use by a laptop computer for calibration of the doorway sensors.

Environmental Requirements

The APC, and all associated equipment and cabling shall comply with the following environmental requirements:

Criteria	**Minimum Conditions to be Met**
Operating Temperatures	Between -13°F to 131°F (-25°C and 55°C)
Storage Temperatures	Between -40°F to 158°F (-40°C and 70°C)
Humidity	5-95% relative humidity, non-condensing
Operating Vibration	Compliant with SAE J1455-06, MIL-STD-810F, or EN 50155

Criteria	Minimum Conditions to be Met
Mechanical Shock	Compliant with SAE J1455-06, MIL-STD-810F, or EN 50155
Solid Object and Moisture Protection	IEC IP65

The APC components—electrical, mechanical, and other connections— shall be designed to operate without degradation during and after exposure to vibration as encountered in normal service.

The APC shall meet electromagnetic immunity standards of SAE J1113/13 and protect against surge and reverse polarity.

Electrical Requirements

The APC shall run on standard vehicle power and operate at a nominal +12VDC or +24VDC, and be fully functional within operating supply voltage ranges of + 9VDC to +30 VDC. Voltages shall be measured at the power connector to the device. The Contractor shall coordinate with the Department to verify the compatibility of the on-board equipment with the power supply units in each type of bus.

Functional Requirements

APC Sensors

The APC system shall utilize overhead sensors.

The doorway sensors shall be able to detect door openings, and count and differentiate between boarding and alighting passengers.

The doorway sensors for all doorways shall be connected to one or more APC controllers.

The doorway sensors shall be able to count moving passengers with speed between 0.1 and 3 meters per second.

The doorway sensors shall be able to separately count successive passengers that are walking as close together as is practicable, either one behind the other or side by side.

The doorway sensors shall be able to count moving passengers with heights between one meter in height and the maximum height of the doorway.

The doorway sensors shall be able to separately count a small child being carried by another passenger.

The doorway sensors shall not register as multiple passengers the passage of a single passenger that reaches into or out of the doorway passage, or is swinging their arms, while passing through the sensor beams.

The doorway sensors shall not separately count objects carried by passengers, such as shopping bags or umbrellas.

Boarding and alighting counts shall only be recorded when the doorway is open, to avoid any counting of passengers moving in the vicinity of the doorway passages between stops.

Boarding and alighting counts shall only be recorded when the vehicle MDC is logged in. If there is a breakdown and passengers need to transfer to a replacement vehicle, this will allow the passenger transfer to be done with both vehicles logged out so that the transferring passengers are not erroneously double-counted.

The APC sensors shall send boarding and alighting counts to the APC Controller.

APC Controller

The APC controller shall receive, process, and record the information received from the APC sensors.

The APC controller shall be interfaced with a wheelchair lift sensor, if any, with the number of wheelchair lift operational cycles at each stop also recorded.

For each stop, i.e. between a detected door opening and door closing, a data record shall be created to store the number of accumulated boarding and alighting passengers for each doorway.

As soon as a door closing is detected by the APC sensors, the APC controller(s) shall send a data record of the number of accumulated boarding and alighting passengers for each doorway to the MDC.

The APC controller shall not erase or allow the overwriting of a data record until confirmation is received from the MDC that the data record was successfully received.

The APC Controller shall automatically record and log errors.

Utility software shall be provided, for use on a laptop computer connected via the USB or RS-232 communications port to the APC controller, which supports calibration of the doorway sensors.

Performance Specifications

The APC system shall count boardings and alightings at each doorway for each stop with an error relative to accurate manual counts of ≤ 5%, respectively to be measured as detailed in Testing Requirements section.

All individual components of the APC shall have a minimum Mean Time Between Failure (MTBF) of 50,000 hours.

Warranty Requirements

The APC and all associated equipment and cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The APC and all associated equipment and cabling shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

Spare Parts Requirements

The Contractor shall provide the following spare parts:

- Spare APC Sensors equivalent to 10% of the total number of installed APC Sensors, including all cabling required to connect to the APC controllers and power supply
- Spare APC Controllers equivalent to 10% of the total number of installed APC Controllers, including all cabling required to connect to the Mobile Data Computer and power supply

All the spare parts shall be of the same make and model as the originals used to operate the APC.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting finished surfaces from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged hardware, as determined by the Engineer or a designated Department representative.

Installation

General

The Contractor shall be responsible for all installation and configuration of APC, on each type of bus.

The location and mounting method for the APC sensors and controller(s) shall be determined in collaboration with the Engineer. The Contractor shall identify whether existing enclosure spaces are sufficient for APC Controller, and shall propose a solution in case additional enclosure space is required. The solution shall have to be accepted by the Department before the Contractor may proceed to installation. If deemed necessary by the Department, the Contractor shall rearrange

the installed locations of other on-board equipment to achieve a suitable overall arrangement of equipment.

Protective assemblies shall be designed as necessary to reasonably secure any APC system on-board equipment located in plain sight or otherwise easily accessible to passengers.

APC system on-board equipment shall be installed to meet minimum height and width clearances for all transit vehicle entrances/exits.

APC Sensor

APC sensors shall be mounted so as to avoid any protrusions into the doorway passage.

Cabling to the APC sensors shall be shielded and routed to avoid sources of electromagnetic interference, such as fluorescent lighting ballasts.

The alignment of the doorway sensors shall be calibrated after installation to establish the alignment settings for each vehicle that achieve the most accurate performance (and the calibration settings for each vehicle shall be documented for future Department reference).

APC Controller

The APC controller(s) shall be installed in locations that are not accessible to the vehicle operator or passengers.

Security/Maintenance

All components of the APC shall be removable and replaceable by a single technician with basic hand tools.

Documentation and Training

The APC, and all associated equipment and cabling shall comply with the documentation and training requirements stated in Specification 100 – General Provisions and Specification 300 – Training.

The Contractor shall provide documentation and training on all the installation, configuration, management functions, operating features and maintenance procedures for the APC.

Testing

The Contractor shall be responsible for all testing required to establish approval and acceptance of the APC System as stated in the Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 203 – On-board Equipment Pilot Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests,

Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

In addition, for each type of bus, the Department will collect manual ride-check data of at least seven hundred (700) boarding and alighting passengers or the boarding and alighting counts for at least three revenue trips (whichever is the greater number of boarding and alighting passengers), which shall be used as the basis for assessing the accuracy of the APC system.

METHOD OF MEASUREMENT

Specification 560 – Automatic Passenger Counter (1-doorway)

This work shall be measured for payment by the number of transit vehicles equipped with an Automatic Passenger Counter (1-doorway) of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each Automatic Passenger Counter (1-doorway) installed shall be as indicated by the Contractor in the negotiated contract price proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

Specification 561 – Automatic Passenger Counter (2-doorway)

This work shall be measured for payment by the number of transit vehicles equipped with an Automatic Passenger Counter (2-doorway) of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each Automatic Passenger Counter (2-doorway) installed shall be as indicated by the Contractor in the negotiated contract price proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

Specification 562 – Automatic Passenger Counter (3-doorway)

This work shall be measured for payment by the number of transit vehicles equipped with an Automatic Passenger Counter (3-doorway) of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each Automatic Passenger Counter (3-doorway) installed shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the CT***fastrak*** ITS and

Communications Systems shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 563 – MOBILE COMMUNICATIONS GATEWAY AND ROUTER

DESCRIPTION

This item shall consist of furnishing, installing, and testing a Mobile Communications Gateway and Router (MCGR), all needed components and accessories required for a full and complete installation, including all associate equipment and cabling.

The MCGR shall consist of an on-board router with both wireless and wired communications functionality.

References and Standards

Environmental and Enclosure

- SAE J1455 – Recommended Environmental Practices for Electronic Equipment Design in Heavy-Duty Vehicle Applications
- SAE J1113/13 – Electromagnetic Compatibility Measurement Procedure for Vehicle Components--Part 13: Immunity to Electrostatic Discharge
- MIL-STD-810 – Department of Defense Test Method Standard for Environmental Engineering Considerations and Laboratory Tests
- International Electrotechnical Commission (IEC) Standard 60529 – Degrees of Protection provided by Enclosures
- European Norm (EN) 50155: Railways Applications Electronic Equipment Used on Rolling Stock
- Federal Communications Commission (FCC) Code of Federal Regulations 47 Part 15 Class A

Communications

- SAE J1708 – Serial Data Communications between Microcomputer Systems in Heavy-Duty Vehicle Applications
- SAE J1939 – Recommended Practice for a Serial Control and Communications Vehicle Network
- Institute of Electrical and Electronics Engineers (IEEE) 802.3 Ethernet Standards collection
- IEEE 802.11 Wireless Local Area Network Standards collection

Software Development Standards

- IEEE SA – 1455-1999 – IEEE Standard for Message Sets for Vehicle/Roadside Communications
- IEEE SA – 1488-2000 – IEEE Standard for Message Set Template for Intelligent Transportation Systems
- IEEE SA – 1489-1999 – IEEE Standard for Data Dictionaries for Intelligent Transportation Systems

Product Safety

- Underwriters Laboratory (UL) 60950: Information technology equipment – safety, International Electrotechnical Commission (IEC) 60950: Safety of information technology equipment, European Norm (EN) 60950: Safety of information technology equipment, Canadian Standards Association (CSA) 60950-95: Safety of Information Technology Equipment, or similar

MATERIALS

General

The contractor shall equip all revenue vehicles with an on-board Mobile Communications Gateway and Router (MCGR), including all required wireless cards, cellular modem cards, and SIM cards.

The MCGR shall be connected to the Multiband Antenna using appropriate Radio Frequency cabling and connectors (refer to Specification 565 – Multiband Antenna).

The MCGR shall be connected to the Vehicle Logic Unit (VLU) of the Mobile Data Computer (MDC) via an Ethernet connection (refer to Specification 563 – Mobile Data Computer).

The MCGR and all associated equipment and cabling shall comply with the Materials requirements stated in Specification 100 – General Provisions. If conflicts exist, this Item specification shall govern.

Manufacturer Requirements

The MCGR Manufacturer shall, in the past five (5) years, have successfully installed similar equipment for at least three (3) public transit agencies where the equipment is installed on a fleet of at least fifty (50) vehicles.

Physical Requirements

The MCGR shall be designed to fit in an appropriately sized enclosure in the interior of the vehicle. The Contractor shall coordinate with the Department to ascertain the size of the enclosure.

The MCGR shall incorporate at least four (4) internal card interfaces where modem or communication cards providing the required wireless capabilities may be installed. These cards shall be easily replaceable to accommodate changes in technology and wireless standards. A PCMCIA, PCI or other types of acceptable standard slot devices may be used.

The MCGR shall have at least four (4) Ethernet ports for communications with on-board devices. The MCGR shall include a minimum of two (2) USB 2.0 connections for communications with on-board equipment.

The MCGR shall have at least two (2) connector ports to connect to the WLAN and cellular data components of the Multiband Antenna.

Environmental Requirements

The MCGR, and all associated equipment and cabling shall comply with the following environmental requirements:

Criteria	**Minimum Conditions to be Met**
Operating Temperatures	Between -13°F to 131°F (-25°C and 55°C)
Storage Temperatures	Between -40°F to 158°F (-40°C and 70°C)
Humidity	5-95% relative humidity, non-condensing
Operating Vibration	Compliant with SAE J1455-06, MIL-STD-810F, or EN 50155
Mechanical Shock	Compliant with SAE J1455-06, MIL-STD-810F, or EN 50155
Solid Object and Moisture Protection	IEC IP53

The MCGR components—electrical, mechanical, and other connections— shall be designed to operate without degradation during and after exposure to vibration as encountered in normal service.

The MCGR shall meet electromagnetic immunity standards of SAE J1113/13 and FCC Part 15 Class A, and protect against surge and reverse polarity.

Electrical Requirements

The MCGR shall run on standard vehicle power and operate at a nominal +12VDC or +24VDC, and be fully functional within operating supply voltage ranges of + 9VDC to +30 VDC. Voltages shall be measured at the power connector to the device. The Contractor shall coordinate with the Department to verify the compatibility of the on-board equipment with the power supply units in each type of bus.

Functional Requirements

General

The MCGR shall support the following wireless services for external data communications:

- Cellular data communications technologies including, but not limited to, 3G technologies (such as CDMA2000, GSM EDGE, UMTS) supported by the major wireless carriers (such as AT&T, Verizon, Sprint, T-Mobile) through a compatible cellular modem or card.
- "WiFi" supporting 802.11 b, g, and n standards through an internal card.

The MCGR shall be designed to be able to support expansion to 4G communications technologies (such as LTE, HSPA, HSPA+).

The MCGR shall interface with the Cellular Data Communications Gateway in the BOC over a cellular network to enable exchange of data to and from the CAD/AVL Central Software.

