Special Specification 6184
Fiber Optic Transceiver

1. DESCRIPTION

Furnish, install, and test fiber optic transceivers of the type specified in designated Intelligent Transportation System (ITS) field equipment cabinets or in Department Traffic Management Centers (TMC) as shown on the plans.

A fiber optic transceiver (OTR) is defined as a device that transmits and receives data by means of serial communication and converts media from copper to fiber optic cable. A matched pair of OTRs are needed to provide communication to an ITS field device.

A video optical transceiver (VOTR) is defined as a device that transmits analog video data and converts media from copper to fiber optic cable. Some VOTRs also have the functionality to transmit and receive serial data. These are defined as a VOTR with data. A matched pair of VOTRs are needed to provide communication to an ITS camera.

2. MATERIALS

Provide new, corrosion resistant materials that comply with the details shown on the plans and the requirements of this Item.

3. EQUIPMENT

3.1. **Fiber Optic Transceiver (OTR).**

3.1.1. **Functional Requirements.** Provide a fiber optic transceiver that supports data transmission over serial communication. Data transmitted and received must be full duplex, switch selectable, and conform to all requirements of Electronic Industries Associations Standard RS-232, RS-422, and RS-485 governed by the Electronic Components Association (ECA). Provide an OTR that operates over single mode fiber optic cable or multimode fiber optic cable as shown on the plans.

Furnish an OTR that is stable, maintenance free, easily configured with minimal effort, and able to communicate with other OTRs through optical modulation. The OTR must have fail-safe design such that device failure does not cause failure of any other equipment.

Provide anti-streaming logic to detect the presence of a signal and data applied to the transmitted data port, and to inhibit the control signal and block the transmitted data port should the maximum selected transmission time be exceeded. When the anti-streaming logic has been activated, light a failure indicator on the modem, keep the control signal inhibited and the transmitted data port blocked until the modem is reset by maintenance personnel.

Provide OTR with diagnostic light emitting diodes (LED) for power and data activity levels for the transmitter and the receiver.

3.1.2. **Electrical Requirements.**

3.1.2.1. **Power Requirements**. Provide a maximum 48 VDC from a separate power supply for each OTR to be provided as part of this bid item. Maximum power draw must be less than 10 W each.

Provide separate power supply capable operating from 120 VAC ± 15 VAC for each OTR.

3.1.2.2. **Surge Protection.** Install OTR in an environment that has protection from power surges and sags.

3.1.2.3. **Power Service Transients.** Supply equipment that meets all requirements in the National Electrical Manufacturers Association (NEMA) Standard TS-2 for Traffic Control System, Section 2.1.6., "Transients," or latest revision.

3.1.2.4. **Wiring.** Meet the requirements of the most current version of the National Electric Code (NEC). Provide wires that are cut to proper length before assembly. No splicing of cables permitted. Provide cable slacks to facilitate removal and replacement of assemblies, panels, and modules. Do not double back any wire to take up slack. Lace wires neatly together with nylon lacing or outdoor rated plastic straps. Secure the cables inside the cabinet with outdoor rated plastic straps.

3.1.3. **Optical Requirements.**

3.1.3.1. **Transmitting device.** Provide a laser as the transmitting device for a single mode fiber optic unit and an LED as the transmitting devices for a multimode fiber optic unit.

3.1.3.2. **Transmitter Optical Output.** Supply output power to single mode fiber optic cable at a wavelength of 1310 nm or 1550 nm sufficient enough to accommodate a loss budget of 23 dB minimum. Supply output power to multimode fiber optic cable at a wavelength of 850 or 1310 nm sufficient enough to accommodate a loss budget of 14 dB minimum at each wavelength.

3.1.3.3. **Optical Detector.** Provide an APD diode or Pin diode optical detector for the receiver.

3.1.3.4. **Receiver Optical Input.** Supply a minimum receiver input sensitivity of 23 dB, at each wavelength, for single mode fiber below the transmitter output level and operate within the parameters of this specification. Supply a minimum receiver input sensitivity of 14 dB, at each wavelength, for multimode fiber below the transmitter output level and operate within the parameters of this specification.

