

# ALABAMA DEPARTMENT OF TRANSPORTATION

DATE: February 21, 2014

Special Provision No. 12-0943

EFFECTIVE DATE: August 1, 2014

SUBJECT: Intelligent Transportation Systems.

Alabama Standard Specifications, 2012 Edition, shall be amended by the addition of Section 734, Section 746 and Section 893 as follows:

## SECTION 734 FIBER OPTIC SYSTEMS

### 734.01 Description.

This Section shall cover the work of furnishing, installing, and testing fiber optic cable and associated equipment and materials. These requirements may be supplemented or amended by the requirements given elsewhere in the Specifications, or on the Plans and Special and Standard Highway Drawings.

Descriptions and definitions of the equipment, words and terminology used in the furnishing and installing of fiber optic systems are given in the National Electrical Safety Code (NESC), the National Electrical Manufacturers Association (NEMA), the National Electrical Code (NEC), publications of the Underwriters Laboratories (UL), publications of the International Municipal Signal Association (IMSA), publications of the Institute of Electrical and Electronics Engineers (IEEE), the Electronic Industries Alliance (EIA), and the Telecommunications Industry Association (TIA).

### 734.02 Materials.

All materials furnished for use shall conform to the requirements given in Section 893 and the requirements shown on the plans. All furnished materials and equipment shall be new and free from defects.

### 734.03 Construction.

#### (a) DESIGN AND CONSTRUCTION CODES AND COORDINATION OF THE WORK.

##### 1. CODES.

All installations shall comply with the regulations of the latest edition of the National Electrical Code and the latest edition of the National Electrical Safety Code, and with the service rules of the Utility Company providing the electricity.

##### 2. COORDINATION OF THE WORK.

Coordination of the work with roadway and bridge work will be of prime importance to prevent undue damage to completed items of work and existing facilities. Any damage to existing facilities caused by the installation of the material or equipment required under this Section shall be repaired by the Contractor at no additional cost to the Department.

#### (b) DRAWINGS AND SPECIFICATIONS.

Omissions from the plans and specifications or the misdescription of details of work which are evidently necessary to carry out the intent of the plans and specifications or which are customarily performed, shall not relieve the Contractor from performing such omissions and details of work. In any case of discrepancy in descriptions on the plans or in these Specifications, the matter shall be promptly submitted to the Engineer, who will make a determination in writing. Any adjustments in the plans, details, specifications, and proposal by the Contractor without written permission of the Engineer shall be at the Contractor's own risk and expense.

**(c) MATERIAL AND EQUIPMENT LISTS, SHOP DRAWING APPROVAL.**

Material and equipment listings shall be submitted to the Engineer for approval within thirty calendar days after the issuance of the "Notice to Proceed". Materials shall not be installed prior to approval. Partial listings and shop drawings will not be accepted for consideration and shall be returned for correction without review.

Seven (7) copies of each submittal shall be furnished for review. Material and equipment lists shall include catalog cutouts or published data sheets and a completed Department's Material Submittal Form. The Material Submittal form shall have each item sequentially numbered, a reference to the Specification Section and/or plan sheet, and a description of the material. This material description shall include the type, model number, catalog number, and manufacturer, and shall include a legible manufacturer's catalog cut sheet with each item being submitted clearly identified. All individual components of assembled equipment (cabinets, controllers, etc.) shall be itemized on the submittal form. Submittals shall be clear and complete. Pay Items are not to be referenced on the form.

Unacceptable items on the submittal form will be returned for corrective action. A copy of the approved material and equipment listings will be returned to the Contractor.

Any changes to the approved material and equipment lists must be requested in writing through proper channels.

If requested by the Engineer, the Contractor shall submit for inspection and approval samples of both the specified and proposed substitute items at no cost to the Department. The Department will not be liable for any materials purchased or work done or any delay incurred before such approval. Failure of the Engineer to note unsatisfactory material as received will not relieve the Contractor from responsibility. Manufacturers' warranties and guaranties furnished on equipment used in the work shall be delivered to the Engineer; likewise, instruction sheets and parts lists shall be delivered to the Engineer upon receipt of the equipment.

All units of any one item shall be made by the same manufacturer and of the same firmware version throughout the entire project.

**(d) APPROVED INTELLIGENT TRANSPORTATION SYSTEMS DEVICES AND MATERIALS.**

Some materials and equipment required to be furnished under this Section will be standard production type products. Acceptance will be made by the Engineer based on selected confirmation tests, the manufacturer's certification of the materials and equipment, and visual inspection at the job site. Approved devices are shown on the Department's Approved Intelligent Transportation Systems Devices and Materials list. Information concerning this list is given in Subarticle 106.01(f) and ALDOT-355.