The MCGR shall interface with the Bulk Data Gateway in the BOC over a WLAN network to enable exchange of data to and from the CAD/AVL Central Software. It is anticipated that the WLAN access points infrastructure and bulk data gateway may not be available at the start of service. For the period that the WLAN network is not available, the MCGR shall be configured to use the cellular network for exchange of bulk data.

MDC Integration

The MCGR shall interface with the MDC via on-board Ethernet connection to facilitate transmission of data to and from the MDC.

The MDC shall upload and download all data to be exchanged with the CAD/AVL Central Software via the MCGR. The MDC shall initiate the process of sending data files to the CAD/AVL Central Software via the MCGR.

The MCGR shall be configurable by a laptop connected to the MCGR via a USB port or through the MDC.

The MCGR shall provide information to the MDC to display the channel and other user prompts required to operate or diagnose the unit via the Ethernet connection.

Network Connectivity and Communications

The Contractor shall coordinate with the Department to identify the specific Cellular Data Modem Card to be provided, during the Design Review stage, based on the Department selection of the cell data service provider.

The MCGR shall be configurable to control which data on-board systems can send using the various available methods, based upon the speed of outbound connections (i.e. which data can be sent when low-speed communications are available, and which can be sent when higher speed communications are available).

The MCGR shall have the ability to configure rate limits on traffic coming to on-board systems (ingress interfaces).

The MCGR shall have the ability to configure rate limits on the outbound connection, in order to efficiently utilize a shared wireless environment (egress interfaces).

The MCGR shall automatically switch data traffic between available wireless networks according to administrator-defined switching policies. Routing policies shall be based upon, at a minimum, network availability, network priority, time of day, vehicle location, and bandwidth capacity.

To assure that only appropriate application traffic is routed over each wireless infrastructure; the MCGR shall perform port filtering for each available wireless network.

The MCGR shall allow bulk data processing to be initiated whenever the vehicle is within WLAN coverage of an approved SSID and the time until scheduled departure from the current location is more than a configurable period of time beyond the current time. It is anticipated that the WLAN access points infrastructure and bulk data gateway may not be available at the start of service. For the period that the WLAN network is not available, the MCGR shall be configured to use the cellular network for exchange of bulk data.

The MCGR shall seamlessly continue data transfers, regardless of which wireless network last handled the data transfer.

Start-up Diagnostics

The unit shall perform a self-diagnostic test each time it is turned on. This test shall be automatic and shall include all router operating parameters.

At the conclusion of a successful test, no operator intervention shall be required. The MCGR unit will send a health status message to the MDC for logging.

A test that is not successful shall notify the MDC. The MDC shall notify the operator with a visual and audible indication and log the event. Applicable error codes shall also be provided to the MDC for logging.

Security

The MCGR shall provide IPsec Virtual Private Network (VPN) services.

The MCGR shall provide stateful firewall services.

Warranty Requirements

The MCGR and all associated equipment and cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The MCGR and all associated equipment and cabling shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

Spare Parts Requirements

The Contractor shall provide the following spare parts:

- MCGRs equivalent to 10% of the total number of installed MCGRs, including all cabling required to connect to the MDC, the Multiband Antenna and on-board power supply

All the spare parts shall be of the same make and model as the originals used to operate the MCGR.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting finished surfaces from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged hardware, as determined by the Engineer or a designated Department representative.

Installation

The location and mounting method for the MCGR shall be determined in collaboration with Department staff. The Contractor shall identify whether existing enclosure spaces are sufficient for the MCGR, and shall propose a solution in case additional enclosure space is required. The solution shall have to be accepted by the Department before the Contractor may proceed to installation. If deemed necessary by the Department, the Contractor shall rearrange the installed locations of other on-board equipment to achieve a suitable overall arrangement of equipment.

The MCGR shall be securely mounted in an appropriate enclosure that is inaccessible to the vehicle operator and passengers or if within reach, is secured against access. The enclosure shall be designed to protect the MCGR from splash or spray.

The Contractor shall coordinate with the Department to establish the necessary cellular data account and acquire the associated cellular modem card.

The Contractor shall install and configure cellular modem cards and any SIM cards, as identified during Design Review, on the MCGR.

The Contractor shall connect the MCGR to the designated on-board power supply on each type of vehicle.

The Contractor shall connect the MCGR to the MDC and the Multiband Antenna.

The Contractor shall be responsible for all configuration of the MCGR, as directed by the Department.

Security/Maintenance

The MCGR and all installed components such as SIM cards or wireless access cards shall be removable and replaceable by a single technician with basic hand tools.

Documentation and Training

The MCGR, and all associated equipment and cabling shall comply with the documentation and training requirements stated in Specification 100 – General Provisions and Specification 300 – Training.

The Contractor shall provide documentation and training on all the installation, configuration, management functions, operating features and maintenance procedures for the MCGR.

Testing

The MCGR, and all associated equipment and cabling shall comply with the testing requirements stated in the Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 203 – On-board Equipment Pilot Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The Contractor shall be responsible for all testing that may be required to establish approval and acceptance of the MCGR.

The MCGR shall be tested for the following:

- Verification of communications from all the installed wireless and cellular modem cards
- Verification of communications between the MDC and the MCGR
- Verification of security features of MCGR

METHOD OF MEASUREMENT

This work shall be measured for payment by the number of units of Mobile Communications Gateway and Routers of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each Mobile Communications Gateway and Routers shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the CT***fastrak*** ITS and Communications Systems shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 564 – MOBILE DATA COMPUTER

DESCRIPTION

This item shall consist of furnishing, installing, and testing a Mobile Data Computer (MDC), all needed components and accessories required for a full and complete installation, including all associate equipment and cabling.

The MDC shall consist of the Mobile Data Terminal (MDT), the Vehicle Logic Unit (VLU) and an integrated GPS Receiver. The MDT will be the on-vehicle interface between the vehicle operator and the VLU. The VLU will serve as the controlling computing device for the overall MDC. The integrated GPS Receiver will interface with a GPS Antenna to provide location sensing capability.

References and Standards

Environmental and Enclosure

- SAE J1455 – Recommended Environmental Practices for Electronic Equipment Design in Heavy-Duty Vehicle Applications
- SAE J1113/13 – Electromagnetic Compatibility Measurement Procedure for Vehicle Components--Part 13: Immunity to Electrostatic Discharge
- MIL-STD-810 – Department of Defense Test Method Standard for Environmental Engineering Considerations and Laboratory Tests
- International Electrotechnical Commission (IEC) Standard 60529 – Degrees of Protection provided by Enclosures
- European Norm (EN) 50155: Railways Applications Electronic Equipment Used on Rolling Stock
- Federal Communications Commission (FCC) Code of Federal Regulations 47 Part 15 Class A

Communications

- SAE J1708 – Serial Data Communications between Microcomputer Systems in Heavy-Duty Vehicle Applications
- SAE J1939 – Recommended Practice for a Serial Control and Communications Vehicle Network
- IEEE 802.3 Ethernet Standards collection

Software Development Standards

- IEEE SA – 1455-1999 – IEEE Standard for Message Sets for Vehicle/Roadside Communications
- IEEE SA – 1488-2000 – IEEE Standard for Message Set Template for Intelligent Transportation Systems
- IEEE SA – 1489-1999 – IEEE Standard for Data Dictionaries for Intelligent Transportation Systems

Product Safety

- Underwriters Laboratory (UL) 60950: Information technology equipment – safety, International Electrotechnical Commission (IEC) 60950: Safety of information technology equipment, European Norm (EN) 60950: Safety of information technology equipment, Canadian Standards Association (CSA) 60950-95: Safety of Information Technology Equipment, or similar

MATERIALS

General

The contractor shall equip all transit vehicles with an MDC, consisting of a VLU, connected to or integrated with an MDT and a GPS Receiver, and including all required cabling between these components.

The MDC shall be connected using cabling and other communication hardware complying with SAE J-1708, SAE J-1939, or approved alternate, to the following on-board devices:

- Automatic Passenger Counter (APC) Controller (refer to Specification 560 – Automatic Passenger Counter (1-doorway), Specification 561 – Automatic Passenger Counter (2-doorway) and Specification 562 – Automatic Passenger Counter (3-doorway))
- AVA Controller (refer to Specification 567 – AVA Controller)
- Headsign
- Farebox
- P-25 Compatible Radio Subscriber Unit

The MDC shall be connected using cabling and other communication hardware complying with IEEE 802.3 Ethernet standards, or approved alternate, to the following on-board devices:

- Mobile Communications Gateway and Router (MCGR) (refer to Specification 563 – Mobile Communications Gateway and Router)
- Digital Video Recorder (DVR)

The MDC shall be connected using approved Radio Frequency (RF) cabling and other communication hardware to the following devices:

- Global Positioning System (GPS) Antenna (refer to Specification 565 – Multiband Antenna)

The devices to be connected and the connection details shall be discussed with and approved by the Department during Design Review.

The MDC shall be interfaced with the CAD/AVL Central Software via the MCGR using cellular data and WLAN services. (Refer to Specification 553 – CAD/AVL Central Software)

The MDC shall comply with the safety standards referenced in References and Standards.

The MDC and all associated equipment and cabling shall comply with the Materials requirements stated in Specification 100 – General Provisions. If conflicts exist, then this Item specification shall govern.

Manufacturer Requirements

The Manufacturer shall, in the past five (5) years, have provided similar VLU and MDT equipment for at least three (3) public transit agencies where the equipment is installed on a fleet of at least fifty (50) vehicles. If the VLU and MDT are from different manufacturers, then each manufacturer shall meet this requirement.

Physical Requirements

The MDC shall have an appropriate port (e.g. a USB or RS-232 console port) or use the operator terminal to allow local configuration, diagnosis and maintenance using a portable programming device. Utility software shall be provided for this purpose that can be installed on portable computers.

MDT

The MDT shall incorporate a touch screen with a color backlit display capable of displaying information to vehicle operators.

The MDT shall incorporate such measures as vehicle operator-controlled brightness control, anti-glare coating and adjustable orientation mounting.

The MDT display shall be designed to be readable by the vehicle operator from the seated position under the full range of ambient illumination conditions.

The MDT shall incorporate a speaker to provide audible feedback.

The MDT shall be a physically separate unit from the VLU.

The MDT shall be designed to be removable and replaceable as an entire component to minimize vehicle down times and simplify maintenance.

VLU

The VLU shall be a physically separate unit from the MDT.

The VLU shall be designed to be removable and replaceable as an entire component to minimize vehicle down times and simplify maintenance.

The VLU shall have an integrated GPS Receiver that supports the parallel tracking of at least twelve (12) channels.

The VLU shall have an internal battery back-up to power the equipment for up to five (5) minutes while the vehicle battery power is disconnected or not available.

The VLU shall have an internal battery back-up to maintain the time while bus battery power is disconnected.

The VLU shall include data storage capacity to store complete schedule information, headsign display messages, passenger counts, location information, schedule adherence information, route adherence information, predefined text messages, alarm messages, and event messages, at a minimum, along with any other data required to support contract requirements and a complete system. The Contractor shall coordinate with the Department during Design Review to finalize the data storage capacity.

On-board memory shall use non-volatile storage so that continuous power supply is not required to retain the stored data.

The VLU shall have provision for expanding data storage capacity in the future.

The VLU shall have a USB port to allow a user to manually access and download data stored on the VLU (as a redundant back-up option) using a laptop connected to a USB port. Files shall be in a text file format that can be uploaded and viewed using commercially available utility software.

Environmental Requirements

The MDC, and all associated equipment and cabling shall comply with the following environmental requirements:

Criteria	Minimum Conditions to be Met
Operating Temperatures	Between -13°F to 131°F (-25°C and 55°C)
Storage Temperatures	Between -40°F to 158°F (-40°C and 70°C)
Humidity	5-95% relative humidity, non-condensing
Operating Vibration	Compliant with SAE J1455-06 and MIL-STD-810F, or EN 50155
Mechanical Shock	Compliant with SAE J1455-06 and MIL-STD-810F, or EN 50155
Solid Object and Moisture Protection	IEC IP53

The MDC components—electrical, mechanical, and other connections— shall be designed to operate without degradation during and after exposure to vibration as encountered in normal service.

The MDC shall meet electromagnetic immunity standards of SAE J1113/13 and FCC Part 15 Class A, and protect against surge and reverse polarity.

Electrical Requirements

The MDC shall run on standard vehicle power and operate at a nominal +12VDC or +24VDC, and be fully functional within operating supply voltage ranges of + 9VDC to +30 VDC. Voltages shall be measured at the power connector to the device. The Contractor shall coordinate with the Department to verify the compatibility of the on-board equipment with the power supply units in each type of bus.

Functional Requirements

General

The MDC shall be capable of displaying information to vehicle operators, providing audible feedback, and accepting operator input.

MDCs shall turn on automatically when the vehicle power is turned on, and shall shut down at an agency configurable time after the vehicle power is turned off. MDCs shall be configured to allow for a managed and graceful shutdown, allowing all active sessions and connections to be closed under control of the firmware during the shutdown process.