3.1.3.5. **Transmitting and Receiving Devices.** Provide a minimum mean time between failure of at least 100,000 hr. for transmitting and receiving devices.

3.1.3.6. **Input and Output Impedance.** Meet impedance in accordance with EIA RS-232 standards.

3.1.3.7. **System Bandwidth.** Provide a minimum bandwidth of 38.4 Kbaud.

3.1.3.8. **Optical Fiber Compatibility.** Provide fiber optic cables in accordance with Special Specification 6XXX, "ITS Fiber Optic Cable."

3.1.3.9. **Bit Error Rate (BER).** The bit error rate must not exceed 10^{-9} within optical budget for each channel.

3.1.4. **Mechanical Requirements.**

3.1.4.1. **Modular Design.** Provide equipment that is modular in design to allow for ease of component replacement in the field.

Sockets and connectors must be mechanically keyed to prevent insertion of unlike functions into the wrong socket or connector.

Clearly identify all modules and assemblies with name, model number, serial number, and any other pertinent information required to facilitate equipment maintenance, inventory, and tracking. All identifying information markings must be permanent, ultrviolet resistant and intended for harsh environments.

3.1.4.2. **Connectors.** Make all external connections by means of connectors. Key the connectors to preclude improper hookups. Color code or appropriately mark all wires to and from the connectors. Serial data interface connections must be RS-232, 425, or 485 DB connector types as required for compatibility with the intended device communications protocol.

Plate each and every conductive contact surface or pin with a minimum of 20 microns of gold.

For all installations supply fiber optic patch cables necessary to integrate the OTR with the communication equipment and patch panel as shown on the plans, or as directed, at no additional cost to the Department.

3.1.4.3. **Optical Connectors.** Provide input and output connectors of the same connector type to be compatible with the interface requirements of the data communications equipment as shown on the plans or as directed.

3.1.4.4. **Copper Connectors.** Provide input and output connectors with pinned connectors configured in a format compatible with the interface requirements of the data communications equipment.

3.1.4.5. **Harnesses.** Provide connecting harness of appropriate length and terminated with matching connectors for interconnection with the terminal equipment shown on the plans or as directed.

3.1.4.6. **Housing.** Provide standard compact serviceable modules.

3.1.5. **Environmental Design Requirements.** Provide equipment conforming to NEMA TS-2-2003 (R2008), International Electrotechnical Commission 60529, and NEMA 250-2008, or most current version, for the following categories:

3.1.5.1. **Temperature.** Provide equipment that conforms to NEMA TS-2 Section 2.1.5.1, or most current version, and meets all the specified requirements during and after being subjected to any combination of the following conditions:

- ambient temperature range of -29°F to 165°F;
- temperature shock not exceeding 30°F per hour;
- relative humidity of 0 to 95%; and
- moisture condensation on all exterior surfaces caused by temperature changes.

3.1.5.2. **Vibration.** Provide equipment that conforms to NEMA TS-2 Section 2.1.9 and Section 2.2.3, or most current version, and meets all the specified requirements during and after being subjected to a vibration of 5 to 30 Hz up to 0.5g's applied in each of three mutually perpendicular planes for 30 min.

3.1.5.3. **Shock.** Provide equipment that conforms to NEMA TS-2 Section 2.1.10. and Section 2.2.4., or most current version, and does not yield permanent mechanical deformation or any damage that renders the unit inoperable when subjected to a shock of 10g applied in each of three mutually perpendicular planes for 30 min.

3.1.5.4. **Corrosion.** Provide equipment that is tested to conform to NEMA 250-2003 Section 5.10., or most current version, when located in coastal Districts. Coastal Districts include Beaumont (BMT), Corpus Christi (CRP), Houston (HOU), Pharr (PHR), and Yoakum (YKM).

3.2. **Video Optical Transceiver (VOTR).** Furnish and install Video Optical Transceiver (VOTR) that is compliant with the specifications of this section and all of the specifications of the OTR except as modified herein. A VOTR is defined as a device that transmits and receives simplex analog video signals and converts media from copper to fiber optic cable. When plans call for a VOTR to transmit and receive serial data, provide a VOTR with data meeting OTR requirements for transmitting and receiving data specified above.