**(e) AS-BUILT DRAWINGS, DIAGRAMS AND MANUALS.**

The Contractor shall submit as-built documentation of all work provided in accordance with these Specifications prior to completion of the Burn-In period as required in this Specification. The Contractor shall furnish at least two (2) copies of all bound documentation. The following documents as a minimum as they are applicable shall be included:

**1. OPERATIONAL MANUAL.**

The Contractor shall furnish a manual containing detailed operating instructions for each different type of equipment.

**2. MAINTENANCE PROCEDURES MANUAL.**

The Contractor shall furnish a manufacturer's manual containing detailed preventative and corrective maintenance procedures for each different type or model of equipment.

**3. SYSTEM CONNECTION DIAGRAMS.**

The Contractor shall furnish diagrams showing fiber optic and electric system interconnection cables, conduits and terminations.

**4. DRAWINGS.**

The Contractor shall provide the Department with drawings that detail the final installation route of all cable. These drawings shall include as-built plan set showing in detail all

changes on construction from the original plan details with special notation given to conduit location and elevation.

**(f) GROUND RESISTANCE TEST.**

At each ground rod location, a resistance to ground test shall be conducted by the Contractor in the presence of the Engineer. This test shall be conducted using a null balance earth tester with two auxiliary ground rods placed 50 feet and 100 feet [15 meter and 30 meter], respectively, from the tested ground rod. A reading of 25 ohms or less is satisfactory. Any reading over 25 ohms will require the installation of additional ground rods to be placed in a pattern as directed by the Engineer and in accordance with the National Electrical Code. If additional ground rods is installed, the test shall be repeated and ground rod(s) be added until a reading of 25 ohms or less is obtained.

**(g) ACCEPTANCE TESTING AND BURN-IN.**

The Contractor shall perform Burn-In on the ITS electronic equipment (e.g. ethernet switch, video encoder, and video decoder) installed under this Project and have materials specified within the Specifications. The Acceptance Test and Burn-In shall be in accordance with Section 746.

**(h) CONTRACTOR WARRANTY.**

The State of Alabama shall be protected from any latent defect within the passive network, all active components and/or cable system by the following guarantees:

1. The Contractor shall provide to the State the manufacturer's warranties on all devices and equipment; and,
2. The Contractor warrants and guarantees satisfactory in-service operation of the cable, splices, connectors, terminations, all active components and all apparatus for a period of one year following project acceptance. Before final payment is made, the Contractor shall supply the State of Alabama Contracts Office a letter setting forth the dates of the guarantee giving a telephone number and a person to contact for any required warrantee service.

**(i) ETHERNET FIELD SWITCH.**

**1. INSTALLATION REQUIREMENTS.**

The Contractor shall furnish and install the ethernet field switch device inside a field cabinet as shown on the plans. The Contractor shall ensure that the ethernet field switch is installed such that it is resistant to all electromagnetic interference (EMI).

**2. TESTING.**

**a. GENERAL**

The Contractor shall perform Bench and Site Testing as specified within the Specifications.

**b. FIELD TESTING**

Upon installation of the ethernet field switch, the Contractor shall perform the following minimum Site Testing items:

1. Inspect the quality and tightness of ground and surge protector connections.
2. Verify proper voltages for all power supplies and related power circuits.
3. Verify all connections, including correct installation of communication and power cables.
4. Verify configuration of the ethernet field switch Internet Protocol (IP) addresses and subnetwork mask.
5. Verify the network connection to the ethernet field switch through PING and TELNET sessions from a remote personal computer (PC).

**734.04 Method of Measurement.**

Fiber Optic Systems control items of work will be measured for payment in accordance with the following:

Pay Items 734-N will be measured per each unit installed.

**734.05 Basis of Payment.**

**(a) UNIT PRICE COVERAGE.**

Item 734-N. Ethernet Field Switch, Type C, measured as noted above, will be paid for at the contract bid price, which shall be full compensation for furnishing and installing complete in place and

operational, as indicated on the Plans, and shall include all testing, materials, power supply and wiring/cables, manufacturer's operational software packages and firmware, labor, equipment, tools and incidentals to complete this item of work.