The vehicle operator shall not be able to manually shut off or disconnect the MDC power or manually shut down the application software.

The MDC software shall be developed in accordance with recognized standards such as those mentioned under software development standards in References and Standards.

The MDC shall be able to implement firmware and configuration data updates for itself and connected devices, including:

- Headsign
- Automatic Passenger Counter
- Mobile Communications Gateway and Router
- AVA Controller

The MDC shall be able to be locally configured, diagnosed and maintained using a portable programming device (e.g., via a USB or RS-232 console port or the operator terminal).

The MDC shall allow a user to manually access and download stored data (as a redundant back-up option) using a laptop connected to a USB port.

The MDC shall be operated using touch screen programmable buttons on the MDT, with visual feedback via a change in the onscreen button indication and audible feedback via the speaker when a touch screen button is pressed.

The MDC shall allow the user to adjust the speaker volume at any time while the MDC is on.

The MDC time shall be synchronized with the CAD/AVL Central Software time at least once a day.

The MDC shall have the capability to all the dispatcher to route radio transmissions to either the onboard speakers or the handset without requiring the dispatcher to select a private call function.

<u>Schedule Data</u>

The MDC shall periodically download bulk data files containing run/block data from the CAD/AVL Central Software. Run/block data shall be stored on the MDC, with sufficient on-board memory capacity to allow for storage of at least three (3) full picks of run/block data schedule files.

The MDC shall provide a versioning mechanism for files to be immediately downloaded to the vehicle, but for the MDC to delay implementation of the file until some later date. Any stored version may be initiated and made current.

When an operator logs on with a run ID, the MDC shall be able to access, initiate and display the relevant schedule data file for that run ID on the MDT.

MDC Logon and Logoff:

The MDC shall allow the vehicle operator to logon by entering their operator ID and run ID on the MDT. The MDC shall interact with the CAD/AVL Central Software to confirm that the operator ID and run ID are valid and that another vehicle has not already logged on using either of these IDs.

Once the operator ID and run ID have been validated, the MDC shall complete the logon by selecting the trip/block schedule data stored in the MDC that corresponds with that run.

After logon, the MDC shall display the current block, run, route, trip, next timepoint, and operator ID.

Once the MDC logon has been completed, the MDC shall use the block data to:

- switch the voice radio to the busway talk group when vehicle begins a busway trip and switch the voice radio back to its regular non-busway talk group upon ending a busway trip;
- log onto the farebox (even if currently logged on to ensure consistency); and
- begin automatically sending display commands to the headsign based on vehicle location.

Upon successful logon, the MDC shall display an agency configurable pre-trip inspection screen that shall be filled in by the vehicle operator after conducting their pre-trip inspection of the vehicle.

The MDC shall allow the vehicle operator to logoff by selecting the logoff key. The MDC shall send a message to the dispatcher as a confirmation of the vehicle operator logoff. Before completing the logoff, the MDC shall display an agency configurable post-trip inspection screen which shall be filled in by the vehicle operator after conducting a post-trip inspection of the vehicle.

Both pre-trip and post-trip inspection reports shall be sent to the CAD/AVL Central Software and saved for use by dispatch and maintenance personnel.

The MDC shall periodically attempt to resend a logon or logoff message until it receives an acknowledgement message from the CAD/AVL Central Software. If no response is received from the CAD/AVL Central Software within an agency configurable time, then the MDC shall provide the operator with a message that no logon response or no logoff response has been received.

The MDC shall allow for remote logon from the CAD/AVL Central Software. This logon capability will only be available to agency staff logged on to the CAD/AVL Central Software with appropriate privileges.

GPS Receiver

The GPS Receiver shall include multi-path rejection capabilities to help eliminate spurious signals caused by reflections off buildings or other structures.

The GPS Receivers shall continuously report latitude, longitude, speed, time, direction of travel (heading) and whether the receiver has a GPS position lock.

The GPS Receivers shall be parallel tracking receivers, capable of simultaneously tracking at least four GPS satellites in the best available geometry, while also tracking at least the eight next best and/or upcoming (rising) satellites.

The GPS Receivers shall be Wide Area Augmentation System (WAAS)-capable.

The GPS Receivers shall report the loss of WAAS service to the MDC.

The GPS Receivers shall be capable of instantly reporting loss of GPS location to the MDC, where the information will be logged.

Location Reporting

The MDC shall store the most recent location received from the GPS Receiver.

The MDC shall send the most recent location report to the CAD/AVL Central Software once an agency configurable number of minutes have passed since the previous location report. All location reports shall include: date and time stamp, “GPS lock” status, GPS location latitude and longitude, heading, vehicle number, operator ID, run ID, trip ID, block ID, and schedule adherence.

All data transmissions from the MDC to the CAD/AVL Central Software shall include a location report.

Schedule Adherence

When a vehicle operator is logged in to a run, the MDC shall continuously calculate the current schedule adherence, defined as the difference between the estimated on-schedule time for the current location (not just the schedule adherence as of the previous timepoint) and the current time to the nearest second. The estimated on-schedule time between timepoints shall be based on the typical link operating speeds.

The MDC shall continuously display the current schedule adherence, updated every second on the MDT. The MDC shall send the most recent schedule adherence information as part of each location report.

Route Adherence

The MDC shall compute and determine whether the vehicle is running off-route based on agency configurable thresholds.

The MDC shall send a message to the CAD/AVL Central Software when a vehicle has been determined to have gone off-route or to have come back on-route.

The MDC shall periodically attempt to resend an off-route message until it receives an acknowledgement message from dispatch. The MDC shall display on the MDT whether the vehicle is on-route or off-route.

Text Messaging

The MDC shall allow the vehicle operator to send a text message to the CAD/AVL Central Software by selecting from a set of agency configurable predefined messages on the MDT. The MDC shall allow the vehicle operator to ask for an acknowledgement of receipt or Yes/No response to certain text messages.

All text messages to the CAD/AVL Central Software shall include a location report.

The MDC shall signal with a distinct audible alert tone when a text message is received from the CAD/AVL Central Software and available for viewing on the MDT.

The MDC shall store an agency configurable number of text messages received from the CAD/AVL Central Software, indicate to vehicle operators when there are unread text messages, allow stored text messages to be viewed, and allow read messages to be deleted.

The MDC shall allow the vehicle operator to view received text messages that are longer than that can fit on one line of the display.

The MDC shall also allow the vehicle operator to send an acknowledgement of receipt or Yes/No response to certain text messages received from the CAD/AVL Central Software. The MDC shall periodically attempt to resend a text message or response until it receives an acknowledgement message from the CAD/AVL Central Software.

Overt Alarm

A user shall be able to activate the overt alarm using a maximum of three (3) steps (touches on the screen) from any screen on the MDT.

When the overt alarm has been activated, the MDC shall send the overt alarm message to the CAD/AVL Central Software and place the MDC into the overt alarm mode.

When in overt alarm mode, the MDC shall send the most recent location report to the CAD/AVL Central Software automatically whenever an agency configurable number of minutes have passed since the previous location report.

The MDC shall terminate the overt alarm mode only when it receives a message from the CAD/AVL Central Software that the overt alarm has been cancelled.

Covert Alarm

When the MDC receives a notification from the P-25 Compatible Radio Subscriber Unit that the covert alarm has been activated, the MDC shall send the covert alarm message to the CAD/AVL Central Software and place the MDC into the covert alarm mode.

When in covert alarm mode, the MDC shall send the most recent location report to the CAD/AVL Central Software automatically whenever an agency configurable number of minutes have passed since the previous location report.

The MDC shall terminate the covert alarm mode only when it receives a message from the CAD/AVL Central Software that the covert alarm has been cancelled.

When in covert alarm mode, there shall be no indication on the MDT other than subtle symbols or icons approved by the agency, signifying that the covert alarm mode has been activated.

Mobile Communications Gateway and Router (MCGR) Integration

The MDC unit will receive a health status message from the MCGR when it is turned on. The MDC shall log the health status message along with a timestamp.

Any unsuccessful health status notification received from the MCGR shall be brought to the notice of the operator by the MDC through a visual and audible indication. The event and applicable error codes received from the MCGR shall be logged along with a timestamp.

The MDC shall exchange real-time information such as location reports, text messages, and operator login verification information with the CAD/AVL Central Software, via the MCGR using cellular data.

The MDC shall exchange bulk data such as schedule data with the CAD/AVL Central Software via the MCGR using WLAN when available, and via the MCGR using cellular data when WLAN is unavailable. It is anticipated that the WLAN network may not be available at the start of service, and for this period the MCGR shall be configured to use cellular data for bulk data exchange.

The MDC shall automatically initiate data transfer with the CAD/AVL Central Software via the MCGR when the vehicle is in range of a cellular network or WLAN, requiring no operator interaction.

The MDC shall be able to keep account of incomplete transfers of data files between the vehicle and the CAD/AVL Central Software and initiate a continuation or restart of the transfer via the MCGR whenever possible.

The MDC shall provide a versioning mechanism for files to be immediately downloaded to the vehicle, but for the MDC to delay implementation of the file until some later date.

Automatic Voice Announcement (AVA) Controller Integration

The MDC shall send location information and route to the AVA Controller to allow for location-based announcements and displays.

The MDC shall be capable of triggering voice announcements and/or text displays from the AVA Controller.

When a stop requested signal gets activated by a customer, the MDC shall send a signal to the AVA Controller.

P25-compatible Radio Subscriber Unit Integration

The MDC shall automatically switch the voice radio on the P25-compatible Radio Subscriber Unit to the 'Busway' talk group when vehicle operators begin a 'Busway' trip. The MDC shall accept a notification from the P25-compatible Radio Subscriber Unit when the covert alarm (on the subscriber radio unit) has been activated.

Headsign Integration

When the vehicle is logged into a run using the MDC and operating a trip of the run, the MDC shall automatically command the headsign to display an agency configurable message for that trip. This message could be the route number and/or route name.

When the vehicle is logged into a run using the MDC but operating on deadhead from the garage to the first trip of the run, the MDC shall automatically command the headsign to display an agency configurable message. This message could be "OUT OF SERVICE", "FROM GARAGE" or the message that will be displayed during the first trip.

When the vehicle is logged into a run using the MDC but operating on deadhead to the garage from the final trip of the run, the MDC shall automatically command the headsign to display an agency configurable message. This message could be "OUT OF SERVICE", "TO GARAGE" or the message that will be displayed during the final trip.

When the vehicle is logged into a run using the MDC but operating on deadhead for interlining between trips in the course of a run, the MDC shall automatically command the headsign to display an agency configurable message. This message could be "OUT OF SERVICE" or the message displayed during either the previous or upcoming trip.

When the vehicle is logged into a "special" run using the MDC, the MDC shall automatically command the headsign to display an agency configurable message for that run. This message could be "OUT OF SERVICE", or "IN TRAINING".

When the vehicle is logged into a run using the MDC, the operator shall be able to manually command the headsign to display from a set of agency configurable predefined messages. This message could be "OUT OF SERVICE", or "IN TRAINING".

The operator shall continue to be able to use all features of the existing headsign controller, regardless of whether or not the operator has logged into a run using the MDC or whether the MDC is operational.

Digital Video Recorder (DVR) for Security Camera Integration

The MDC shall be interfaced with the Digital Video Recorder (DVR) for Security Cameras. The Security Cameras and DVR will be provided as part of the vehicle procurement.

When the vehicle is logged into a run using the MDC, the MDC shall provide the run ID, operator ID, vehicle ID, route ID, trip ID and vehicle location to the DVR.

The MDC shall receive and log any diagnostic messages received from the DVR.

Automatic Passenger Counter (APC) System Integration

The MDC shall receive data records containing raw passenger counts from the APC controller when door closings are detected and immediately append location data, run/block/route/trip information, and nearest stop information (where available) to the data record.

The MDC shall associate each data record with the correct nearest stop and add its stop ID, based on an algorithm that uses the recorded GPS latitude and longitude, the route, and the stops assigned to preceding and following data records.

The MDC shall not add a stop ID to the data record if the GPS latitude and longitude recorded for the stop are not within an agency configurable distance from a stop on the current route/trip.

Each data record shall also include the current GPS location latitude and longitude, as well as the current date/time, vehicle number, vehicle operator ID number, block ID, run ID, route ID, and trip ID.

APC data records shall be stored in the MDC, with sufficient on-board memory capacity to allow for storage for a minimum of ten (10) days of APC data. The number of days that APC data will be stored shall be agency configurable.

The MDC shall be able to prepare an APC data package at the end of every trip to periodically send to the CAD/AVL Central Software via the MCGR. The MDC shall be able to request an acknowledgment receipt from the CAD/AVL Central Software when the APC data package is received. The MDC shall automatically allow the data package to be overwritten in its memory once acknowledgement has been received from the CAD/AVL Central Software.

Performance Specifications

The MDC response time to any touch screen button shall not exceed one second.