3.2.1. **Functional Requirements**. Provide the VOTR optical interface to accommodate single mode fiber and allows full duplex operation; operating at an optical wavelength of 1310 nm over 2 fibers; or, operating at optical wavelengths of 1310 nm and 1550 nm over 1 fiber.

Provide a VOTR capable of transmitting video in either the NTSC, PAL, or SECAM format. Provide analog video data interface connections with a coaxial connector type compatible with the intended camera cabling.

Provide single video channel VOTR when integrating one video camera in the field. Provide dual video channel VOTR when supporting two videos from two cameras in the field. Provide quad video channel VOTR when supporting four videos for four cameras in the field. Each link must meet EIA/TIA Standard 250C medium haul video requirements.

Provide single video channel VOTR with data when integrating one video stream with full duplex digital data links for 1 camera in the field. Provide dual video channel VOTR with data when supporting 2 video streams with full duplex digital data links for 2 cameras in the field. Provide quad video channel VOTR with data when supporting 4 video streams with full duplex digital data links for 4 cameras in the field. Each link must meet EIA/TIA Standard 250C medium haul video requirements.

3.2.2. **Transmitter Video Input**. Provide transmitter video input at 75 Ohms nominal, 1.0 Volt peak-to-peak between sync tip, and 100% white level in accordance with EIA/TIA Standard 250C.

3.2.3. **Receiver Video Output**. Provide receiver video output at 75 Ohms nominal, 1.0 Volt peak-to-peak between sync tip and 100% white level in accordance with EIA/TIA Standard 250C.

3.2.4. **Modulation**. Provide pulse frequency modulation or digital.

3.2.5. **Signal to Noise Ratio**. Provide a system signal to noise ratio greater than 60 dB, measured as peak-to-peak white to blanking, to rms noise (ppwb/rms) in a 10 kHz to 5 MHz bandwidth.

3.2.6. **Linearity**. Provide linearity greater than 1%.

3.2.7. **Tilt**. Provide tilt less than 2%.

3.2.8. **Differential Phase**. Provide less than 2° differential phase for a 10% to 90% average picture level (APL).

3.2.9. **Differential Gain**. Provide less than 2% differential gain at 10% to 90% average picture level (APL).

3.2.10. **Video Bandwidth**. Frequency response must be ±0.2 dB, 10 Hz to 0.5 MHz; ±0.5 dB, 0.5 MHz to 4.2 MHz. Units provided must have minimum video bandwidth of 5 Hz to 7 MHz.

4. CONSTRUCTION

4.1. **General**. Utilize the latest available techniques with a minimum number of parts, subassemblies, circuits, cards, and modules to maximize standardization and commonality.

Design for ease of maintenance, with all component parts readily accessible for inspection and maintenance.

Provide test points for checking essential voltages and waveforms.

4.2. **Mechanical Components**. Provide stainless steel external screws, nuts, and locking washers. Self-tapping screws are prohibited.

Provide corrosion resistant parts, such as plastic, stainless steel, anodized aluminum or brass.

Protect all materials used in construction from fungus growth and moisture deterioration.

Separate all dissimilar metals by an inert dielectric material.

4.3. **Mounting.** Provide all mounting hardware as shown on the plans, or as directed by the Engineer at no additional cost to the Department.

4.4. **Documentation Requirements.** Provide a minimum of 2 complete sets of operation and maintenance manuals, at least 45 days prior to testing, in hard copy format, bound, as well as an electronic version in Adobe PDF format on a CD/DVD or removable flash drive that includes the following:

- complete network configuration diagram which documents locations of installed equipment, serial and model numbers, communication protocol settings, cabling, power service connections, and fiber assignments,
- complete installation procedures,
- compliance matrix documenting conformance to this specification,
- complete parts list including names of vendors for parts not identified by universal part number such as JEDEC, RETMA, or EIA,
- operations manuals,
- warranty documentation,
- complete maintenance and trouble-shooting procedures,
- testing procedures identifying threshold values,
- recovery procedures for malfunction,
- instructions for gathering maintenance assistance from manufacturer, and
- provide the Department with certification documentation verifying conformance with environmental and testing requirements contained in this special specification. Certifications may be provided by the manufacturer or through independent certified labs.