Ethernet Field Switch, Type C will be paid for as follows:

1. 40% of the contract unit price upon successful completion of the Bench Test.
2. Additional 30% of the contract unit price upon Field Test.
3. Final 30% of the contract unit price upon completion of the Burn-In according to these Specifications.

Item 734-N. Ethernet Gigabit Field Switch, Hub, Rack Mount, measured as noted above, will be paid for at the contract bid price, which shall be full compensation for furnishing and installing complete in place and operational, as indicated on the Plans, and shall include all testing, materials, power supply and wiring/cables, manufacturer's operational software packages and firmware, labor, equipment, tools and incidentals to complete this item of work.

Ethernet Gigabit Field Switch, Hub, Rack Mount will be paid for as follows:

1. 40% of the contract unit price upon successful completion of the Bench Test.
2. Additional 30% of the contract unit price upon Field Test.
3. Final 30% of the contract unit price upon completion of the Burn-In according to these Specifications.

(b) PAYMENT WILL BE MADE UNDER ITEM NO.

734-N Ethernet Field Switch, Type C - per each  
Ethernet Gigabit Field Switch, Hub, Rack Mount - per each

## SECTION 746

### INTELLIGENT TRANSPORTATION SYSTEM

### ACCEPTANCE TESTING, BURN-IN AND TRAINING

#### 746.01 Description and Definitions.

This Section shall cover the work of furnishing and testing an Intelligent Transportation System (ITS) and associated equipment and materials. These requirements may be supplemented or amended by the requirements given elsewhere in the Specifications, or on the Plans and Special and Standard Highway Drawings.

Descriptions and definitions of the equipment, words and terminology used in the furnishing and testing of an Intelligent Transportation System are given in the publications of the National Electrical Code (NEC), the National Electrical Manufacturers Association (NEMA), the Electronic Industries Association (EIA), the American Society of Testing and Materials (ASTM), and the American National Standards Institute (ANSI).

Wherever the following terms are used in Section 734, Section 737, Section 738, Section 739, and Section 746 the intent and meaning shall be interpreted as follows:

(a) TERMS.

- **ITS Electronic Equipment** - Electronic equipment paid for under Section 734, Section 737, Section 738, Section 739, and Section 746.
- **Interoperability** - The capability to operate devices from different manufacturers or different device types within the same communications system.

## 746.02 Materials.

Not applicable.

## 746.03 Construction Requirements.

### (a) ACCEPTANCE TEST.

#### 1. GENERAL.

Acceptance Test shall consist of these two tests: (1) Bench Test, and (2) Site Test.

The Contractor shall secure a test site for the Bench Test as required on the Plans and in these Specifications. The test site must be submitted by the Contractor at the Pre-Construction meeting for approval by the Engineer. The Contractor shall provide the test location and facility, which shall be in the State of Alabama and within a twenty-five (25) mile radius of the project limits unless otherwise approved by the Engineer. If the Contractor fails to get test location approval prior to commencing any tests, the Contractor may be required to move testing to another site at the Contractor's expense.

There will be no direct payment to the Contractor for the cost of a suitable test site and for the setting up of the equipment for these tests.

The Contractor shall notify the Engineer to schedule an Acceptance Test a minimum of seven (7) calendar days before each proposed test date. After successfully confirming attendance of all necessary personnel, the Engineer shall provide the approved test date to the Contractor and all attendees.

The Contractor shall perform all tests in the presence of the Engineer. When problems arise during testing, the Engineer can require the Contractor to have a qualified technical representative on site during the specific testing. The Contractor shall arrange, at no additional expense to the Department, the attendance of the equipment manufacturer's qualified technical representative.

For each piece of ITS electronic equipment and ITS cabinet that requires testing, the Test Result Documentation shall provide at a minimum the following applicable information:

- site location,
- manufacturer's part number and serial number of each piece of equipment,
- manufacturer's firmware version,
- test equipment along with calibration date and details,
- tester's name(s) and signature(s),
- start time and date of each level of testing,
- test observation comments,
- state whether the equipment Passed or Failed for each test performed,
- document reason(s) for any re-test along with date and time of each re-test, and
- record test duration. (Duration shall mean the time the ITS electronic equipment is under test, and does not include any setup time.)

If any ITS electronic equipment requires re-test, the above minimum test information shall be provided for each re-test per each piece of equipment.

Once an Acceptance Test is completed, a copy of the Test Result Documentation shall be submitted to the Engineer within seven (7) calendar days following completion of test activities. Any given test session is considered incomplete until the Engineer has approved the documentation for that test session.

