



STATE OF NORTH CAROLINA  
DEPARTMENT OF TRANSPORTATION

ROY COOPER  
GOVERNOR

August 31, 2017

JAMES H. TROGDON, III  
SECRETARY

WBS No: 44856.3.2 and 50138.3.99  
County: Union  
Description: Grading, Paving, Drainage, Concrete Monolithic Islands, Traffic Signals, and Thermoplastic Pavement Markings on US 74 Highway, Old Pageland-Monroe Road (SR-1941), and S. Secrest Avenue.

Addendum No. 1  
September 13, 2017 Letting

To: Prospective Bidders

Please note the following revision to the proposal for the above referenced project.

- **Removed - Master Item No. 7516000000-E – Communications Cable (Single Mode SMF012 Fiber)**
- **Removed - Master Item No. 7540000000-N – Splice Enclosure**
- **Removed - Master Item No. 7552000000-N – Interconnect Center**
- **Removed – Master Item No. 7564000000-N – Fiber-Optic Transceiver, Drop & Repeat**
- **Added - Master Item No. 7980000000-N – 900 MHz Serial/ Ethernet Spread Spectrum Radio**
- **Added - Master Item No. 7980000000-N – Ethernet Edge Switch**

The attached Signals and Intelligent Transportation Systems Special Provision shall be included in the Contract Proposal.

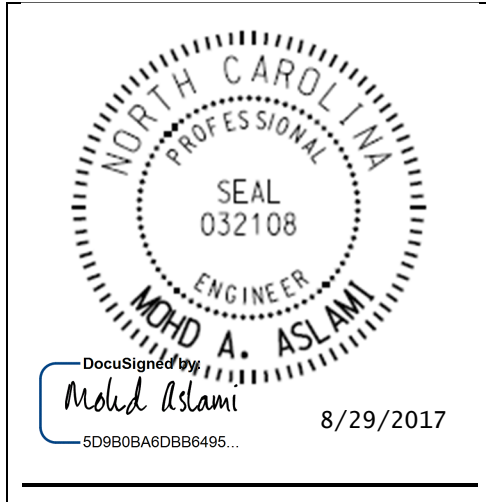
To submit your electronic bid package you must go to the Division 10 Letting site and download and use the DJ00257.001 addendum file. The Division 10 Letting site can be accessed at the following link [https://connect.ncdot.gov/letting/Pages/Letting-Details.aspx?let\\_type=10&let\\_date=2017-09-13](https://connect.ncdot.gov/letting/Pages/Letting-Details.aspx?let_type=10&let_date=2017-09-13)

If you have any questions, please contact me at (704) 983-4400.