4.5. **Testing.**

4.5.1. **General.** Unless otherwise shown on the plans, perform the following tests on the applicable equipment or systems.

4.5.2. **Test Procedures Documentation**. Provide 5 copies of the test procedures to include tests identified in Section 4.5.2. through Section 4.5.7. inclusive and blank data forms to the Engineer for review and comment at least 45 days prior to testing for each test required on this project. Include the sequence of the tests in the procedures. The Engineer will comment, approve, or reject test procedures within 30 days after Contractor submittal of equipment for tests. Contractor to resubmit, if necessary, rejected test procedures for final approval within 10 days prior to testing. Review time is calendar days. Conduct all tests in accordance with the approved test procedures.

Record measured test data on the data forms against threshold values, as well as quantitative results. No bid item measurement or payment will be made until the Engineer has verified the test results meet the minimum requirements of the specification. The data forms for all tests, except design approval tests, must be signed by an authorized representative of the Contractor.

Provide written notice to the Engineer within 48 hr. of discovery of any testing discrepancy identified during testing by the Contractor. Furnish data forms containing the acceptable range of expected results as well as the measured values.

4.5.3. **Design Approval Test**. Conduct a design approval test on randomly selected units from the prototype design manufacturing run. If only 1 design prototype is manufactured, perform this test on that unit. If supplying multiple types of the equipment, provide and test a sample of each type.

Certification from an independent testing laboratory of a successfully completed design approval test is acceptable. Ensure that the testing by this laboratory is performed in accordance with the requirements of this specification. Failures of independent tests to comply with the requirements of this specification are grounds for rejection of any certification.

Provide a copy of the certification to the District in which this contract is executed. The data forms for the design approval tests must be signed by an authorized representative (company official) of the equipment manufacturer or by an authorized representative of an independent testing facility.

Notify the Engineer 10 working days before conducting this testing. The Department may witness all the tests. Perform the following tests:

4.5.3.1. **Power Service Transients**. The equipment must meet the performance requirements, specified in this Item, when subjected to the power service transients as specified in Section 2.2.7.2., “Transient Tests (Power Service)” of the NEMA TS 2 standard, most current version.

4.5.3.2. **Temperature and Condensation**. The equipment must meet the performance requirements, specified in this Item, when subjected to the following conditions in the order specified below:

- stabilize the equipment at -30°F and test as specified in Sections 2.2.7.3., “Low-Temperature Low-Voltage Tests” and 2.2.7.4., “Low-Temperature High-Voltage Tests” of the NEMA TS 2 standard, most current version.
- allow the equipment to warm up to room temperature in an atmosphere having relative humidity of at least 40%. Operate the equipment for 2 hr., while wet, without degradation or failure.
- stabilize the equipment at 165°F and test as specified in Sections 2.2.7.5., “High-Temperature High Voltage Tests” and 2.2.7.6., “High-Temperature Low-Voltage Tests” of the NEMA TS 2 standard, most current version.

4.5.3.3. **Relative Humidity**. The equipment must meet the performance requirements, specified in this Item, within 30 min. of being subjected to a temperature of 165°F and a relative humidity of 18% for 48 hr.

4.5.3.4. **Vibration**. The equipment must show no degradation of mechanical structure, soldered components, or plug-in components and must operate in accordance with the manufacturer's equipment specifications after being subjected to the vibration tests as described in Section 2.2.8., “Vibration Test” of the NEMA TS 2 standard, most current version.

4.5.3.5. **Power Interruption**. The equipment must meet the performance requirements, specified in this Item, when subjected to nominal input voltage variations as specified in Section 2.2.10., “Power Interruption Test” of the NEMA TS 2 standard, most current version.

4.5.4. **Demonstration Test**. Conduct a demonstration test on applicable equipment at an approved Contractor facility. The Contractor may submit procedures and results from previous contracts in the same District as this contract provided the materials and equipment are identical, provided results are less than 5 yr. old. Notify the Engineer 10 working days before conducting this testing. The Department may witness all the tests. Perform the following tests:

4.5.4.1. **Examination of Product**. Examine each unit carefully to verify that the materials, design, construction, markings and workmanship comply with the requirements of this Item.

