The Contractor shall furnish and install fiber optic modems of the type specified in field equipment cabinets and equipment enclosures specified in these Contract documents and as shown on the Plans or as directed by the Engineer.

The modems will be used as follows:

- Modem – Fiber Optic – Video – Data/RS422 will be used to transmit video from a new or existing camera to the Traffic Operations Center (TOC), and to transmit camera control data between the camera and TOC.
- Modem – Fiber Optic – Data/RS232 – Full Duplex will be used to transmit data between a new or existing weather station and the TOC.
- Modem – Fiber Optic – Data/RS232 – Multi-Drop/Self-Healing will be used to transmit data between a new dynamic message sign and the TOC.
- Modem – Fiber Optic – Bridging will be used to tie a new workstation computer or a new highway advisory radio station to the local area network (LAN) in the TOC.
- Modem – Fiber Optic – Video will be used to transmit video from the Traffic Operations Center (TOC) to new monitors and workstations in remote locations.

MATERIALS

All materials furnished, assembled, fabricated or installed shall be new and in accordance with these Contract documents. All modems covered by the same item number shall be identical, except as explained below.

Each of the above categories includes modems in the TOC as well as modems in other locations. The modems in the TOC shall be modules that slide into a rack-mounted card cage. The card cage shall distribute power to all the modules. If compatible, modems of different types may share the same card cage. The Contractor shall provide as many rack-mounted card cages as needed for the modems he installs in the TOC, and their cost shall be included in the price of the modems. The modems outside the TOC will be standalone units. The same price will be paid for all modems, whether stand alone or in a card cage.

Stand-alone modems shall be designed to operate in a NEMA 3R outdoor enclosure and their circuit boards shall have conformal coating.

The price of the modems includes appropriate power supplies. All modems in the same card cage shall share a power supply, which may be in the card cage with the modems or separate. Either way, the power supply must be able to power the card cage when the cage is filled to
capacity. Standalone modems shall be furnished with a DC power supply, provided by the modem manufacturer, meeting the same environmental requirements as the fiber optic modem.

All point to point modems shall operate on one or two dedicated fiber(s). Point to Multi-point shall operate on two dedicated fibers for string configuration and on four fibers for ring configuration.

All fiber optic modems shall use laser diode emitters and operate on single mode optical fiber at operating wavelengths of 1310 and/or 1550 nm.

The minimum requirements are:

- Operating Temperature: -30°C to +70°C
- Operating Humidity: 0 to 95% non condensing
- Optical Loss Budget: 23 dB
- BER (for Data): 10⁻⁹
- Asynchronous Data Rate: 38.4 Kbps
- Optical Input/Output Connectors: ST

**Modem - Fiber Optic - Video - Data/RS422**
The Modem - Fiber Optic - Video - Data/RS422 shall be compatible with the existing and new camera assemblies. It shall carry video from the camera to the video switch in the TOC and shall also carry bidirectional EIA-422 data for camera monitoring and control. It shall do all this using no more than two fibers. The video signal to noise ratio shall be 60 dB or better.

**Modem - Fiber Optic - Data/RS232 - Full Duplex**
The Modem - Fiber Optic - Data/RS232 - Full Duplex shall be compatible with the new and existing RWIS equipment.

**Modem - Fiber Optic - Data/RS232 - Multi-Drop/Self Healing**
The Modem - Fiber Optic - Data/RS232 - Multi-Drop/Self Healing shall be compatible electrically and support the Dynamic Message Sign (DMS) protocol. The modem shall have an optical budget of 20 dB or greater.

The fiber optic modems shall be capable of full duplex RS232 data. All data transmitted from the master location must appear at all remote or slave locations. The master must receive all data transmitted from the slave units.

The self-healing feature shall automatically re-route data traffic for any equipment or cable failure.

The fiber optic modem shall have an anti-streaming capability to prevent a single modem from
blocking out data on the data path.

**Modem - Fiber Optic - Bridging**
The Modem - Fiber Optic - Bridging shall extend the TOC’s Ethernet LAN to remote workstations and HAR Sites.