The MDC shall be reliable. MDC availability shall be 99.9% or better, computed as follows: availability shall be determined by comparing the total out-of-service time to the total operating time. Out-of-service time shall include reboots and system maintenance, excluding planned and approved preventive maintenance.

Integrated GPS Receiver

The GPS Receiver shall have a cold start solution time of sixty (60) seconds or less and a re-acquisition time (100% blockage of the satellite signals for duration of less than two minutes) of fifteen (15) seconds or less.

Velocity measurements provided by the GPS equipment shall be accurate to within 0.1 meters per second.

The GPS/vehicle location system shall provide vehicle position within +/- 15 meters 95% of the time, without WAAS signal availability, and +/- 3 meters 95% of the time, with WAAS signal availability.

Vehicle location information lag time shall not exceed one second in the vehicle (lag time is defined as the time it takes to compute position information, differentially corrected, if necessary, and format it for transmission).

Warranty Requirements

The MDC and all associated equipment and cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The MDC and all associated equipment and cabling shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

Spare Parts Requirements

The Contractor shall provide the following spare parts:

- MDTs and VLUS equivalent to 10% of the total number of installed MDCs, including all cabling required to connect to the power supply and to each other
- 10% of all mounting equipment required for the total number of installed MDTs and VLUs

All the spare parts shall be of the same make and model as the originals used to operate the MDC. Each spare shall be supplied as a packaged kit containing all ancillary components (e.g., fasteners) needed to enable the replacement of a failed installed unit with a spare.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting finished surfaces from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged hardware, as determined by the Engineer or a designated Department representative.

Installation

The Contractor shall be responsible for all installation and configuration of the MDC.

The location and mounting method for the VLUs and MDTs shall be determined in collaboration with the Engineer. The Contractor shall identify whether existing enclosure spaces are sufficient for the MDT and the VLU, and shall propose a solution in case additional enclosure space is required. The solution shall have to be accepted by the Department before the Contractor may proceed to installation. If deemed necessary by the Department, the Contractor shall rearrange the installed locations of other on-board equipment to achieve a suitable overall arrangement of equipment.

MDT

The MDT shall be securely mounted in the interior of the vehicle clearly visible to, and within comfortable reach from a seated position for the full range of operators and vehicle types, but at the same time not interfering with regular vehicle operations. Further, it will be mounted so as to avoid blocking driver sightlines to front and side windows.

The Contractor shall connect the MDT to the designated on-board power supply.

The Contractor shall connect the MDT to the VLU.

VLU

The VLU shall be mounted in a lockable enclosure existing in the buses, not accessible to the vehicle operator and secured from unauthorized tampering with the equipment.

The Contractor shall connect the VLU to the designated on-board power supply.

The Contractor shall connect the VLU to the following devices:

- APC Controller
- AVA Controller
- Headsign
- Farebox
- P-25 Compatible Radio Subscriber Unit
- MCGR
- DVR
- GPS Antenna

Security/Maintenance

All components of the MDC shall be removable and replaceable by a single technician with basic hand tools.

Documentation and Training

The MDC, and all associated equipment and cabling shall comply with the documentation and training requirements stated in Specification 100 – General Provisions and Specification 300 – Training.

The Contractor shall provide documentation and training on all the installation, configuration, management functions, operating features and maintenance procedures for the MDC.

Testing

The MDC, and all associated equipment and cabling shall comply with the testing requirements stated in the Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 203 – On-board Equipment Pilot Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The Contractor shall be responsible for all testing that may be required to establish approval and acceptance of the MDC.

The Contractor shall employ industry-standard methods and tools to measure and monitor MDC performance and compliance with availability requirements throughout the term of the Contract, including all ongoing technical support and maintenance periods.

METHOD OF MEASUREMENT

This work shall be measured for payment by the number of units of Mobile Data Computers of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each Mobile Data Computer shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the CT***fastrak*** ITS and Communications Systems shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 565 – MULTIBAND ANTENNA

DESCRIPTION

This item shall consist of furnishing, installing, and testing a GPS/3G/WLAN-capable Multiband Antenna, all needed accessories required for a full and complete installation, including all associate equipment and cabling, as described herein.

References and Standards

Environmental and Enclosure

- SAE J1455 – Recommended Environmental Practices for Electronic Equipment Design in Heavy-Duty Vehicle Applications
- SAE J1113/13 – Electromagnetic Compatibility Measurement Procedure for Vehicle Components--Part 13: Immunity to Electrostatic Discharge
- MIL-STD-810 – Department of Defense Test Method Standard for Environmental Engineering Considerations and Laboratory Tests
- International Electrotechnical Commission (IEC) Standard 60529 – Degrees of Protection provided by Enclosures
- European Norm (EN) 50155: Railways Applications Electronic Equipment Used on Rolling Stock
- Federal Communications Commission (FCC) Code of Federal Regulations 47 Part 15 Class A

Communications

- IEEE 802.11 Wireless Local Area Network Standards collection

Product Safety

- Underwriters Laboratory (UL) 60950: Information technology equipment – safety, International Electrotechnical Commission (IEC) 60950: Safety of information technology equipment, European Norm (EN) 60950: Safety of information technology equipment, Canadian Standards Association (CSA) 60950-95: Safety of Information Technology Equipment, or similar

MATERIALS

General

The contractor shall equip all revenue vehicles with a Multiband Antenna capable of supporting WLAN, 3G and GPS wireless technologies.

The Contractor may propose a different configuration, including multiple antennas satisfying all the wireless technology requirements, with justification.

The WLAN and 3G cellular data components of the Multiband Antenna shall be connected to the Mobile Communications Gateway and Router (MCGR) via appropriate RF cabling and connectors to facilitate transmission of data to and from the MCGR (refer to Specification 563 – Mobile Communications Gateway and Router).

The GPS component of the Multiband Antenna shall be connected to the Vehicle Logic Unit (VLU) of the Mobile Data Computer (MDC) via appropriate RF cabling and connectors to facilitate reception of GPS and WAAS satellite signals (refer to Specification 564 – Mobile Data Computer).

The Multiband Antenna shall comply with the safety standards referenced in References and Standards.

The Multiband Antenna, and all associated equipment and cabling shall comply with the Materials requirements stated in Specification 100 – General Provisions. If conflicts exist, this Item specification shall govern.

Manufacturer Requirements

The manufacturer of the Multiband Antennas shall be regularly engaged in the manufacture and production of vehicle communications antennas for use in public transportation systems.

Physical Requirements

The Multiband Antenna shall be designed to be securely mounted on a bus and not interfere with its normal functioning. They should be wash rack serviceable and of a low profile design.

The Multiband Antenna shall use a sealed and UV stable random enclosure to protect the antenna components from splash and spray and other weather conditions. The enclosure should not disrupt wireless communications.

Environmental Requirements

The Multiband Antenna, and all associated equipment and cabling shall comply with the following environmental requirements:

Criteria	Minimum Conditions to be Met
Operating Temperatures	Between -40°F to 158°F (-40°C and 70°C)
Storage Temperatures	Between -40°F to 158°F (-40°C and 70°C)
Humidity	5-95% relative humidity, non-condensing
Operating Vibration	Compliant with SAE J1455-06, MIL-STD-810F, or EN 50155
Mechanical Shock	Compliant with SAE J1455-06, MIL-STD-810F, or EN 50155
Solid Object and Moisture Protection	IEC IP67

The Multiband Antenna components—electrical, mechanical, and other connections— shall be designed to operate without degradation during and after exposure to vibration as encountered in normal service.

The Multiband Antenna shall meet electromagnetic immunity standards of SAE J1113/13 and FCC Part 15 Class A, and shall protect against surge and reverse polarity.

Electrical Requirements

The Multiband Antenna shall be powered through the RF cables.

Functional Requirements

Network Connectivity and Communications

The Multiband Antenna shall support the following wireless services for external data communications between the vehicle and the central system:

- Cellular data communications technologies including, but not limited to, “3G” technologies (such as CDMA2000, GSM EDGE, UMTS) supported by the major wireless carriers (such as AT&T, Verizon, Sprint).
- “WiFi” supporting IEEE 802.11 b, g, and n standards.
- GPS technology.

GPS

The Multiband Antenna shall support GPS technology with multi-path rejection capabilities to help eliminate spurious signals caused by reflections of buildings or other structures.

The Multiband Antenna shall be Wide Area Augmentation System (WAAS)-capable.

Performance Specifications

The Multiband Antenna must comply with all performance specifications of the integrated GPS receiver as detailed in Specification 564 – Mobile Data Computer.

Warranty Requirements

The Multiband Antenna and all associated equipment and cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The Multiband Antenna and all associated equipment and cabling shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

Spare Parts Requirements

The Contractor shall provide the following spare parts:

- Multiband Antennas equivalent to 10% of the total number of installed Multiband Antennas, including all cabling required to connect to the MDC and the MCGR

All the spare parts shall be of the same make and model as the originals used to operate the Multiband Antenna.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting finished surfaces from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged hardware, as determined by the Engineer or a designated Department representative.

Installation

The Contractor shall coordinate with the Department to identify locations for mounting the Multiband Antenna on each type of bus.

The Contractor shall install the Multiband Antenna in the identified locations for each type of bus.

The Multiband Antenna, mounting and sealants shall be impervious to splash and spray and other weather conditions, as well as to physical and chemical attack by automatic bus washing equipment.

The Contractor shall connect the Multiband Antenna to the MDC and the MCGR using RF connectors.

The antenna shall be supplied complete with cabling pigtails for all three components, to allow for the replacement of an antenna without need to remove all the cabling to the MCGR/VLU. This shall include the use of connectors between the pigtails and cabling that are accessible from the bus interior without need to remove the antenna in the event cabling ever needs to be replaced.

Security/Maintenance

All components of the Multiband Antenna shall be removable and replaceable by a single technician with basic hand tools.

Documentation and Training

The Multiband Antenna, and all associated equipment and cabling shall comply with the Documentation and Training requirements stated in Specification 100 – General Provisions and Specification 300 – Training.

The Contractor shall provide documentation and training on all the installation, configuration, management functions, operating features and maintenance procedures for the Multiband Antenna.

Testing

The Multiband Antenna, and all associated equipment and cabling shall comply with the testing requirements stated in the Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 203 – On-board Equipment Pilot Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The Contractor shall verify the Wifi and cell communication capabilities of the Multiband Antenna by running wireless data transfer speed tests and diagnostics through the MDC or the MCGR. The tests will be run for all installed wireless services at multiple different locations along the busway route, as specified by the Department.

The Contractor shall verify the GPS communications capabilities of the Multiband Antenna by running GPS diagnostics from the MDC, and verifying the accuracy of measurements with an independent high-accuracy GPS receiver. The tests will be run at multiple different locations along the busway route, as specified by the Department.

METHOD OF MEASUREMENT

This work shall be measured for payment by the number of units of Multiband Antennas of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each Multiband Antennas shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the CT***fastrak*** ITS and Communications Systems shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 566 – NON-REVENUE VEHICLE EQUIPMENT

DESCRIPTION

This item shall consist of furnishing, installing, and testing Non-Revenue Vehicle Equipment, including all needed components, accessories and cabling required for a full and complete installation, for non-revenue vehicles (including maintenance, supervisory, and administrative vehicles).

Non-revenue vehicles would include 15 existing supervisory vehicles (hybrid Ford Escapes or similar) and up to five (5) additional supervisory and administrative vehicles by the time the busway is implemented. It is estimated that another ten (10) maintenance vehicles, including snow plows of various types, will also be used to maintain the busway.

The Non-Revenue Vehicle Equipment shall consist of:

- An On-board Processing Device with an integrated GPS Receiver and a Cellular Data Modem Card; and
- A multimode external Antenna which supports GPS and cellular data frequencies.

The integrated GPS Receiver shall be connected to the Antenna to provide location determination capability, while the Cellular Data Modem Card shall be connected to the Antenna to provide cellular data connectivity. The On-board Processing Device shall be interfaced with the CAD/AVL Central Software (refer to Specification 553 – CAD/AVL Central Software) via the Cellular Data Modem to provide location updates for the non-revenue vehicle.

References and Standards

Environmental and Enclosure

- SAE J1455 – Recommended Environmental Practices for Electronic Equipment Design in Heavy-Duty Vehicle Applications
- SAE J1113/13 – Electromagnetic Compatibility Measurement Procedure for Vehicle Components--Part 13: Immunity to Electrostatic Discharge
- MIL-STD-810 – Department of Defense Test Method Standard for Environmental Engineering Considerations and Laboratory Tests
- International Electrotechnical Commission (IEC) Standard 60529 – Degrees of Protection provided by Enclosures
- European Norm (EN) 50155: Railways Applications Electronic Equipment Used on Rolling Stock

- Federal Communications Commission (FCC) Code of Federal Regulations 47 Part 15 Class A

Communications

- SAE J1708 – Serial Data Communications between Microcomputer Systems in Heavy-Duty Vehicle Applications
- SAE J1939 – Recommended Practice for a Serial Control and Communications Vehicle Network

Product Safety

- Underwriters Laboratory (UL) 60950: Information technology equipment – safety, International Electrotechnical Commission (IEC) 60950: Safety of information technology equipment, European Norm (EN) 60950: Safety of information technology equipment, Canadian Standards Association (CSA) 60950-95: Safety of Information Technology Equipment, or similar

MATERIALS

General

The contractor shall equip all supervisory and maintenance vehicles with Non-Revenue Vehicle Equipment, consisting of:

- An On-board Processing Device with an integrated GPS Receiver and a Cellular Data Modem Card;
- A multimode external Antenna that supports both Cellular 3G and GPS frequencies; and
- Including all required cabling between these components.