Sincerely,

Donald Griffith  
DDC Engineer

CC: Mr. Terry Burleson  
Ms. Kellie Crump  
Mr. Scott Cole, PE  
File



**Signals and Intelligent Transportation Systems**

**Project Special Provisions**

*(Version 12.5)*

Prepared By:    I. N. Avery   

29-Aug-17

**DOCUMENT NOT CONSIDERED FINAL  
 UNLESS ALL SIGNATURES COMPLETED**

**Contents**

**1. ETHERNET EDGE SWITCH.....3**

1.1. DESCRIPTION .....3

    A. Ethernet Edge Switch: .....3

    B. Network Management: .....3

1.2. MATERIALS .....3

    A. General:.....3

    B. Compatibility Acceptance.....3

    C. Standards:.....4

    D. Functional: .....4

    E. Physical Features: .....5

    F. Management Capabilities:.....5

    G. Electrical Specifications:.....7

    H. Environmental Specifications: .....7

    I. Ethernet Patch Cable: .....7

1.3. CONSTRUCTION METHODS.....8

    A. General:.....8

    B. Edge Switch: .....8

1.4. MEASUREMENT AND PAYMENT .....8

**2. 900 MHZ SERIAL/ETHERNET SPREAD SPECTRUM RADIO .....9**

2.1. DESCRIPTION .....9

2.2. MATERIALS .....9

    A. 900 MHz Serial/Ethernet Spread Spectrum Radio.....9

    B. Software.....10

    C. Directional Antenna (Yagi).....10

    D. Omnidirectional Antenna.....12

    E. Antenna Mounting Hardware Kit.....12

    F. Coaxial Cable .....13

    G. Standard N-Type Male Connector.....13

    H. Coaxial Cable Shield Grounding and Weatherproofing Kits.....14

    I. Lightning Arrestor.....14

    J. Coaxial Cable – Power Divider (Splitter) .....14

    K. Disconnect Switch.....15

- L. *Warning Signs and Decal* ..... 15
- 2.3. CONSTRUCTION METHODS ..... 15
  - A. *General*..... 15
  - B. *Disconnect Switch*..... 16
  - C. *Warning Sign(s) and Decal(s)*..... 16
- 2.4. MEASUREMENT AND PAYMENT ..... 17

## 1. ETHERNET EDGE SWITCH

Furnish and install a managed Ethernet edge switch as specified below that is fully compatible, interoperable, and completely interchangeable and functional within the existing City or Division traffic signal system communications network.

### 1.1.DESCRPTION

#### A. Ethernet Edge Switch:

Furnish and install a hardened, field Ethernet edge switch (hereafter “edge switch”) in each traffic signal controller cabinet. Ensure that the edge switch provides wire-speed, fast Ethernet connectivity at transmission rates of 100 megabits per second from each remote ITS device location to the routing switches.

Contact the City or Division to arrange for the programming of the new Field Ethernet Switches with the necessary network configuration data, including but not limited to, the Project IP Address, Default Gateway, Subnet Mask and VLAN ID information. Provide a minimum five (5) days working notice to allow the City or Division to program the new devices.

#### B. Network Management:

Ensure that the edge switch is fully compatible with the City’s or Division’s existing Network Management Software.

### 1.2.MATERIALS

#### A. General:

Ensure that the edge switch is fully compatible and interoperable with the trunk Ethernet network interface and that the edge switch supports half and full duplex Ethernet communications.

Furnish an edge switch that provide 99.999% error-free operation, and that complies with the Electronic Industries Alliance (EIA) Ethernet data communication requirements using single-mode fiber-optic transmission medium and copper transmission medium. Ensure that the edge switch has 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.

#### B. Compatibility Acceptance

The Engineer has the authority to require the Contractor to submit a sample Field Ethernet Switch and Field Ethernet Fiber Optic Transceiver (Ethernet SFP Modules) along with all supporting documentation, software and testing procedures to allow a compatibility acceptance test be performed prior to approving the proposed Field Ethernet Switch and Field Ethernet Transceiver for deployment. **The Compatibility Acceptance testing will ensure that the proposed device is 100% compatible and interoperable with the existing City Signal System network, monitoring software and Traffic Operations Center network hardware.** Allow fifteen (15) working days for the Compatibility Acceptance Testing to be performed

**C. Standards:**

Ensure that the edge switch complies with all applicable IEEE networking standards for Ethernet communications, including but not limited to:

- IEEE 802.1D standard for media access control (MAC) bridges used with the Spanning Tree Protocol (STP);
- IEEE 802.1Q standard for port-based virtual local area networks (VLANs);
- IEEE 802.1P standard for Quality of Service (QoS);
- IEEE 802.1w standard for MAC bridges used with the Rapid Spanning Tree Protocol (RSTP);
- IEEE 802.1s standard for MAC bridges used with the Multiple Spanning Tree Protocol;
- IEEE 802.1x standard for port based network access control, including RADIUS;
- IEEE 802.3 standard for local area network (LAN) and metropolitan area network (MAN) access and physical layer specifications;
- IEEE 802.3u supplement standard regarding 100 Base TX/100 Base FX;
- IEEE 802.3x standard regarding flow control with full duplex operation; and
- IFC 2236 regarding IGMP v2 compliance.
  