It shall be the Contractor's responsibility for successful completion of each test. Any equipment which fails any tests shall be subject to re-test at no additional cost to the Department.

The Engineer's approval of test procedures, Test Result Documentation, and witnessing of such tests shall not relieve the Contractor of their responsibility to provide a completely acceptable and operating ITS project.

## 2. BENCH TEST.

The Contractor shall perform a Bench Test on all ITS electronic equipment and ITS cabinets prior to installation. The Bench Test shall be performed by the Contractor at the approved test location and witnessed by the Engineer.

The Bench Test shall consist of the following two test phases: (1) Visual Inspection and (2) performing the Manufacturer's Startup and Diagnostics test.

The Visual Inspection phase shall consist of visually inspecting all ITS electronic equipment, ITS cabinets and materials to insure there is no physical damage; and that the equipment and cabinets conform to their approved material submittal cut sheets.

The Manufacturer's Startup and Diagnostics test phase shall consist of the Contractor performing the manufacturer's out-of-the-box startup and diagnostic test for each piece of ITS electronic equipment, using the respective manufacturer's recommended startup diagnostics, configuration, and testing. The Contractor shall submit with the Material Submittal the manufacturer's recommended startup and diagnostic test procedures for review and approval prior to conducting Bench Test.

The Contractor shall supply all temporary wiring and cabling (e.g. CAT-5/6, RS-232, DVI, VGA, Coaxial, etc.), laptop, diagnostic software, and electrical service necessary for the Bench Test.

Test Result Documentation for the Bench Test, for each item in full contract quantity, shall be submitted to the Engineer for approval. The Engineer's approval shall be in writing.

The Contractor shall deliver all manufacturers' configuration and diagnostic software to the Engineer at the completion of the Burn-In.

## 3. SITE TEST.

The Site Test shall demonstrate that the ITS electronic equipment is properly operating, configured, and transmitting data to the Department's Advanced Traffic Management System (ATMS) software as shown on the Plans and in these Specifications.

The Contractor shall not begin the Site Test until all ITS electronic equipment has successfully passed the Bench Test and its Test Result Documentation has been approved by the Engineer in writing.

Before beginning any Site Test, the Contractor shall develop and submit for the Engineer's written approval a "Functional Operations Test Procedures (FOTP)" document. The purpose of the "FOTP" document is to: (1) identify the functional requirements to be tested; (2) define the test procedure steps required for testing these functional requirement(s); and, (3) identify the expected results for successfully passing each test procedure.

The "FOTP" document shall consist of the following items for each requirement to be tested, at a minimum:

- identify the ITS electronic equipment to be tested,
- provide wiring diagram/sketch of the test setup configuration,
- identify and state the functional requirement(s) for equipment,
- identify any equipment and materials needed to perform the test,
- list the test steps to be performed, and
- define the expected outcome for the test steps (clearly identify pass/fail criteria).

The Contractor shall submit the Site Test "FOTP" document in its entirety such that a thirty (30) day review process may occur by the Engineer. No Site Test at any given site can begin until the Site Test "FOTP" document has been approved by the Engineer.

The Contractor shall perform a Site Test for each individual device on the pole.

The Contractor shall not begin any site Test until all work at that location is complete.

The Site Test shall consist of the following: (1) Visual Inspection; (2) verifying Installation; and, (3) performing Functional Operation Test Procedures.

The Visual Inspection shall consist of the Engineer visually inspecting all ITS electronic equipment, ITS cabinets and materials to insure that they were not damaged while being transported from the Bench Test location to the project site and being installed.

The Installation shall consist of the Contractor demonstrating to the satisfaction of the Engineer the following minimum requirements:

- all ITS electronic equipment, ITS cabinets and associated materials have been installed as specified on the Plans;
- all ITS electronic equipment has been properly connected (including the patch cables, fiber drop cable, and cable termination);
- perform Continuity Test on all supplied network, DVI and VGA cabling; and,
- inspect the installation of grounding and the surge protection systems (includes performing and successfully completing the Insulation Test, Continuity Test, and Ground Resistance Test as required on the Plans and in the Specifications).