The Cellular Data Modem Card shall be connected to the Antenna via Radio Frequency (RF) cabling and connectors to facilitate transmission of data between the On-board Processing Device and the CAD/AVL Central Software.

The GPS Receiver shall be connected to the Antenna via RF cabling and connectors to facilitate reception of GPS and WAAS satellite signals.

The Non-Revenue Vehicle Equipment shall comply with the safety standards referenced in References and Standards.

The Non-Revenue Vehicle Equipment, and all associated equipment and cabling shall comply with the Materials requirements stated in Specification 100 General Provisions. If conflicts exist, this Item specification shall govern.

Manufacturer Requirements

The Non-Revenue Vehicle Equipment Manufacturer shall be regularly engaged in the manufacture of high quality vehicle tracking and fleet management equipment.

Physical Requirements

On-board Processing Device

The On-board Processing Device shall be designed to fit within an enclosure mounted in the interior of the vehicle. The Contractor shall coordinate with the Department to ascertain the feasible size and mounting location for the enclosure.

The On-board Processing Device shall include data storage capacity to store log files. On-board memory shall use non-volatile storage so that continuous power supply is not required to retain the stored data.

The On-board Processing Device shall have a USB port to allow a user to manually access and upload stored data files using a laptop connected to a USB port. Files shall be in a text file format that can be uploaded and viewed using commercially available utility software

The On-board Processing Device shall have a USB or RS-232 console port to allow its local configuration, diagnosis and maintenance using a portable computer. Utility software shall be provided for this purpose that can be installed on portable computers.

The On-board Processing Device shall have an internal battery back-up to power the equipment for up to five (5) minutes while the vehicle battery power is disconnected or not available.

The On-board Processing Device shall incorporate at least two (2) internal slots/interfaces where modem or other types of communications interface cards providing the required wireless capabilities may be installed. The Cellular Data Modem Card shall be installed in one of the card interfaces. These cards shall be easily replaceable by the Department in the future to accommodate changes in technology and wireless standards (such as use of 4G technologies). PCMCIA, PCI or other types of acceptable standard slot/interface devices may be used.

The GPS Receiver shall support the parallel tracking of at least sixteen (16) satellites.

Antenna

The Antenna shall be designed to be securely mounted on the roof of a vehicle without this interfering with its normal functioning. It should be wash rack serviceable and of a low profile design.

The Antenna shall use a sealed and UV stable radome enclosure to protect the antenna components from splash and spray and other weather conditions. The enclosure should not disrupt cellular communications.

Environmental Requirements

General

The Non-Revenue Vehicle Equipment components—electrical, mechanical, and other connections— shall be designed to operate without degradation during and after exposure to vibration as encountered in normal service.

The Non-Revenue Vehicle Equipment shall meet electromagnetic immunity standards of SAE J1113/13 and FCC Part 15 Class A, and protect against surges and reverse polarity.

On-board Processing Device

The On-board Processing Device, and all integrated components, associated equipment, and cabling shall comply with the following environmental requirements:

Criteria	**Minimum Conditions to be Met**
Operating Temperatures	Between -13°F to 131°F (-25°C and 55°C)
Storage Temperatures	Between -40°F to 158°F (-40°C and 70°C)
Humidity	5-95% relative humidity, non-condensing
Operating Vibration	Compliant with SAE J1455-06 and MIL-STD-810F, or EN 50155
Mechanical Shock	Compliant with SAE J1455-06 and MIL-STD-810F, or EN 50155
Solid Object and Moisture Protection	IEC IP53

Antenna

The Antenna, and all associated equipment and cabling shall comply with the following environmental requirements:

Criteria	**Minimum Conditions to be Met**
Operating Temperatures	Between -40°F to 158°F (-40°C and 70°C)
Storage Temperatures	Between -40°F to 158°F (-40°C and 70°C)
Humidity	5-95% relative humidity, non-condensing

Criteria	Minimum Conditions to be Met
Operating Vibration	Compliant with SAE J1455-06, MIL-STD-810F, or EN 50155
Mechanical Shock	Compliant with SAE J1455-06, MIL-STD-810F, or EN 50155
Solid Object and Moisture Protection	IEC IP67

Electrical Requirements

The Non-Revenue Vehicle Equipment shall run on standard vehicle power and operate at a nominal +12VDC or +24VDC, and be fully functional within operating supply voltage ranges of + 9VDC to +30 VDC. Voltages shall be measured at the power connector to the device. The Contractor shall coordinate with the Department to verify the compatibility of the on-board equipment with the power supply units in each type of vehicle.

The Antenna shall be powered through the RF cables.

Functional Requirements

General

The On-board Processing Device shall turn on automatically when the vehicle power is turned on, and shall shut down at an agency configurable time after the vehicle power is turned off. The On-board Processing Device shall be configured to allow for a managed and graceful shutdown, allowing all active sessions and connections to be closed under control of the firmware during the shutdown process.

The vehicle operator shall not be able to manually shut off or disconnect the On-board Processing Device power or manually shut down the device firmware.

The On-board Processing Device shall be able to implement firmware and configuration data updates for itself, the integrated GPS receiver, and the installed Cellular Data Modem Cards.

The On-board Processing Device shall be able to be locally configured, diagnosed and maintained using a portable programming device (e.g., via a USB or RS-232 console port or the operator terminal).

The On-board Processing Device shall allow a user to manually access and download stored data (as a redundant back-up option) using a laptop connected to a USB port.

The On-board Processing Device time shall be synchronized with the CAD/AVL Central Software time at least once a day.

Network Communications

The On-board Processing Device card slots/interfaces shall be designed to be able to support 3G cellular data cards, as well as expansion to cards using 4G communications technologies (such as LTE, HSPA, HSPA+).

The On-board Processing Device shall interface with the Cellular Data Communications Gateway in the BOC over a cellular network to enable exchange of data to and from the CAD/AVL Central Software.

Cellular Data Modem Card

The Contractor shall coordinate with the Department to identify the specific Cellular Data Modem Card to be provided, during the Design Review stage, based on the Department selection of the cell data service provider.

The Cellular Data Modem Card shall support cellular data communications technologies for data communications between the vehicle and the central system. These shall include, but not be limited to, 3G technologies (such as CDMA2000, GSM EDGE, UMTS) supported by the major wireless carriers (such as AT&T, Verizon, Sprint) using a compatible cellular data modem or card.

GPS Receiver

The GPS Receiver shall include multi-path rejection capabilities to help eliminate spurious signals caused by reflections off buildings or other structures.

The GPS Receiver shall continuously report latitude, longitude, speed, time, direction of travel (heading) and whether the receiver has a GPS position lock.

The GPS Receiver shall be a parallel tracking receiver, capable of simultaneously tracking at least the four GPS satellites in the best available geometry for location determination purposes, while also tracking at least the sixteen next best and/or upcoming (rising) satellites.

The GPS Receiver shall be Wide Area Augmentation System (WAAS)-capable.

The GPS Receiver shall report the loss of WAAS service to the MDC.

The GPS Receiver shall be capable of instantly reporting loss of GPS location determination lock to the MDC, where the information will be logged.

Antenna

The Antenna shall support cellular data communications technologies for external data communications between the vehicle and the central system. These shall include, but not be limited to, 3G technologies (such as CDMA2000, GSM EDGE, UMTS) supported by the major wireless carriers (such as AT&T, Verizon, Sprint).

The Antenna shall support GPS technology with multi-path rejection capabilities to help eliminate spurious signals caused by reflections off buildings or other structures.

The Antenna shall be Wide Area Augmentation System (WAAS)-capable.

On-board Processing Device Start-up Diagnostics

The On-board Processing Device shall perform a self-diagnostic test each time it is turned on. This test shall be automatic and shall include all wireless operating parameters.

At the conclusion of a successful test, the On-board Processing Device shall send a health status message and applicable error codes to the CAD/AVL Central Software for logging.

The On-board Processing Device unit shall receive a health status message from the GPS Receiver when it is turned on. The On-board Processing Device shall log the health status message with a timestamp.

Location Reporting

The On-board Processing Device shall store the most recent location received from the GPS Receiver.

The On-board Processing Device shall send the most recent location report to the CAD/AVL Central Software once an agency configurable number of seconds have passed since the previous location report. All location reports shall include: date and time stamp, “GPS lock” status, GPS location latitude and longitude, heading, and vehicle number.

The On-board Processing Device shall automatically initiate data transfer when the vehicle is in range of a cellular network, requiring no operator interaction.

All data transmissions from the On-board Processing Device to the CAD/AVL Central Software shall also include the current location report data.

Security

The On-board Processing Device shall provide stateful firewall services.

Performance Specifications

Integrated GPS Receiver

The GPS Receiver shall have a cold start solution time of sixty (60) seconds or less and a re-acquisition time (100% blockage of the satellite signals for duration of less than two minutes) of fifteen (15) seconds or less.

Velocity measurements provided by the GPS equipment shall be accurate to within 0.1 meters per second.

The GPS/vehicle location system shall provide vehicle position within +/- 15 meters 95% of the time, without WAAS signal availability, and +/- 3 meters 95% of the time, with WAAS signal availability.

Vehicle location information lag time shall not exceed one second in the vehicle (lag time is defined as the time it takes to compute position information, differentially corrected, if necessary, and format it for transmission)

Warranty Requirements

The On-board Processing Device, GPS Receiver, Antenna, and all associated equipment and cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The On-board Processing Device, GPS Receiver, Antenna, and all associated equipment and cabling shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

Spare Parts Requirements

The Contractor shall provide the following spare parts:

- On-board Processing Devices equivalent to 10% of the total number of installed On-board Processing Devices, including integrated GPS Receiver, Cellular Data Modem Cards and on-board power supply cabling
- Antennas equivalent to 10% of the total number of installed Antennas, including all cabling required to connect to the On-board Processing Device

All the spare parts shall be of the same make and model as the originals used to operate the Non-Revenue Vehicle Equipment. Each spare shall be supplied as a packaged kit containing all ancillary components (e.g., fasteners) needed to enable the replacement of a failed installed unit with a spare.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting finished surfaces from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged hardware, as determined by the Engineer or a designated Department representative.

Installation

General

The location and mounting method for the On-board Processing Device and Antenna shall be determined in collaboration with Department staff, for each type of non-revenue vehicle.

The Contractor shall be responsible for all configuration of the Non-Revenue Vehicle Equipment.

On-board Processing Device

The On-board Processing Device shall be securely mounted in an appropriate enclosure secured against driver access. The enclosure shall be designed to protect the On-board Processing Device from splash or spray.

The Contractor shall propose the enclosure installation space, which shall need to be accepted by the Department before the Contractor may proceed to installation. If deemed necessary by the Department, the Contractor shall rearrange the installed locations of other on-board equipment to achieve a suitable overall arrangement of equipment.

The Contractor shall install and configure the Cellular Data Modem Card, and any associated SIMs, in the On-board Processing Device.

The Contractor shall connect the On-board Processing Device to the on-board power supply and ignition sense tie-in points on each type of vehicle as designated by the Department.

Antenna

The Contractor shall coordinate with the Department to identify the location for mounting the Antenna on each type of non-revenue vehicle.

The Contractor shall install the Antenna in the identified locations for each type of non-revenue vehicle.

The Antenna, mounting and sealants shall be impervious to splash and spray and other weather conditions, as well as to physical and chemical attack by automatic bus washing equipment.

The Contractor shall connect the Antenna to the Cellular Data Modem Card and the GPS Receiver using RF cabling and connectors.

The Antenna shall be supplied complete with cabling pigtails for all components, to allow for the replacement of an antenna without need to remove all the cabling to the On-board Processing Device. This shall include the use of connectors between the pigtails and cabling that are accessible from the vehicle interior without need to remove the antenna in the event that cabling ever needs to be replaced.

Security/Maintenance

All installed components of the Non-Revenue Vehicle Equipment shall be replaceable by a single technician with basic hand tools.

Documentation and Training

The Non-Revenue Vehicle Equipment and cabling shall comply with the documentation and training requirements stated in Specification 100 – General Provisions and Specification 300 – Training.

The Contractor shall provide documentation and training on all the installation, configuration, management functions, operating features and maintenance procedures for the Non-Revenue Vehicle Equipment.