- IEEE 802.1AB Link Layer Discovery Protocol (LLDP)
- IEEE 802.3ad Ethernet Link Aggregation
- IEEE 802.3i for 10BASE-T (10 Mbit/s over Fiber-Optic)
- IEEE 802.3ab for 1000BASE-T (1Gbit/s over Ethernet)
- IEEE 802.3z for 1000BASE-X (1 Gbit/s Ethernet over Fiber-Optic)

**D. Functional:**

Ensure that the edge switch supports 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:

- An STP healing/convergence rate that meets or exceeds specifications published in the IEEE 802.1D standard.
- An RSTP healing/convergence rate that meets or exceeds specifications published in the IEEE 802.1w standard.
- An Ethernet edge 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 (254 simultaneous).
- 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.
- A minimum 4-kilobit MAC address table.
- Support of Traffic Class Expediting and Dynamic Multicast Filtering.
- Support of, at a minimum, snooping of Version 2 & 3 of the Internet Group Management Protocol (IGMP).
- Support of remote and local setup and management via telnet or secure Web-based GUI and command line interfaces.

- Support of the Simple Network Management Protocol version 3 (SNMPv3). Verify that the Ethernet edge switch can be accessed using the resident EIA-232 management port, a telecommunication network, or the Trivial File Transfer Protocol (TFTP).
- Port security through controlling access by the users. Ensure that the Ethernet edge switch has the capability to generate an alarm and shut down ports when an unauthorized user accesses the network.
- Support of remote monitoring (RMON-1 & RMON-2) of the Ethernet agent.
- Support of the TFTP and SNMP. Ensure that the Ethernet edge switch supports port mirroring for troubleshooting purposes when combined with a network analyzer.

#### **E. Physical Features:**

*Ports:* Provide 10/100/1000 Mbps auto-negotiating ports (RJ-45) copper Fast Ethernet ports for all edge switches. Provide auto-negotiation circuitry that will automatically negotiate the highest possible data rate and duplex operation possible with attached devices supporting the IEEE 802.3 Clause 28 auto-negotiation standard.

*Optical Ports:* Ensure that all fiber-optic link ports support SFP Modules and operate at 1310 or 1550 nanometers in single mode. Provide Type LC connectors for the optical ports, as specified in the Plans or by the Engineer. Do not use mechanical transfer registered jack (MTRJ) type connectors.

Provide an edge switch having a minimum of two optical 100/1000 Base X ports capable of transmitting data at 100/1000 megabits per second. Ensure that each optical port consists of a pair of fibers; one fiber will transmit (TX) data and one fiber will receive (RX) data. Ensure that the optical ports have an optical power budget of at least 15 dB.

*Copper Ports:* Provide an edge switch that includes a minimum of eight copper ports. Provide Type RJ-45 copper ports and that auto-negotiate speed (i.e., 10/100/1000 Base) and duplex (i.e., full or half). Ensure that all 10/100/1000 Base TX ports meet the specifications detailed in this section and are compliant with the IEEE 802.3 standard pinouts. Ensure that all Category 5E unshielded twisted pair/shielded twisted pair network cables are compliant with the EIA/TIA-568-B standard.

*Port Security:* Ensure that the edge switch supports/complies with the following (remotely) minimum requirements:

- Ability to configure static MAC addresses access;
- Ability to disable automatic address learning per ports; know hereafter as Secure Port. Secure Ports only forward; and
- Trap and alarm upon any unauthorized MAC address and shutdown for programmable duration. Port shutdown requires administrator to manually reset the port before communications are allowed.