The Functional Operation Test Procedures shall consist of the Contractor demonstrating to the satisfaction of the Engineer the following minimum requirements:

- demonstrate that each piece of ITS electronic equipment is fully operational by performing the manufacturer's recommended startup and diagnostic test procedures;
- demonstrate that each piece of ITS electronic equipment performs their respective specific functional requirements (as outlined within the following CCTV and RVD equipment requirements within this Specification; and, as detailed in their respective Specifications and on the Plans); and,
- demonstrate that each piece of ITS electronic equipment transmits data to the ATMS software located at ALDOT's Division Traffic Management Center (TMC). [*ALDOT Division personnel will verify if the transmitted data is received properly by the ATMS software.*]

The following ITS electronic equipment shall be tested for these minimum functional requirements:

1. Closed Circuit Television (CCTV) Equipment.

The Contractor shall furnish a laptop, the manufacturer's CCTV Embedded Protocol Control Software, and a 13-inch or larger color video monitor to demonstrate full operation of the CCTV camera. This demonstration of operation shall include: pan, tilt, focus, zoom, iris, position feedback, and communications address configuration. The video signal strength shall be measured at the video connector of the communications equipment.

2. Radar Vehicle Detection (RVD) Equipment:

The Contractor shall furnish a laptop with the manufacturer's configuration, diagnostic, and monitoring software to demonstrate full operation of the RVD equipment. This demonstration of operation shall include: true presence detection, vehicle count, occupancy, speed information, and communications address configuration. The testing for the Functional Accuracy Requirements as specified in Section 739 shall be included.

The Contractor shall supply all temporary wiring and cabling (e.g. CAT-5/6, RS-232, DVI, VGA, Coaxial, etc.), laptop, and diagnostic software necessary for the Site Test.

The Contractor shall deliver the manufacturers' CCTV and RVD Embedded Protocol Control software to the Engineer at the completion of the Burn-In.

The Contractor shall generate Test Result Documentation for the Site Test which shall be broken down by project site and include all ITS electronic equipment installed at each site. The complete package of the Test Result Documentation for the Site Test shall be submitted to the Engineer for approval. The Engineer's approval shall be in writing.

**(b) BURN-IN.**

The Contractor shall perform Burn-In on the ITS electronic equipment, ITS cabinets and materials to ensure their proper operation, interoperability and service for an extended time frame within actual field conditions and without any failures or maintenance problems.

The Contractor shall not begin the Burn-In until Site Test for all sites have been successfully completed and approved by the Engineer in writing.

The Contractor shall notify the Engineer to schedule Burn-In a minimum of seven (7) calendar days before proposed date. After confirming all sites have successfully completed the Acceptance Test, the Engineer shall send written notice to the Contractor and all necessary personnel of the authorized Burn-In start date.

The Burn-In Period shall be thirty (30) continuous calendar days. During the Burn-In Period, the Contractor shall expeditiously perform any necessary adjustment and replace any malfunctioning parts of the equipment required to place the system in an acceptable operational condition to the satisfaction of the Engineer. No extra compensation will be allowed for any work so required, such being considered incidental to furnishing and installing a complete operational system.

During the Burn-In Period, time charges shall be suspended if all other work has been completed and acceptance of the work is dependent upon the results of the Burn-In.

An equipment failure during the Burn-In Period is defined as a condition where a component stops functioning. A system failure is defined as a condition under which the system is unable to function as a whole or in significant part to provide the services as designated. While a single component failure may not constitute a system failure, chronic failure of that component or component type may be sufficient to be considered a system failure as determined by the Engineer. What constitutes a chronic failure shall be agreed upon in writing by the Contractor and the Engineer prior to beginning the Burn-In.

ITS electronic equipment which has repeated failures (repeated failures are defined as more than two in a thirty day period) during the Burn-In Period shall be replaced by the Contractor at no cost to the Department. Appropriate Acceptance Test requirements must be conducted for the new equipment and the Engineer's approval shall be obtained for said testing. Upon satisfactory completion of the testing, the Engineer will provide written authorization to commence with a thirty (30) day Burn-In Period for the new equipment.

If any piece of ITS electronic equipment has failed during the 15th through the 30th day of the Burn-In Period, final acceptance will be withheld until the repaired equipment is functioning properly for thirty (30) consecutive days after repair. Final acceptance shall mean successful completion of Burn-In to the satisfaction of the Engineer.

If any equipment or device fails to complete the thirty (30) day Burn-In Period, the Burn-In Period shall be suspended. The Burn-In Period will not be restarted except when the following has been met: (1) repairs to the malfunctioning equipment/device have been satisfactory completed; and, (2) the repaired equipment/device is to be re-tested and proven to be functioning properly. Only upon the Engineer's acceptance of the repaired equipment/device, will the Contractor be allowed to resume the Burn-In Period.