Testing

The Non-Revenue Vehicle Equipment, and all associated equipment and cabling shall comply with the testing requirements stated in the Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 203 – On-board Equipment Pilot Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The Contractor shall be responsible for all testing required to establish acceptance of the Non-Revenue Vehicle Equipment.

The Contractor shall verify the cellular data communication capabilities of the On-board Processing Device and Antenna by running wireless data transfer speed tests and diagnostics. The tests will be run at multiple different locations along the busway route, as specified by the Department. This testing will not necessarily be limited to the pilot testing, since one potential cause of problems could be antenna cabling issues specific to an individual installation.

METHOD OF MEASUREMENT

This work shall be measured for payment by the number of vehicles equipped with Non-Revenue Vehicle Equipment of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each set of equipped Non-Revenue Vehicle Equipment shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 General Provisions. The release of payment for all work associated with the implementation of the CT***fastrak*** ITS and Communications Systems shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 567 – AVA CONTROLLER

DESCRIPTION

This item shall consist of furnishing, installing, and testing an Automatic Vehicle Annunciation (AVA) Controller, all needed components and accessories required for a full and complete installation, including all associate equipment and cabling.

The AVA Controller shall provide voice announcements and text displays to passengers.

References and Standards

Environmental and Enclosure

- SAE J1455 – Recommended Environmental Practices for Electronic Equipment Design in Heavy-Duty Vehicle Applications
- SAE J1113/13 – Electromagnetic Compatibility Measurement Procedure for Vehicle Components--Part 13: Immunity to Electrostatic Discharge
- MIL-STD-810 – Department of Defense Test Method Standard for Environmental Engineering Considerations and Laboratory Tests
- International Electrotechnical Commission (IEC) Standard 60529 – Degrees of Protection provided by Enclosures
- European Norm (EN) 50155: Railways Applications Electronic Equipment Used on Rolling Stock
- Federal Communications Commission (FCC) Code of Federal Regulations 47 Part 15 Class A/B

Communications

- SAE J1708 – Serial Data Communications between Microcomputer Systems in Heavy-Duty Vehicle Applications
- SAE J1939 – Recommended Practice for a Serial Control and Communications Vehicle Network
- IEEE 802.3 Ethernet Standards collection

Software Development Standards

- IEEE SA – 1455-1999 – IEEE Standard for Message Sets for Vehicle/Roadside Communications
- IEEE SA – 1488-2000 – IEEE Standard for Message Set Template for Intelligent Transportation Systems
- IEEE SA – 1489-1999 – IEEE Standard for Data Dictionaries for Intelligent Transportation Systems

Product Safety

- Underwriters Laboratory (UL) 60950: Information technology equipment – safety, International Electrotechnical Commission (IEC) 60950: Safety of information technology equipment, European Norm (EN) 60950: Safety of information technology equipment, Canadian Standards Association (CSA) 60950-95: Safety of Information Technology Equipment, or similar

MATERIALS

General

The contractor shall equip all transit vehicles with an AVA Controller, including all required cabling. The AVA Controller may be an independent device or be represented by functionality incorporated into the Vehicle Logic Unit (VLU) of the Mobile Data Computer (MDC).

The AVA Controller shall be connected using cabling and other communication hardware complying with SAE J-1708, SAE J-1939, Ethernet, or approved alternate, to the following on-board devices:

- VLU of the MDC (refer to Specification 564 – Mobile Data Computer)
- On-Board Variable Message Signs (VMS) (refer to Specification 568 – On-Board VMS (Single VMS), and Specification 569 – On-Board VMS (Dual VMS))

The AVA Controller shall be connected using audio cabling, data cabling, or approved alternate, to the following existing on-board devices:

- Public Address (PA) System

The Contractor shall coordinate with the Department to coordinate and finalize the integration with the PA System.

The devices to be connected and the connection details shall be discussed with and approved by the Department during Design Review. The Contractor shall be responsible for ensuring that the AVA Controller is compatible with all connected devices.

The AVA Controller shall be interfaced with the AVA Software via the MDC or MCGR using cellular data and WLAN services. (Refer to Specification 570 – AVA and Trigger Location Management Software).

The AVA Controller shall comply with the safety standards referenced in References and Standards.

The AVA Controller and all associated equipment and cabling shall comply with the Materials requirements stated in Specification 100 – General Provisions. If conflicts exist, then this Item specification shall govern.

Manufacturer Requirements

The Manufacturer shall, in the past five (5) years, have provided similar AVA Controller equipment for at least three (3) public transit agencies where the equipment is installed on a fleet of at least fifty (50) vehicles.

Physical Requirements

The AVA Controller shall have an appropriate port (e.g. a USB or RS-232 console port) to allow local configuration, diagnosis and maintenance using a portable programming device. Utility software shall be provided for this purpose that can be installed on portable computers.

The AVA Controller shall include data storage capacity to store all AVA information including AVA software, headsign display messages, audio announcement messages, and trigger locations for all system-wide stops, emergency announcement messages, along with any other data required to support contract requirements and a complete system. The Contractor shall coordinate with the Department during Design Review to finalize the data storage capacity.

On-board memory shall use non-volatile storage so that continuous power supply is not required to retain the stored data.

The AVA Controller shall have a USB port to allow a user to manually access and download data to be stored (as an alternate download method) or to upload the stored data (as a redundant back-up option) using a laptop connected to the USB port.

The AVA Controller shall have sufficient number of ports to display messages on up to at least two (2) On-Board VMS(s).

Environmental Requirements

The AVA Controller, and all associated equipment and cabling shall comply with the following

environmental requirements:

Criteria	**Minimum Conditions to be Met**
Operating Temperatures	Between -13°F to 131°F (-25°C and 55°C)
Storage Temperatures	Between -40°F to 158°F (-40°C and 70°C)
Humidity	5-95% relative humidity, non-condensing
Operating Vibration	Compliant with SAE J1455-06 and MIL-STD-810F, or EN 50155
Mechanical Shock	Compliant with SAE J1455-06 and MIL-STD-810F, or EN 50155
Solid Object and Moisture Protection	IEC IP53

The AVA Controller components—electrical, mechanical, and other connections— shall be designed to operate without degradation during and after exposure to ongoing vibration as encountered in normal service.

The AVA Controller shall meet electromagnetic immunity standards of SAE J1113/13 and FCC Part 15 Class A/B, and protect against surge and reverse polarity.

Electrical Requirements

The AVA Controller shall run on standard vehicle power and operate at a nominal +12VDC or +24VDC, and be fully functional within operating supply voltage ranges of + 9VDC to +30 VDC. Voltages shall be measured at the power connector to the device. The Contractor shall coordinate with the Department to verify the compatibility of the on-board equipment with the power supply in each type of bus.

Functional Requirements

General

The AVA Controller shall provide audio and visual announcements to on-board riders and audio announcements those waiting to board. As each vehicle approaches a stop or other designated location, a digitally-recorded announcement shall be automatically made over the existing on-board public address (PA) system speakers and displayed on On-Board VMS inside the vehicle to inform passengers about upcoming stops, major intersections and landmarks.

The AVA Controller shall be capable of making time-based, location-based and vehicle operator-initiated announcements/displays.

Time-based announcements/displays shall be programmed to be made on-board the vehicle at specific times of the day or at a set frequency within specified time periods, on specific days of the week.

No vehicle operator interaction shall typically be required to operate the AVA Controller.

MDC Integration

Location-based announcements/displays shall be programmed to be made on-board the vehicle when that vehicle passes any location, designated in the downloaded data as a "trigger zone".

The AVA Controller shall use the vehicle location information from the MDC to trigger the appropriate announcements on-board the vehicle whenever the vehicle enters a "trigger zone." A trigger zone is a user-defined area that is located just prior to each stop location. For example, the trigger zone may begin 800 feet before a stop as well as at selected other announcement locations. Trigger zones will be pre-defined by the AVA software and downloaded to the AVA Controller. The location information announced/displayed shall provide the stop name and transfer opportunities.

The dispatcher shall be able to activate a stored announcement on demand through the central system AVA and Trigger Location Management Software. Dispatchers shall be able to activate an announcement simultaneously on a selected group of buses.

The AVA Controller shall be capable of making vehicle operator-initiated announcements/displays (e.g., safety-related announcements). These shall be made at vehicle operator discretion using the MDC.

Automated announcements shall continue to operate normally when the MDC is in covert alarm mode.

In the event that a vehicle is operating off-route, the automated announcements/displays shall not be made.

Once the route is reacquired, the system shall automatically determine and announce the next valid bus stop or other designated location. Off-route and on-route detection and recovery shall be automatic and not require vehicle operator intervention or action.

PA System Integration

The AVA controller shall make an exterior announcement of the current route number and destination when doors open at a stop.

The AVA Controller shall also make preset location-based interior announcements.

The vehicle operator shall have the ability to manually trigger activation of any pre-recorded announcement if needed.

The AVA Controller shall not interfere with any existing PA system capabilities.

Vehicle operators will be allowed to override AVA Controller announcements for manual PA announcements for configurable time durations. The AVA Controller shall revert to automated announcements after the time limit expires.

The AVA Controller shall provide a recorded voice announcement for the "stop requested" message, or alternative Department-approved voice announcement, when stop requested signal gets activated by a customer.

When the "stop requested" message is playing and a stop announcement is triggered, the "stop requested" message shall be interrupted. When a stop announcement is playing and the "stop requested" message is triggered, the "stop requested" message shall be queued and played immediately after completion of the stop announcement.

When a periodic time-based message is playing, it shall be interrupted by either the "stop requested" message or stop announcement.

<u>On-Board VMS Integration</u>

The AVA Controller shall be integrated with all interior On-Board VMS to provide stored text for display.

The AVA Controller shall provide each text announcement on all interior On-Board VMS in one of the following three (3) display modes: static messages, static messages displayed as a sequence of message "pages," and static messages displayed by scrolling a static message from right to left. The parameter for the duration to display a page, the blank interval between pages, and the scrolling speed shall be configurable by the Department.

As any transit vehicle approaches a stop or other designated location, the AVA system shall provide a stored text announcement. The announcement on the PA System and the On-Board VMS shall be synchronized.

The AVA Controller shall provide stored text for location triggered, periodic or operator-activated announcements.

The AVA Controller shall provide the current date/time for display when not displaying a triggered announcement.

The AVA Controller shall provide for display of the "stop requested" message when stop requested signal gets activated by a customer. This shall be activated through a signal sent by the MDC.

The On-Board VMS(s) on vehicles shall indicate the name of the next bus stop for a configurable duration, triggered by arriving at a stored location upstream of that stop. These messages shall be activated through an interface to the OBC and shall automatically change as required based on the vehicle location.

The On-Board VMS(s) shall not display any messages if the vehicle is off-route or out-of-service, apart from showing the date and time or any public safety message.

A "stop requested" display shall be replaced by a triggered stop announcement display. A triggered "stop requested" display shall be queued and displayed immediately after timed display duration of the stop announcement display.

A displayed periodic time-based message shall be interrupted by either the triggered "stop requested" or stop announcement display.

AVA Software Integration

The AVA Controller shall be interfaced with the AVA central software through the MDC or MCGR to receive software updates, voice messages, text displays, trigger locations and all other required information for operation.

The AVA Controller shall be check for updates from the AVA central software at a configurable time interval.

Diagnostics

The AVA Controller shall automatically run diagnostics software at startup. Any faults or failures shall be communicated to the central system AVA and Trigger Location Management Software via the MDC or MCGR.

Volume Level Control

The AVA Controller shall provide the capability to adjust the minimum and maximum volume levels separately for interior and exterior announcements.

The AVA Controller and PA volume level controls shall also allow the operator to separately adjust the volumes for the driver and handset speakers.

The AVA Controller shall be capable of automatically adjusting the volume of interior announcements according to the noise level on the vehicle at the time. This shall be achieved through a bus ambient noise sensor microphone installed within the bus.

The AVA Controller shall be capable of automatically adjusting the volume of exterior announcements according to the noise level outside the vehicle at the time. This shall be achieved through a bus ambient noise sensor microphone installed outside the bus.

Warranty Requirements

The AVA Controller and all associated equipment and cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The AVA Controller and all associated equipment and cabling shall have a manufacturer-provided equipment warranty for a period of at least two (2) years.

Spare Parts Requirements

The Contractor shall provide the following spare parts, when the AVA Controller is not represented by functionality incorporated into the VLU of the MDC:

- AVA Controllers equivalent to 10% of the total number of installed AVA Controllers, including all cabling required to connect to the power supply, MDC, and PA System.
- One replacement cable harness of the required length to connect from the AVA controller to the power supply, MDC, and PA System.

All spare parts shall be of the same make and model as the originals installed. Each spare shall be supplied as a packaged kit containing all ancillary components (e.g., fasteners) needed to enable the replacement of a failed installed unit with a spare.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting finished surfaces from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged hardware, as determined by the Engineer or a designated Department representative.