#### **F. Management Capabilities:**

Ensure that the edge switch supports 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:

- An STP healing/convergence rate that meets or exceeds specifications published in the IEEE 802.1 D standards;
- An RSTP healing/convergence rate that meets or exceeds specifications published in the IEEE 802.1w standard;

- An Ethernet edge 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 (254 simultaneous);
- A forwarding/filtering rate that is a minimum of 14,880 packets per second for 10 megabits per second, 148,800 packets per second for 100 megabits per second and 1,488,000 packets per second for 1000 megabits per second;
- A minimum 4-kilobit MAC address table;
- Support of Traffic Class Expediting and Dynamic Multicast Filtering.
- Support of, at a minimum, snooping of Version 2 & 3 of the Internet Group Management Protocol (IGMP);
- Support of remote and local setup and management via telnet or secure Web-based GUI and command line interfaces; and
- Support of the Simple Network Management Protocol (SNMP). Verify that the Ethernet edge switch can be accessed using the resident EIA-232 management port, a telecommunication network, or the Trivial File Transfer Protocol (TFTP).

*Network Capabilities:* Provide an edge switch that supports/complies with the following minimum requirements:

- Provide full implementation of IGMPv2 snooping (RFC 2236);
- Provide full implementation of SNMPv1, SNMPv2c, and/or SNMPv3;
- Provide support for the following RMON-I groups, at a minimum:
  - Part 1: Statistics
  - Part 2: History
  - Part 3: Alarm
  - Part 9: Event
- Provide support for the following RMON-2 groups, at a minimum:
  - Part 13: Address Map
  - Part 16: Layer Host
  - Part 17: Layer Matrix
  - Part 18: User History
- Capable of mirroring any port to any other port within the switch;
- Meet the IEEE 802.1Q (VLAN) standard per port for up to four VLANs;
- Meet the IEEE 802.3ad (Port Trunking) standard for a minimum of two groups of four ports;
- Password manageable;
- Telnet/CLI;
- HTTP (Embedded Web Server) with Secure Sockets Layer (SSL); and
- Full implementation of RFC 783 (TFTP) to allow remote firmware upgrades.

*Network Security:* Provide an edge switch that supports/complies with the following (remotely) minimum network security requirements:

- Multi-level user passwords;
- RADIUS centralized password management (IEEE 802.1X);
- SNMPv3 encrypted authentication and access security;
- Port security through controlling access by the users: ensure that the Ethernet edge switch has the capability to generate an alarm and shut down ports when an unauthorized user accesses the network;
- Support of remote monitoring (RMON-1&2) of the Ethernet agent; and



- Support of the TFTP and SNTP. Ensure that the Ethernet edge switch supports port mirroring for troubleshooting purposes when combined with a network analyzer.

**G. Electrical Specifications:**

Ensure that the edge switch operates and power is supplied with 115 volts of alternating current (VAC). Ensure that the edge switch has a minimum operating input of 110 VAC and a maximum operating input of 130 VAC. Ensure that if the device requires operating voltages other than 120 VAC, supply the required voltage converter. Ensure that the maximum power consumption does not exceed 50 watts. Ensure that the edge switch has diagnostic light emitting diodes (LEDs), including link, TX, RX, speed (for Category 5E ports only), and power LEDs.

**H. Environmental Specifications:**

Ensure that the edge switch performs all of the required functions during and after being subjected to an ambient operating temperature range of -30 degrees to 165 degrees Fahrenheit as defined in the environmental requirements section of the NEMA TS 2 standard, with a noncondensing humidity of 0 to 95%.

Provide certification that the device has successfully completed environmental testing as defined in the environmental requirements section of the NEMA TS 2 standard. Provide certification that the device meets the vibration and shock resistance requirements of Sections 2.1.9 and 2.1.10, respectively, of the NEMA TS 2 standard. Ensure that the edge switch is protected from rain, dust, corrosive elements, and typical conditions found in a roadside environment.