General communication outage or failure due to hardware is considered a system failure in any case. Communication failure due to a minor component may not be a system failure. Specifically exempted as system failures are failures caused by accident, natural disasters, or other external forces. The Engineer will advise the Contractor in writing when it considers that a system failure has occurred or a chronic failure exists.



Each system failure during this Burn-In Period shall require an additional two (2) calendar days of successful operation prior to being eligible for final acceptance (i.e., if there are two system failures during the initial 30 day period, the period would be increased by 4 days). Successful completion of the Burn-In Period shall occur at the end of thirty (30) complete calendar days of operation without a system failure ascribable to hardware, software, or communications components.

The Contractor shall generate Test Result Documentation for the Burn-In which shall also include at a minimum: (1) documentation for any ITS electronic equipment failures, system failures or communications failures; (2) document corrective actions taken by the Contractor for equipment repairs; (3) any re-test documentation for the repaired or replacement equipment; (4) all manufacturers' ITS electronic equipment protocol control software; and, (5) all manufacturers' configuration and diagnostic software along with licenses transferred to the Department. This Test Result Documentation shall also consist of the minimum applicable information as specified within Acceptance Test of this Specification. Once the Burn-In Period is successfully completed, the Contractor shall submit the complete package of the Test Result Documentation for Burn-In to the Engineer for approval. The Engineer's approval shall be in writing. Payment of the Final 20% is contingent upon the Engineer's written approval which acknowledges receipt of the Test Result Documentation along with verification that Burn-In was successfully completed.

If equipment or device failures occur, the Engineer may request for the Contractor to submit advance copies of the Burn-In Test Result Documentation so as to gain insight to the equipment problems and any corrective actions taken to date.

**(c) TRAINING.**

The Contractor shall provide installation, operations and maintenance training for up to ten (10) people. Training shall be performed by product manufacturer(s) for the ITS electronic equipment installed on the Project; and, shall be performed both in the field and in the office (or classroom).

The Contractor shall notify the Engineer to schedule training a minimum of seven (7) calendar days before the proposed training date. After successfully confirming attendance of all necessary personnel, the Engineer shall provide the approved training date to the Contractor and all attendees. The Contractor shall be responsible for coordinating approved training date with the product manufacturer instructor(s), along with any field and in-office preparations for completing this training. The Contractor shall take into consideration any time necessary for product manufacturer's instructor(s) travel (including lead times for booking flights and/or rental cars, time for actual commutes, and time for any field or classroom setup).

The Contractor shall include in the cost of training all supplies, equipment, materials, user manuals, handouts, travel, and subsistence necessary to conduct the training. A training notebook shall be provided to each trainee in a labeled 3-ring binder.

The Contractor shall submit the proposed training package to the Engineer for approval. The training package shall include detailed course curriculum(s), detailed daily training schedule, draft manuals, handouts, and resumes of all instructors. This training package shall be submitted a minimum of thirty (30) calendar days prior to scheduling training. The Engineer shall review the proposed training materials and reserves the right to request modifications to the training program and materials as appropriate. The Engineer's approval of the training package shall be in writing.

Training shall not last for more than eight (8) hours of any given day (i.e., twenty-four (24) hours of training would be conducted over at least a three (3) day period). Training shall be a mixture of formal classroom and hands-on training, and at least half of the training shall be hands-on. Training shall be conducted at a facility approved by the Engineer and shall be completed within sixty (60) days after completion of Burn-In. Upon the request of the Contractor, the Engineer may approve training to be conducted prior to completion of Burn-In.

The training shall be for the ITS electronic equipment as required on the Plans or in the Specifications; and, for any modifications or enhancements made by the Contractor to the Department's ATMS software or overall ITS system. The training course content shall include the following minimum items, as applicable to ITS electronic equipment required on the Plans:

1. Closed Circuit Television (CCTV) Equipment
  - A. Installation of all CCTV equipment,
  - B. Operations of all CCTV equipment,
  - C. Explanation of video quality,
  - D. Troubleshooting and Maintenance of all CCTV components,
  - E. Use of the CCTV embedded protocol control software,
  - F. Measurement of video signals,
  - G. Discussion of all warranty clauses, and
  - H. In-field maintenance training.
  
2. Radar Vehicle Detection (RVD) Equipment
  - A. Installation of all RVD equipment,
  - B. Operations of all RVD equipment,
  - C. Troubleshooting and Maintenance of all RVD components,
  - D. Use of the RVD embedded protocol software,
  - E. Discussion of all warranty clauses, and
  - F. In-field maintenance training.
  