4.5.4.2. **Continuity Tests**. Check the wiring to determine conformance with the requirements of the appropriate paragraphs in this Item.

4.5.4.3. **Operational Test**. Operate each unit for at least 15 min. to permit equipment temperature stabilization and an adequate number of performance characteristics to ensure compliance with the requirements of this Item.

4.5.5. **Field Acceptance (Stand-Alone) Test.** Conduct a field acceptance test for each unit after installation as required by the Engineer in order to demonstrate compliance with the functional requirements with this Item. The test must exercise all stand-alone (non-network) functional operations. Notify the Engineer 5 working days before conducting this test. The field acceptance test may consist of the following:

4.5.5.1. **Physical Construction.** Verify physical construction is completed in accordance with the plans and specification.

4.5.5.2. **Electrical and Communication**. Verify that all connectors for grounding, surge suppression, and electrical distribution are tightened correctly. Verify all power supplies and circuits are operating under the proper voltages. Verify all power and communications cables are terminated correctly, secured inside the cabinet, and fitted with appropriate connectors.

4.5.5.3. **Communication Link Quality.** Conduct signal tests for each communication link, including data transmit, data receive, bandwidth, proper operation of alarm and switches, and bit error rate. Document results in a written report to the Engineer.

4.5.6. **System Integration Test.** Conduct a system integration test on the complete functional system. Demonstrate all control and monitor functions for each system component for 24 hr.. Notify the Engineer 10 working days before conducting this testing. The Department may witness all the tests.

Provide systems integration test procedures for proper adjustment and calibration of subsystem components. Proper adjustment and calibration involves documenting settings used to meet functional requirements while providing a margin for adjustment when future conditions change. Utilize Department software (when available) to perform subsystem testing. At a minimum, utilize this software to verify commands and confirms, as well as detector actuations and occupancy dwell time. The Contractor is responsible for being familiar with any existing Department equipment and software.

The failure of any one component material or equipment item in a system integration test is justification for rejecting the entire subsystem. Each subsystem component must function as a complete integrated subsystem for a minimal continuous 24 hr. period during the system integration test.

4.5.7. **Final Acceptance Test.** Following completion of the demonstration test, field acceptance test, and system integration test for all subsystems, provide completed data forms containing all of the data taken, including quantitative results for all tests, a set of “as built” working drawings, and a written request to begin a data communication and final acceptance test. Provide “as built” working drawings indicating the actual material, equipment, and construction of the various subsystem components.

Within 10 calendar days of the request, execute a data communications test using a Department supplied software program or Contractor supplied software approved by the Department. The data communications test may be executed by the Engineer or the Contractor with the prior approval of the Engineer. The purpose of this test is to verify that the communications plan operates with application software provided by the Department.

Perform the data communications test for a period of 72 hr. If a message error or component failure occurs anywhere in the network, resume the test once repairs are completed. All components of the communications network must operate as an integral system for the duration of the test.

A message error is defined as the occurrence of a parity error, framing error, or data error in any component of the message. The error-free message rate is defined as the ratio of the number of messages in which no message error occurs to the number of messages transmitted. The error-free message rate must exceed 99.99% for acceptable transmission quality, both for the system as a whole, and for each component of the network.

Provide all additional test results to the Engineer for review once a successful data communications test has been completed. If all the requirements of this special provision have been satisfied, contract time will be suspended and all subsystems must be placed into operation and operate as a complete system for a period of at least 90 calendar days.

Notify the Engineer of any defects suspected in integration or function of material or equipment. Investigate any suspected defects and correct if necessary. Provide a report of findings within 2 calendar days of notice of any suspected defects. Describe the nature of the any defects reported and any corrective action taken in the report. The integrated subsystems must operate defect free as a single complete system for at least 72 continuous hours during the 30 calendar day review period. If the number of defects or frequency of failures prevents all subsystems from operating as described above, the Engineer may reject the entire system integration test results and resume contract time. Provide any necessary corrections and resubmit system integration test results and a request to begin a final acceptance test which may include “as built” plans and a data communications test.