Installation

The Contractor shall be responsible for all installation and configuration of the AVA Controller.

The location and mounting method for the AVA Controllers shall be determined in collaboration with the Engineer. The Contractor shall identify whether existing enclosure spaces are sufficient for the AVA Controller, and shall propose a solution in case additional enclosure space is required. The solution shall have to be accepted by the Department before the Contractor may proceed to installation. If deemed necessary by the Department, the Contractor shall rearrange the installed locations of other on-board equipment to achieve a suitable overall arrangement of equipment.

The AVA Controller shall be mounted in a lockable enclosure existing in the buses, not accessible to the vehicle operator and secured from unauthorized tampering with the equipment.

The AVA Controller shall be connected to the designated on-board power supply.

The AVA Controller shall be connected to the MDC, PA System, and On-Board VMS.

If ambient noise sensors need to be installed to enable automatic volume adjustment, the Contractor shall coordinate with the Department to finalize their location and installation details.

Security/Maintenance

All components of the AVA Controller shall be removable and replaceable by a single technician with basic hand tools.

Documentation and Training

The AVA Controller, and all associated equipment and cabling shall comply with the documentation and training requirements stated in Specification 100 – General Provisions and Specification 300 – Training.

The Contractor shall provide documentation and training on all the installation, configuration, management functions, operating features and maintenance procedures for the AVA Controller.

Testing

The AVA Controller, and all associated equipment and cabling shall comply with the testing requirements stated in the Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 203 – On-board Equipment Pilot Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The Contractor shall be responsible for all testing that may be required to establish approval and acceptance of the AVA Controller.

The AVA Controller shall be tested for, as a minimum, the following:

- Verification of the correct output of voice announcements
- Verification of the voice level range and adjustment capabilities
- Verification of the correct output of text to the On-Board VMS
- Verification of the proper functioning of the bus internal and external ambient noise sensor microphone and the automatic volume adjustment capabilities.
- Verification of message/voice prioritization capabilities
- Verification of all location-based message/voice trigger capabilities

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METHOD OF MEASUREMENT

This work shall be measured for payment by the number of units of AVA Controllers of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each AVA Controller shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the CT***fastrak*** ITS and Communications Systems shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 568 – ON-BOARD VMS (SINGLE VMS)

SPECIFICATION 569 – ON-BOARD VMS (DUAL VMS)

DESCRIPTION

Specification 568 – On-Board VMS (Single VMS)

This item shall consist of furnishing, installing, and testing an On-Board Variable Message Sign (VMS) on each single unit bus, all needed components and accessories required for a full and complete installation, including all associated equipment, cabling, and integration with the AVA Controller.

Specification 569 – On-Board VMS (Dual VMS)

This item shall consist of furnishing, installing, and testing two (2) On-Board Variable Message Signs (VMS), all needed components and accessories required for a full and complete installation, including all associate equipment, cabling, and integration with the AVA Controller.

References and Standards

Technical Standards

- National Transportation Communications for ITS Protocol (NTCIP) Standard 1203 version 03: Object Definitions for Dynamic Message Signs
- NTCIP Standard 9012: Testing Guide for User
- National Electrical Manufacturers Association (NEMA) Standard TS-4: Hardware Standards for Dynamic Message Signs (DMS) with NTCIP Requirements

Environmental and Enclosure

- SAE J1455 – Recommended Environmental Practices for Electronic Equipment Design in Heavy-Duty Vehicle Applications
- SAE J1113/13 – Electromagnetic Compatibility Measurement Procedure for Vehicle Components--Part 13: Immunity to Electrostatic Discharge
- MIL-STD-810 – Department of Defense Test Method Standard for Environmental Engineering Considerations and Laboratory Tests
- International Electrotechnical Commission (IEC) Standard 60529 – Degrees of Protection provided by Enclosures

- European Norm (EN) 50155: Railways Applications Electronic Equipment Used on Rolling Stock
- Federal Communications Commission (FCC) Code of Federal Regulations 47 Part 15 Class A/B

Communications

- SAE J1708 – Serial Data Communications between Microcomputer Systems in Heavy-Duty Vehicle Applications
- SAE J1939 – Recommended Practice for a Serial Control and Communications Vehicle Network
- IEEE 802.3 Ethernet Standards collection

Software Development Standards

- IEEE SA – 1455-1999 – IEEE Standard for Message Sets for Vehicle/Roadside Communications
- IEEE SA – 1488-2000 – IEEE Standard for Message Set Template for Intelligent Transportation Systems
- IEEE SA – 1489-1999 – IEEE Standard for Data Dictionaries for Intelligent Transportation Systems

Product Safety

- Underwriters Laboratory (UL) 60950: Information technology equipment – safety, International Electrotechnical Commission (IEC) 60950: Safety of information technology equipment, European Norm (EN) 60950: Safety of information technology equipment, Canadian Standards Association (CSA) 60950-95: Safety of Information Technology Equipment, or similar

MATERIALS

General

Specification 568 – On-Board VMS (Single VMS)

The contractor shall equip all single unit transit vehicles with one (1) On-Board VMS, and including all required cabling.

The On-Board VMS shall be connected to the AVA Controller using cabling and other communication hardware complying with SAE J-1708, SAE J-1939, or approved alternate.

Specification 569 – On-Board VMS (Dual VMS)

The contractor shall equip all articulated transit vehicles with two (2) On-Board VMS, and including all required cabling.

The two (2) On-Board VMS shall each be connected to the AVA Controller using cabling and other communication hardware complying with SAE J-1708, SAE J-1939, or approved alternate.

General

The location of the On-Board VMS and the wiring details shall be discussed with and approved by the Department during Design Review.

The On-Board VMS shall comply with the safety standards referenced in References and Standards.

The On-Board VMS and all associated equipment and cabling shall comply with the Materials requirements stated in Specification 100 – General Provisions. If conflicts exist, then this Item specification shall govern.

Manufacturer Requirements

The Manufacturer shall, in the past five (5) years, have provided similar On-Board VMS equipment for at least three (3) public transit agencies where the equipment is installed on a fleet of at least fifty (50) vehicles.

Physical Requirements

Each On-Board VMS shall consist of a 1-line Amber Light Emitting Diode (LED) matrix with a minimum of twenty (20) variable characters per line using the fixed width font. Characters should be at least 2 inches high to allow a legibility distance of least 75 feet for any passenger with 20/20 vision.

Environmental Requirements

The On-Board VMS, and all associated equipment and cabling shall comply with the following environmental requirements:

Criteria	**Minimum Conditions to be Met**
Operating Temperatures	Between -13°F to 131°F (-25°C and 55°C)
Storage Temperatures	Between -40°F to 158°F (-40°C and 70°C)

Criteria	Minimum Conditions to be Met
Humidity	5-95% relative humidity, non-condensing
Operating Vibration	Compliant with SAE J1455-06 and MIL-STD-810F, or EN 50155
Mechanical Shock	Compliant with SAE J1455-06 and MIL-STD-810F, or EN 50155
Solid Object and Moisture Protection	IEC IP53

The On-Board VMS components—electrical, mechanical, and other connections— shall be designed to operate without degradation during and after exposure to vibration as encountered in normal service.

The On-Board VMS shall meet electromagnetic immunity standards of SAE J1113/13 and FCC Part 15 Class A/B, and protect against surge and reverse polarity.

Electrical Requirements

The On-Board VMS shall operate on standard vehicle power at a nominal +12VDC or +24VDC, and be fully functional within operating supply voltage ranges of + 9VDC to +30 VDC. Voltages shall be measured at the power connector to the device. The Contractor shall coordinate with the Department to verify the compatibility of the on-board equipment with the power supply in each type of bus.

Functional Requirements

General

The On-Board VMS shall provide visual announcements to on-board riders.

No vehicle operator interaction shall typically be required to operate the On-Board VMS.

The On-Board VMS shall be clearly visible under varying ambient illumination conditions.

The On-Board VMS shall be able to display a message composed of any combination of alphanumeric character fonts and punctuation symbols. The font for the On-Board VMS shall be subject to Department approval.

Display characteristics shall include fully configurable proportional and fixed width fonts.

The On-Board VMS shall be able to display in at least the following three (3) display modes: static messages, static messages displayed as a sequence of message “pages,” and static messages displayed by scrolling a static message from right to left.

AVA Controller Integration

Each On-Board VMS shall be integrated with the AVA Controller on the bus.

The On-Board VMS shall display all text announcements as provided by the AVA Controller, which will indicate both the text and the display mode.

The AVA Controller shall implement all firmware changes for the On-Board VMS.

Performance Specifications

When operating at full intensity, the sign display shall be clearly legible under the full range of ambient illumination conditions from any position seated or standing within the vehicle from which that VMS can be viewed.

Failure of a pixel or module shall not cause failure of any other pixel.

Warranty Requirements

The On-Board VMS and all associated equipment and cabling shall comply with the warranty requirements stated in Specification 400 – Technical Support and Warranty Services. The On-Board VMS shall have a manufacturer-provided warranty for a period of at least two (2) years.

Spare Parts Requirements

Specification 568 – On-Board VMS (Single VMS)

The Contractor shall provide the following spare parts:

- On-Board VMS (Single VMS) equivalent to 10% of the total number of On-Board VMS (Single VMS) installed, capable of being replaced without need to replace the cabling from the VMS to the power supply and the AVA Controller.
- On-Board VMS replaceable components (e.g., LED modules, module controller boards) equivalent to 10% of the total number of each such components in the On-Board VMS (Single VMS) installed.
- One replacement cable harness of the required length to connect from the VMS location to the power supply and the AVA Controller.

All the spare parts shall be of the same make and model as the originals used to operate the On-Board VMS. Each spare shall be supplied as a packaged kit containing all ancillary components (e.g., fasteners) needed to enable the replacement of a failed installed unit with a spare.

Specification 569 – On-Board VMS (Dual VMS)

The Contractor shall provide the following spare parts:

- On-Board VMS (Dual VMS) equivalent to 10% of the total number of On-Board VMS (Dual VMS) installed, capable of being replaced without need to replace the cabling from the VMS to the power supply and the AVA Controller.
- On-Board VMS replaceable components (e.g., LED modules, module controller boards) equivalent to 10% of the total number of each such components in the On-Board VMS (Dual VMS) installed.
- One replacement cable harness of the required length to connect from the forward mounted VMS location to the power supply and the AVA Controller.
- One replacement cable harness of the required length to connect from the rearward mounted VMS location to the power supply and the AVA Controller.

All the spare parts shall be of the same make and model as the originals used to operate the On-Board VMS. Each spare shall be supplied as a packaged kit containing all ancillary components (e.g., fasteners) needed to enable the replacement of a failed installed unit with a spare.

CONSTRUCTION METHODS

Delivery, Storage, and Handling

The Contractor shall be responsible for protecting finished surfaces from damage during fabrication, shipping, storage, installation, testing and acceptance. The Contractor shall be responsible for replacing any damaged hardware, as determined by the Engineer or a designated Department representative.

Installation

The Contractor shall be responsible for all installation and configuration of the On-Board VMS.

Each On-Board VMS shall be connected to the designated on-board power supply.

Each On-Board VMS shall be connected to the AVA Controller.

Specification 568 – On-Board VMS (Single VMS)

The On-Board VMS (Single VMS) shall be installed towards the front of the single unit buses, mounted from the ceiling, likely in-line with the centre-line of the bus, where it can be viewed from everywhere in the bus. The locations and the mounting methods shall be selected in coordination with the Department. The solution shall have to be accepted by the Department before the Contractor may proceed to installation.

Specification 569 – On-Board VMS (Dual VMS)

The On-Board VMS (Dual VMS) shall include the installation of two On-Board VMS. The first On-Board VMS shall be installed towards the front of the articulated buses, mounted from the

ceiling, likely in-line with the centre-line of the bus, where it can be viewed from everywhere in the forward portion of the bus ahead of the articulated component of the articulated buses. The second On-Board VMS shall be installed behind the articulated component, mounted from the ceiling, likely in-line with the centre-line of the bus, where it can be viewed from everywhere in the rearward portion of the bus behind the articulated component.

The locations and the mounting methods shall be selected in coordination with the Department. The solution shall have to be accepted by the Department before the Contractor may proceed to installation.

Security/Maintenance

All components of the On-Board VMS, including both the entire installed unit and the interior replaceable modules supplied as spares, shall be removable and replaceable by a single technician with basic hand tools.

Documentation and Training

The On-Board VMS, and all associated equipment and cabling shall comply with the documentation and training requirements stated in Specification 100 – General Provisions and Specification 300 – Training.

The Contractor shall provide documentation and training on all the installation, configuration, management functions, operating features and maintenance procedures for the On-Board VMS.

The Contractor shall provide wire routing diagrams showing the power and communication cabling routing to each On-Board VMS for each type of bus.