3. Dynamic Message Sign (DMS) Equipment
  - A. Introductory level briefing of the DMS which provides an overview of how each DMS component operates and how the DMS is interconnected and communicates;
  - B. Provide separate operator and engineering session which includes:
    - an overview of DMS subsystem elements,
    - the theory of operation of DMS components,
    - DMS operating procedures and capabilities,
    - DMS software applications;
    - "hands-on" instructions for using all DMS equipment installed in the control center,
    - use of the DMS embedded protocol software,
    - routine troubleshooting, diagnostics and maintenance procedures from the operator's console,
    - showing how to use the system documentation to operate, diagnose, maintain, and expand the system;
  - C. Provide a separate technician level session which includes:
    - relevant topics in electronics and communications interfaces,
    - a detailed description and explanation of the theory of operation of major DMS components,
    - operation and installation procedures,
    - routine troubleshooting, diagnostics and maintenance procedures down to the replaceable module level (including the use of test equipment and diagnostic tools, installation and alignment techniques),
    - showing how to use the system documentation to operate, diagnose, maintain, and expand the system
    - "hands-on" instructions for using the system, a laptop computer with manufacturer's configuration and diagnostic software, system test equipment, and any other Contractor supplied equipment;
  - D. Discussion of all warranty clauses; and
  - E. In-field maintenance training.
  
4. Overall System Training
  - A. Installation of all system/subsystem modules,
  - B. Operations of all system/subsystem modules,
  - C. Troubleshooting and Maintenance of all system/subsystem modules,
  - D. Discussion of all warranty clauses, and
  - E. In-field maintenance training.

Training material shall serve not only as training course guidance, but also as a quick reference guide for future use by the attendee. A copy of all training material, in reproducible form, shall be delivered to the Engineer after training is complete.

**(d) USER MANUALS.**

The Contractor shall deliver five (5) copies of each User Manual to the Engineer upon completion of the Project. The User Manual(s) shall be for the ITS electronic equipment and any software provided on the Project. The User Manuals should be grouped into the following ITS component areas: CCTV, RVD, network devices and other equipment.

**746.04 Method of Measurement.**

Not applicable.

**746.05 Basis of Payment.**

**(a) UNIT PRICE COVERAGE.**

Not applicable.

**(b) PAYMENT WILL BE MADE UNDER ITEM NO.**

Not applicable.

## **SECTION 893 INTELLIGENT TRANSPORTATION SYSTEM DEVICES AND MATERIALS**

**893.01 General.**

The following are the requirements for Intelligent Transportation System (ITS) devices and materials. These requirements may be supplemented or amended by the requirements given elsewhere in the proposal, on the plans, and on the details in the Special and Standard Highway Drawings.

All furnished materials and equipment shall conform to the applicable requirements of the Underwriter's Laboratory Incorporated (UL), the Electronic Industries Association (EIA), the National Electric Code (NEC), the American Society of Testing and Materials (ASTM), the American National Standards Institute (ANSI), International Municipal Signal Association (IMSA), the National Electrical Manufacturers Association (NEMA), and the applicable standards, specifications, and regulations of the Alabama Department of Transportation (ALDOT).

**893.02 Network Devices.**

**(a) ETHERNET FIELD SWITCH**

**1. GENERAL:**

The ethernet field switch shall include Layer 2+ capabilities, including, QoS, IGMP, rate limiting, security filtering, and general management. The network administrator shall be able to manage each ethernet field device individually and as a group for switch configuration, performance monitoring, and troubleshooting.

The ethernet field switch device shall be fully compatible and interoperable with the ITS trunk ethernet network interface, and shall support both half and full duplex ethernet communications.

The ethernet field switch shall provide 99.999% error-free operation, and complies with the Electronic Industries Alliance (EIA) Ethernet data communication requirements using single-mode fiber optic transmission medium and Category 5E copper transmission medium. This ethernet field switch shall provide a switched ethernet connection for each remote ITS field device.

The ethernet field switch shall have a minimum mean time between failures (MTBF) of 10 years, or 87,600 hours, as calculated using the Bellcore/Telcordia SR-332 standard for reliability prediction.