The edge switch shall meet or exceed the following environmental standards:

- IEEE 1613 (electric utility substations)
- IEC 61850-3 (electric utility substations)
- IEEE 61800-3 (variable speed drive systems)
- IEC 61000-6-2 (generic industrial)
- EMF – FCC Part 15 CISPR (EN5502) Class A

**I. Ethernet Patch Cable:**

Furnish a factory pre-terminated/pre-connectorized Ethernet patch cable with each edge switch. Furnish Ethernet patch cables meeting the following physical requirements:

- Five (5)-foot length
- Category 5e or better
- Factory-installed RJ-45 connectors on both ends
- Molded anti-snap hoods over connectors
- Gold plated connectors

Furnish Fast Ethernet patch cords meeting the following minimum performance requirements:

- TIA/EIA-568-B-5, Additional Transmission Performance Specifications for 4-pair 100  $\Omega$  Enhanced Category 5 Cabling
- Frequency Range: 1-100 MHz
- Near-End Crosstalk (NEXT): 30.1 dB
- Power-sum NEXT: 27.1 dB
- Attenuation to Crosstalk Ratio (ACR): 6.1 dB
- Power-sum ACR: 3.1 dB

- Return Loss: 10dB
- Propagation Delay: 548 nsec

**1.3.CONSTRUCTION METHODS**

**A. General:**

Ensure that the edge switch is UL listed.

Verify that network/field/data patch cords meet all ANSI/EIA/TIA requirements for Category 5E and Category 6 four-pair unshielded twisted pair cabling with stranded conductors and RJ45 connectors.

Contact the Signal Shop a minimum of 5 days prior to installation for the most current edge switch IP Address, VLAN, subnet mask, default gateway and configuration files.

**B. Edge Switch:**

Mount the edge switch inside each field cabinet by securely fastening the edge switch to the upper end of the right rear vertical rail of the equipment rack using manufacturer-recommended or Engineer-approved attachment methods, attachment hardware and fasteners.

Ensure that the edge switch is mounted securely in the cabinet and is fully accessible by field technicians without blocking access to other equipment. Verify that fiber-optic jumpers consist of a length of cable that has connectors on both ends, primarily used for interconnecting termination or patching facilities and/or equipment.

**1.4.MEASURMENT AND PAYMENT**

*Ethernet edge switch* will be measured and paid as the actual number of Ethernet edge switches furnished, installed, and accepted.

No separate measurement will be made for Ethernet SFP Modules, Ethernet patch cable, power cord, mounting hardware, nuts, bolts, brackets, or edge switch programming as these will be considered incidental to furnishing and installing the edge switch.

Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>
Ethernet Edge Switch.....	Each

**2. 900 MHZ SERIAL/ETHERNET SPREAD SPECTRUM RADIO**

**2.1. DESCRIPTION**

Furnish and install a 900 MHz Serial /Ethernet spread spectrum radio system with all necessary hardware and signage in accordance with the plans and specifications to provide a data link between field devices (i.e. traffic signal controllers, dynamic message signs, etc.). Provide a radio system with a bi-directional, full duplex communications channel between 2 “line-of-sight” antennas using license free, spread spectrum technology operating in the 902-928 MHz frequency band.

Furnish material and workmanship conforming to the NEC, the NESC, UL or a third-party listing agency accredited by the North Carolina Department of Insurance and all local safety laws. Comply with all regulations and codes imposed by the owner of affected utility poles.

**2.2. MATERIALS**

**A. 900 MHz Serial/Ethernet Spread Spectrum Radio**

Furnish 902 – 928 MHz Serial/Ethernet Spread Spectrum Radios that comply with the following table:

<b>SERIAL/ETHERNET SPREAD SPECTRUM RADIO REQUIREMENTS</b>	
Frequency Range	902 – 928 MHz
Technology	Frequency Hopping Spread Spectrum
Operational Modes	master; repeater; repeater/slave; slave; point-to-point; point-to-multipoint; peer-to-peer
Operating Voltage	Power Cube: 6 – 30 VDC
Operating Temperature/Humidity	-40°C to +75°C; 0 to 95% non-condensing
<b>Transmitter</b>	
Output Power	1 Watt (Max)
Modulation	Frequency Shift Keying
Hopping Patterns /Channels	Minimum of 15/Minimum of 25
Occupied Bandwidth	402.8 kHz
Data Rate(over the air)	867Kbps
<b>Receiver</b>	
Sensitivity	-100 dBm @ 10 <sup>6</sup> BER @ 614Kbps OR -100 dBm @ 10 <sup>4</sup> BER @ 1.1 Mbps
<b>Data Transmission</b>	
Error Detection	32 Bit CRC, retransmit on error
Data Encryption	128-bit
Authentication	Radius Compliant
System Gain	130 dB
<b>LED's</b>	
Signal Strength	Data Port Indicators consisting of a minimum of 3 LED's grouped

Indicators	together representing a Low, Medium or High Signal Strength with regards to the communications link with another targeted radio. Units must be supplied with external labels to identify how to interpret the Signal Strength. OR Combinations of the Front Panel LED indications with flashing rates and LED Colors can be used to identify the signal strength. Units must be supplied with external labels to identify how to interpret the Signal Strength.
Front Panel Indicators	Power COM 1 COM 2 OR Carrier Detect Transmit Clear to Send
Management & Network Protocols	HTTP, SNMP, Local Console, IP Auto Discover
<b>Data Interface</b>	
Antenna	Threaded Connector (Nickel and/or Silver Plated Brass)
Port to Connected Devices	Serial - Dual - DB 9 Female Ports: RS232/422/485 Ethernet: RJ-45 (10/100 BaseT, auto crossover)
Network Protocols	IEEE 802.3; HTTP, TCP, UDP, ARP, IMCP, FTP
Radio Frequency Signal Jumper	RG-58 coaxial cable (6' long) with one end supplied with RF Threaded Connector that is compatible with the supplied radio. The other end furnished with a Standard N-Type Male Connector to mate with the lightning arrestor.
Certification	FCC

**B. Software**

Furnish units with a Field Set-up Software. The Field Set-up Software shall be a Window Based™ software program that uses a GUI (Graphical User Interface) to provide the following features at a minimum: remote programming, remote radio configuration, remote maintenance, remote diagnostics and a spectrum analyzer.

Furnish software supplied with drivers to allow easy set-up with all industry standard traffic signal controllers, including 2070E controllers containing custom software written specifically for the North Carolina Department of Transportation. Manufacturer is required to develop additional drivers (at no charge) for other equipment not supported by their existing pre-written Driver Package when needed. Drivers may be needed for other equipment such as industry standard radar and video detection packages, and Dynamic Message Sign controllers.

**C. Directional Antenna (Yagi)**

Furnish a directional antenna of welded construction that allows for vertical and horizontal polarization.

Furnish mounting hardware with the antenna that will secure the antenna to a mounting pipe that has a 1 ½ inch Nominal Pipe Size (approximately 2 inches OD pipe diameter), as recommended by the manufacturer of the antenna and as approved by the Engineer.

Furnish an 8.5 dBd (11 dBi) Gain or 13 dBd (15.1 dBi) Gain antenna that complies with following Tables:

<b>900 MHz - YAGI ANTENNA - (8.5 dBd / 11 dBi Gain)</b>	
<b>Property</b>	<b>Requirement</b>
Frequency Range	896 - 940 MHz
Nominal Gain	8.5 dBd / 11 dBi
Front to Back Ratio	18 dB
Horizontal Beamwidth (at half power points)	65 degree
Vertical Beamwidth (at half power points)	55 degree
Power Rating, UHF Frequency	200 Watts
Lightning Protection	DC Ground
Termination	Coaxial pigtail with a Standard N-Type Female Connector
Impedance	50 Ω
Rated Wind Velocity	125 mph
Rated Wind Velocity (with 0.5" radial ice)	100 mph
Projected Wind Surface Area (flat plane equivalent)	0.26 ft/sq
Number of Elements	6
Allows for vertical or Horizontal polarization	Yes
Welded construction	Yes