The project will not be accepted, notwithstanding other provisions in the Contract, until the system, inclusive of all subsystems, has operated satisfactorily for a period of 90 days and in full compliance with the plans and specifications after approval of all submitted test results and reports.

4.5.8. **Consequences of Test Failure.** If a unit fails a test, submit a report describing the nature of the failure and the actions taken to remedy the situation prior to modification or replacement of the unit. If a unit requires modification, correct the fault and then repeat the test until successfully completed. Correct minor discrepancies within 14 days of written notice to the Engineer. If a unit requires replacement, provide a new unit and then repeat the test until successfully completed. Major discrepancies that substantially delay receipt and acceptance of the unit are sufficient cause for rejection of the unit.

Failure to satisfy the requirements of any test is considered a defect and the equipment is subject to rejection by the Engineer. The rejected equipment may be offered again for retest provided all noncompliance has been corrected.

If a failure pattern develops in similar units within the system, implement corrective measures, including modification or replacement of units, to all similar units within the system as directed. Perform the corrective measures without additional cost or extension of the contract period.

4.5.8.1. **Consequences of Design Approval Test Failure**. If the equipment fails the design approval test, correct the fault within 30 days and then repeat the design approval test until successfully completed.

4.5.8.2. **Consequences of Demonstration Test Failure**. If the equipment fails the demonstration test, correct the fault within 30 days and then repeat the demonstration test until successfully completed.

4.5.8.3. **Consequences of Field Acceptance (Stand-Alone) Test Failure**. If the equipment fails the stand-alone test, correct the fault within 30 days and then repeat the stand-alone test until successfully completed.

4.5.8.4. **Consequence of System Integration Test Failure**. If the equipment fails the system integration test, correct the fault within 30 days and then repeat the systems integration test until successfully completed.

4.5.8.5. **Consequences of Final Acceptance Test Failure**. If a defect within the system is detected during the final acceptance test, document and correct the source of failure. Once corrective measures are taken, monitor the point of failure until a 30 consecutive day period free of defects is achieved.

If after completion of the initial test period, the system has not operated for 72 consecutive hours free of defects, extend the 30 day test period by an amount of time equal to 72 consecutive hours to demonstrate performance, in addition to the number of days required to complete the performance requirement of the individual point of failure.

4.6. **Training.** Conduct a training class (minimum of 1 hr., up to 4 hr., unless otherwise noted in the plans) for up to 10 representatives designated by the Department on procedures of installation, operations, testing, maintenance and repair of all equipment specified within this specification for each type of unit provided. Submit to the Engineer for approval, 10 copies of the training material at least 30 days before the training begins. Conduct training within the local area unless otherwise authorized by the Engineer.

4.7. **Warranty.** Warrant the equipment against defects or failure in design, materials, and workmanship for a minimum of 3 yr. or in accordance with the manufacturer's standard warranty if that warranty period is greater. The start date of the manufacturer's standard warranty will begin after the equipment has successfully passed all tests contained in the final acceptance test plan. Any OTR or VOTR field equipment with less than 90% of its warranty remaining after the final acceptance test is completed will not be accepted by the Department. Guarantee that equipment furnished and installed for this project performs according to the manufacturer's published specifications. Assign, to the Department, all manufacturer's normal warranties or guarantees on all electronic, electrical, and mechanical equipment, materials, technical data, and products furnished for and installed on the project.

OTRs or VOTRs must be repaired or replaced at the Contractor's expense prior beginning the final acceptance test plan in the event of a malfunction or failure. Furnish replacement parts for all equipment within 10 days of notification of failure by the Department.

5. MEASUREMENT

This Item will be measured by each OTR, VOTR, or VOTR with Data.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price for "Fiber Optic Transceiver (OTR)", "Video Optical Transceiver (VOTR)", or "Video Optical Transceiver with Data" of the type specified. This price is full compensation for furnishing and installing units including all equipment, all cables and connectors, all documentation and testing; and includes the cost of furnishing all labor, materials, training, warranty, equipment, and incidentals.