## 2. NETWORKING STANDARDS:

The ethernet field switch shall comply with all applicable IEEE networking standards for ethernet communications, including but not limited to:

- a. IEEE 802.1D Standard for Media Access Control (MAC) Bridges used with the Rapid Spanning Tree Protocol (RSTP).
- b. IEEE 802.1Q standard for port-based virtual local area networks (VLANs).
- c. IEEE 802.1P standard for Quality of Service (QoS).
- d. IEEE 802.3 standard for local area network (LAN) and metropolitan area network (MAN) access and physical layer specifications.
- e. IEEE 802.3u supplement standard regarding 100 Base TX/100 Base FX.
- f. IEEE 802.3x standard regarding flow control with full duplex operation.

## 3. OPTICAL PORTS:

The ethernet field switch shall have fiber optic link ports which operate at 1,310 or 1,550 nanometers in single mode. These optical ports are to be Type ST, LC, or FC only, as specified on the plans or by the Engineer. The ethernet field switch shall not use mechanical transfer registered jack (MTRJ) type connectors.

The ethernet field switch shall have a minimum of two optical 1000 Base LX ports capable of transmitting data at 1000 megabits per second unless otherwise shown on the plans. **These minimum two ports shall be Type LC.** The ethernet field switch shall be configured with the number and type of ports detailed on the plans. The ethernet field switch shall provide optical ports designed for use with a pair of fibers; one fiber will transmit (TX) data and one fiber will receive (RX) data. The optical ports shall have an optical power budget of at least 15 dB, or as detailed on the plans.

## 4. COPPER PORTS:

The ethernet field switch shall include a minimum of eight copper 10/100 Base TX ports unless otherwise shown on the plans. All copper ports shall be Type RJ-45 and shall auto-negotiate speed (i.e., 10/100 Base) and duplex (i.e., full or half). All 10/100 Base TX ports shall meet the specifications detailed in this section and shall be compliant with the IEEE 802.3 standard pinouts.

## 5. MANAGEMENT CAPABILITY:

The ethernet field switch shall support all Layer 2 management features and certain Layer 3 features related to multicast data transmission and routing. These features shall include, but not be limited to:

- a. An ethernet field switch that is a port-based VLAN and supports VLAN tagging that meets or exceeds specifications as published in the IEEE 802.1Q standard, and has a minimum 4-kilobit VLAN address table.
- b. A forwarding/filtering rate that is a minimum of 14,880 packets per second for 10 megabits per second and 148,800 packets per second for 100 megabits per second.
- c. A minimum 4 kilobit MAC address table.
- d. Support of, at a minimum, Version 2 of the Internet Group Management Protocol (IGMP).
- e. Support of remote and local setup and management via telnet and secure Web-based GUI.
- f. Support of the Simple Network Management Protocol (SNMP). The ethernet field switch shall be accessed using the resident EIA-232 management port, a telecommunication network, or the Trivial File Transfer Protocol (TFTP).
- g. Port security through controlling access by the users. The ethernet field switch shall have the capability to generate an alarm and shut down ports when an unauthorized user accesses the network.

h. Support of remote monitoring (RMON) of the Ethernet agent and the ability to be upgraded to switch monitoring (SMON), if necessary.

i. Support of TFTP and either Network Time Protocol (NTP) or the Simple Network Time Protocol (SNTP). The ethernet field switch shall support port mirroring for troubleshooting purposes when combined with a network analyzer.

**6. MECHANICAL SPECIFICATIONS:**

The ethernet field switch shall be permanently marked with manufacturer name or trademark, part number, and serial number.

Every conductive contact surface or pin is to be gold-plated or made of a noncorrosive, nonrusting, conductive metal.

No self-tapping screws are to be used on the exterior of the assembly.

All parts shall be made of corrosion-resistant materials, such as plastic, stainless steel, anodized aluminum, brass, or gold-plated metal.

**7. ELECTRICAL SPECIFICATIONS:**

The ethernet field switch shall operate on a nominal voltage of 120 volts alternating current (VAC). Supply an appropriate voltage converter for devices that require operating voltages of less than 120 VAC.

The ethernet field switch shall have diagnostic light emitting diodes (LEDs), including link, TX, RX, and power LEDs.

**8. ENVIRONMENTAL SPECIFICATIONS:**

The ethernet field switch shall be a field-hardened device; and, shall operate properly during and after being subjected to the environmental testing procedures described in NEMA TS 2, Sections 2.2.7, 2.2.8., and 2.2.9.

**(b) ETHERNET GIGABIT FIELD SWITCH, HUB.**

The ethernet gigabit field switch shall meet all the requirements for 893.03 (a) ETHERNET FIELD SWITCH except it shall be designed to mount in a standard 19-inch rack as defined by ANSI/EIA-310-D and as shown on the plans.