The price of the modem includes furnishing a bridge or router for each modem to ensure that the fiber optic link is not part of any LAN collision domain. The device shall interface the Ethernet communication on the LAN with the point-to-point data link between the modems. The bridge or router must have an operating temperature range of at least 0°C to 60°C. The bridge shall support the TCP/IP protocol and IEEE 802.3 Ethernet Standard as implemented in the HAR equipment and workstations. It shall include all cables and adapters necessary to connect one of its ports to the LAN switch furnished as part of the item Computer - LAN Server – Furnish and Install. It shall include all cables, adapters, and interface devices to connect the other port to the fiber optic modem.

The modem shall transmit and receive data using full duplex communication over two fibers. It shall sustain a data rate of 1.5 Mbps or higher and have a bit error rate of $10^{-12}$ or better. The modem shall have an optical budget of 26 dB or more.

**Modem -- Fiber Optic -- Video**
Half of these shall be optical transmitters and half receivers. They shall carry four channels of video using frequency or pulse code modulation. Bandwidth shall be at least 10 MHz and differential gain shall be under five percent. Signal-to-noise ratio shall be at least 58 dB. Video connectors shall be BNC-type with a gold-plated center pin. The devices must have either an optical budget of 23 dB at 1310 nm or an optical budget of 17 dB at 1550 nm.

**CONSTRUCTION DETAILS**

All equipment shall be installed in accordance with the manufacturer instructions.

The modems shall be mounted so the operator can view the modem’s visual indicators and controls. The modems shall be mounted for easy removal and replacement by one person using basic hand tools.

A stand alone modem shall be securely mounted in such a way that it can be easily removed without access to the back of the panel supporting the modem. If a remote DC power is required, the DC power supply shall be located near the modems.

The Contractor will be required to verify the type of electrical connector required for data cable that interfaces the fiber optic modem into equipment furnished by others. The Contractor can re-use the data cables at field equipment sites that are being upgraded.
ITEM 680.08040008 – MODEM – FIBER OPTIC – BRIDGING
ITEM 680.08050008 – MODEM – FIBER OPTIC – VIDEO

The Contractor will be required to furnish and install all data cables for new equipment being furnished under this Contract.

All installed equipment and required cabling shall be labeled as specified in these Specifications or as directed by the Engineer.

For self-healing ring modems that are, in fact, part of a ring, the Contractor shall ensure that the modems are configured properly to implement the self-healing feature.

Testing and documentation is as specified in these Contract documents or as directed by the Engineer.

METHOD OF MEASUREMENT
Modem - Fiber Optic - Video - Data/ RS 422; Modem - Fiber Optic - Data/RS 232 - Full Duplex; Modem - Fiber Optic - Data/RS 232 - Multi-Drop/ Self Healing; Modem - Fiber Optic – Bridging; Modem - Fiber Optic - Video will be measured as the number of units furnished, installed and made operational in accordance with the Plans, Specification or as directed by the Engineer.

BASIS OF PAYMENT
The unit price bid for each Modem - Fiber Optic - Video - Data/ RS 422; Modem - Fiber Optic - Data/RS 232 - Full Duplex; Modem - Fiber Optic - Data/RS 232 - Multi-Drop/ Self Healing; Modem - Fiber Optic – Bridging; Modem - Fiber Optic - Video shall include the cost of all labor, materials, equipment necessary to complete the work.

Payment for miscellaneous hardware, modem card cages, power supplies, fabrication cost for special mounting of components and required data cables shall be included in this item. Payment for the bridges, routers, and interface units associated with the bridging modems is included in Modem - Fiber Optic - Bridging.

Progress payment will be made as follows:
Fifty percent (50%) of the bid price for each item will be paid when the equipment is installed. Twenty percent (20%) of the bid price for each item shall be paid upon successful completion of Operational Tests. Twenty percent (20%) of the bid price for each item shall be paid upon successful completion of System Acceptance Tests. Ten percent (10%) of the bid price for each item shall be paid upon successful completion of the Final Acceptance Test.