Testing

The On-Board VMS, and all associated equipment and cabling shall comply with the testing requirements stated in the Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 203 – On-Board Equipment Pilot Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

The Contractor shall be responsible for all testing that may be required to establish approval and acceptance of the On-Board VMS.

The On-Board VMS shall be tested for, as a minimum, the following:

- Verification of the correct output of text to the On-Board VMS
- Verification of the legibility of at least one On-Board VMS from multiple locations within the buses. The locations shall be decided by the Department.

METHOD OF MEASUREMENT

Specification 568 – On-Board VMS (Single VMS)

This work shall be measured for payment by the number of single unit buses installed with On-Board VMS (Single VMS) of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each bus installed with On-Board VMS (Single VMS) shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, spare components, and other incidentals necessary to complete the work.

Specification 569 – On-Board VMS (Dual VMS)

This work shall be measured for payment by the number of articulated buses installed with both On-Board VMS (Dual VMS) of the type specified, installed, integrated, completed, tested and accepted in-place. The unit price for each bus installed with On-Board VMS (Dual VMS) shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include all materials, equipment, tools, labor, testing, documentation, spare components, and other incidentals necessary to complete the work.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the CT***fastrak*** ITS and Communications Systems shall be based on this negotiated total system implementation cost and the milestone completion schedule.

SPECIFICATION 570 – AUTOMATIC VOICE ANNUNCIATION AND TRIGGER LOCATION MANAGEMENT SOFTWARE

DESCRIPTION

This item shall consist of furnishing, installing, and testing the central system Automatic Voice Annunciation (AVA) and Trigger Location Management Software, including all licenses, for use by authorized users at the Busway Operations Center (BOC).

The AVA and Trigger Location Management Software shall be used for preparing all voice announcements and text display information to be downloaded to the bus fleet, including the interior/exterior announcements, On-Board Variable Message Sign (VMS) text messages, and announcement/display trigger locations. This function shall support next stop on-board announcements, stop requested announcements, major intersection announcements, key transfer point announcements, public service information, vehicle-operator initiated messages, and promotional information.

References

The AVA and Trigger Location Management Software shall comply with all NTCIP specifications, including, but not limited to:

- NTCIP 1403 – Transit Communications Interface Profiles – Standard on Passenger Information (PI) Objects
- NTCIP 1407 – Transit Communications Interface Profiles – Standard on Control Center (CC) Objects

The software shall be developed in accordance with recognized standards such as IEEE Software Engineering Standards.

MATERIALS

General

The AVA and Trigger Location Management Software shall be a module of the CAD/AVL Central Software or a separate stand-alone software package that interfaces with the CAD/AVL Central Software. It shall be made available to users in the BOC via a “desktop client” installed on BOC workstations.

The AVA and Trigger Location Management Software shall be interfaced with the CAD/AVL Central Software and the AVA Controllers onboard the bus fleet (refer to specifications: Specification 553 – CAD/AVL Central Software, Specification 567 – AVA Controller). The work to establish the integration of software shall be accomplished as part of the Software Integration work (refer to Specification 206 – Software Integration).

Manufacturer Requirements

The Manufacturer shall, in the past 5 years, have successfully provided similar software for at least three (3) public transit agencies where the software provides AVA information and trigger locations for download on a fleet of at least 50 vehicles in maximum service.

Functional Requirements

General

The AVA and Trigger Location Management Software shall utilize route and bus stop information to provide next stop on-board announcement messages as well as support the annunciation of stop requested, major intersections, key transfer points, promotional information, public service information, vehicle operator initiated messages and advertising. The AVA and Trigger Location Management Software shall generate announcement and sign message content data for transmission to AVA Controllers on-board buses for voice announcement on the bus PA system, and display on On-Board VMS.

The AVA and Trigger Location Management Software shall comply with the general software requirements in Specification 100 – General Provisions.

The hardware required to support the AVA and Trigger Location Management Software is specified in the following specifications: Specification 535 – Servers, Specification 540 – Workstations. The AVA and Trigger Location Management Software shall be a module of the CAD/AVL Central Software or a separate stand-alone software package.

Logon and Logoff Requirements

The AVA and Trigger Location Management Software shall support a logon/logoff feature that is password protected and shall allow a user to logon to a specific user access level. Users shall logon to the AVA and Trigger Location Management Software using the same logon credentials as entered for the CAD/AVL Central Software. Users already logged on to the CAD/AVL Central Software shall be able to logon to the AVA and Trigger Location Management Software without re-entering logon credentials. Users logged off from the CAD/AVL Central Software shall be automatically logged off from the AVA and Trigger Location Management Software.

The AVA and Trigger Location Management Software shall allow users to logon to the system with varying privileges depending on their access level. Access levels may include, but are not limited to:

- BOC System Administrator

- BOC Dispatcher
- BOC Read-only dispatcher
- Busway Supervisor
- 'Home' Operating Company Dispatchers

The AVA and Trigger Location Management Software shall allow users logged in as system administrators to assign specific privileges for users logging in to each access level for the AVA and Trigger Location Management Software or bus AVA Controller machines; add, remove, or change access levels; assign access levels to each user; and add/remove users.

The AVA and Trigger Location Management Software shall support at least ten (10) concurrent users.

Graphical User Interface (GUI) Requirements

The AVA and Trigger Location Management Software shall incorporate a Graphical User Interface (GUI), to display information to users and accept user input in a clear, logical manner.

The GUI shall display in a tabular format the information being sent to bus AVA Controllers for onboard announcements, and display on the On-Board VMS.

The GUI shall also provide interactive user interfaces to enable authorized users to generate audio and text announcement messages to be downloaded on the bus fleet.

The GUI shall display in a tabular format alerts received from the field, either due to AVA Controller faults/failures or loss of communication to AVA Controllers.

The GUI shall support the concurrent display of multiple windows. The GUI shall allow the user to filter the information for display by route, and direction. At a minimum, the GUI shall support function key assignments, paging, scrolling, and shortcuts. The GUI shall support repositioning and resizing each window as desired to present the maximum amount of useable information.

CAD/AVL Central Software Integration

The AVA and Trigger Location Management Software shall have access to the same route and stop schedule data as is used by the CAD/AVL Central Software.

Cellular Data Gateway Support Software Integration

The AVA and Trigger Location Management Software shall be interfaced with the cellular data gateway software, to provide a mechanism to download AVA and trigger locations updates to vehicles connected to cellular communications.

Bulk Data Gateway Support Software Integration

The AVA and Trigger Location Management Software shall be interfaced with the bulk data gateway software, to provide a mechanism to download AVA and trigger locations updates to vehicles connected to WLAN.

Automatic Voice Annunciation (AVA) Controller Integration

The AVA and Trigger Location Management Software shall send trigger locations and announcement message files to all AVA Controllers.

The AVA and Trigger Location Management Software shall receive fault/failure alerts sent from the AVA Controllers. Loss of communication with the AVA Controllers shall also trigger an alert in the AVA and Trigger Location Management Software.

The AVA and Trigger Location Management Software shall be capable of activating a stored announcement on demand through the AVA Controllers. Dispatchers shall be able to activate the announcements simultaneously on a selected group of buses.

Announcement Preparation

The AVA and Trigger Location Management Software shall provide a text-to-speech generator for English and Spanish.

The AVA and Trigger Location Management Software shall provide the ability to create recorded message files in-house.

The AVA and Trigger Location Management Software shall be able to use professionally recorded messages that use a designated file format.

The AVA and Trigger Location Management Software shall provide the ability to create announcement messages that concatenate selected portions of recorded message files with timed pauses and text-to-speech segments.

The AVA and Trigger Location Management Software shall provide the ability to create the VMS text associated with each announcement message.

Trigger Locations Configuration

The AVA and Trigger Location Management Software shall allow the announcement message files and associated VMS text files to be linked with individual announcement trigger locations.

An announcement trigger location is a user-defined area located just prior to a stop location. The AVA and Trigger Location Management Software shall provide a utility that allows the user to configure announcement trigger locations on a global basis (e.g., 800 feet before) and to set or adjust announcement trigger locations individually.

A headsign trigger location is a user-defined area located approaching the start of a trip or deadhead segment, used by the VLU of the MDC to automatically change the headsign display. The AVA and Trigger Location Management Software shall provide a utility that allows the user to configure headsign trigger locations on a global basis (e.g., 800 feet before) and to set or adjust headsign trigger locations individually.

Performance Requirements

The AVA and Trigger Location Management Software shall adhere to the performance requirements listed in Specification 100 – General Provisions.

In addition, the AVA and Trigger Location Management Software desktop client shall meet the following performance criteria under full system loading:

- All windows with non-paging data shall open and populate with data within three (3) seconds;
- All window with paging data shall open and populate with the initial data within three (3) seconds and thereafter page updates shall be retrieved within one (1) second;
- Database searches for a single record shall be completed within five (5) seconds;
- Mouse cursor movements shall be smooth;
- Dragging of the cursor bar for a scrollable list shall cause instantaneous redisplay of the list in time with the movement of the cursor bar.

Warranty Requirements

The Contractor shall develop, test, provide and install all applicable software “patches” or upgrades that become necessary to remedy system software faults or “bugs” identified during the warranty period.

The Contractor shall provide at no additional cost, all version updates, software patches and error corrections available for the system software provided.

The software manufacturer shall commit to continue to offer a maintenance/service agreement for the software for a minimum ten (10) year period. The maintenance/service agreement shall include providing patches, bus fixes, security upgrades, and ongoing technical support.

In addition, the Contractor shall satisfy all Warranty requirements listed in Specification 400 – Technical Support and Warranty Services.

CONSTRUCTION METHODS

Installation

The Contractor shall install the AVA and Trigger Location Management Software on the BOC Servers (specified in Specification 535 – Server).

The Contractor shall install the AVA and Trigger Location Management Software desktop client on three (3) workstations at the BOC. The Contractor shall acquire all needed permits and licenses before software installation.

To the greatest extent possible, industry proven software packages shall be utilized to provide the functionalities specified in this document. Each such software package shall be identified in the proposal. The proposal shall state the purpose of the software package, where it will be used, and how it will be used. If one software package is required to interface with another software package, the interface shall be documented and supported by flowcharts or block diagrams as appropriate.

The AVA and Trigger Location Management Software shall be delivered in a ready-to-run form, including all necessary utility programs and documentation. Utilities for data storage allowing direct access, data archival and restore functions for older data shall be provided.

For software licensing, a minimum of ten (10) concurrent seat licenses or an enterprise site licensing solution shall be provided. The Contractor shall identify all necessary third-party software and associated licenses as part of their proposal.

The AVA and Trigger Location Management Software shall be capable of running in an active directory environment. System applications shall be capable of running concurrently with other Windows programs.

The Contractor shall be responsible for resolving any compatibility issues between software and any other existing Department software or systems. The Contractor shall confirm that software installation, including all third-party applications, will not negatively impact the operations of existing Department software applications available over the internal network.

Security/Maintenance

Security and Maintenance utilities shall be implemented to comply with the General Security and Maintenance Requirements stated in the Specification 100 – General Provisions. Such utilities shall be capable of monitoring the AVA and Trigger Location Management Software to identify security or maintenance issues (e.g., unauthorized security breaches, software component failures).

Documentation and Training

The Contractor shall provide all necessary and appropriate technical and user documentation for the AVA and Trigger Location Management Software, which shall cover the functional features, technical information, training, help, and maintenance information, in compliance with the Software Documentation requirements in the Specification 100 – General Provisions.

The Contractor shall provide all necessary and appropriate operational and maintenance training for the AVA and Trigger Location Management Software. The Contractor shall develop and submit a Training Plan, which shall cover the training for use and maintenance of the AVA and Trigger Location Management Software, in compliance with the Training requirements in Specification 300 – Training.

Testing Requirements

The AVA and Trigger Location Management Software shall comply with the testing requirements stated in Specification 201 – Factory Acceptance Tests, Specification 202 – Prototype Demonstration Test, Specification 204 – System Demonstration Test, Specification 205 – Installation Tests, Specification 206 – Software Integration, Specification 207 – Integration Test, and Specification 208 – Acceptance Test.

METHOD OF MEASUREMENT

This work shall be measured for payment by the contract price for the AVA and Trigger Location Management Software as specified, installed, configured, completed, tested, and accepted in-place. The contract price of this item shall be as indicated by the Contractor in the negotiated contract Price Proposal, and shall include providing, installing and configuring the AVA and Trigger Location Management Software, all materials, licenses, labor, testing, documentation, and other incidentals necessary to complete the work. This work shall not include labor associated with software integration tasks. Software integration should be accomplished as part of Specification 206 – Software Integration.

BASIS OF PAYMENT

Installed unit costs and quantities for all hardware, installed contract costs for all software, and installed unit foot cost and footage for all cabling shall be summed up in the negotiated total system implementation cost as defined in Specification 100 – General Provisions. The release of payment for all work associated with the implementation of the CT***fastrak*** ITS and Communications Systems shall be based on this negotiated total system implementation cost and the milestone completion schedule.