<b>900 MHz - YAGI ANTENNA – (13 dBd / 15.1 dBi Gain)</b>	
<b>Property</b>	<b>Requirement</b>
Frequency Range	896 - 940 MHz
Nominal Gain	13 dBd / 15.1 dBi
Front to Back Ratio	20 dB
Horizontal Beam width (at half power points)	40 degree
Vertical Beam width (at half power points)	35 degree
Power Rating, UHF Frequency	200 Watts
Lightning Protection	DC Ground
Termination	Coaxial pigtail with a Standard N-Type Female Connector
Impedance	50 Ω
Rated Wind Velocity	125 mph
Rated Wind Velocity (with 0.5" radial ice)	100 mph
Projected Wind Surface Area (flat plane equivalent)	0.46 ft/sq
Number Elements	13
Allows for Vertical or Horizontal polarization	Yes
Welded construction	Yes

**D. Omnidirectional Antenna**

Furnish an omnidirectional antenna of a solid, single piece construction. Furnish mounting hardware with the antenna that will secure the antenna to a mounting pipe that has a 1 1/2 inch Nominal Pipe Size (approximately 2 inches OD pipe diameter), as recommended by the manufacturer of the antenna and as approved by the Engineer.

Furnish a 3 dBd (5 dBi) Gain or 6 dBd (8.1 dBi) Gain antenna that complies with the following Tables:

<b>900 MHz – OMNI ANTENNA - (3 dBd / 5 dBi Gain)</b>	
<b>Property</b>	<b>Requirement</b>
Frequency Range	902 - 928 MHz
Nominal Gain	3 dBd / 5 dBi
Termination	Standard N-Type Female Connector
Impedance	50 ohms
VSWR	1.5:1
Vertical Beam Width	33 degrees (3dBd Gain)
Lightning Protection	DC Ground
Power Rating, UHF Frequency	100 Watts
Rated Wind Velocity	125 mph
Solid, single piece construction	Yes
Mount in a vertical direction and limit to vertically polarized RF systems	Yes

<b>900 MHz – OMNI ANTENNA - (6 dBd / 8.1 dBi Gain)</b>	
<b>Property</b>	<b>Requirement</b>
Frequency Range	902 - 928 MHz
Nominal Gain	6 dBd / 8.1dBi
Termination	Standard N-Type Female Connector
Impedance	50 Ω
VSWR	1.5:1
Vertical Beam Width	17 degrees
Lightning Protection	DC Ground
Power Rating, UHF Frequency	100 Watts
Rated Wind Velocity	125 mph
Solid, single piece construction	Yes
Mount in a vertical direction and limit to vertically polarized RF systems	Yes

**E. Antenna Mounting Hardware Kit**

Furnish an antenna mounting kit to support the antenna when attached to a metal pole, mast arm or wood pole.

Ensure the Antenna Mounting Hardware Kit includes at least one 96 inch galvanized steel cable with a stainless steel bolt, nut and lock washer assembly on each end. Ensure the pole base plate accepts a 1 1/2 inch NPT aluminum pipe, and provides a surface that is at least 6 3/4 inches long x 4 1/4 inches to provide contact with the pole. Ensure the pole base plate is designed to allow both

ends of the 96 inch galvanized cables to be secured and tightened to the base plate. Provide a 90 degree elbow with internal threads on both ends to accommodate 1 1/2 inch NPT aluminum pipes. Provide a 1 1/2 inch x 18 inch long aluminum pipe threaded on both ends and a 1 1/2 inch x 24 inch aluminum pipe threaded on one end with an end cap.

**F. Coaxial Cable**

Furnish 400 Series coaxial cable to provide a link between the antenna and the lightning arrester that comply with following Table.

<b>PROPERTIES AND REQUIREMENTS OF COAXIAL CABLE</b>	
<b>Property</b>	<b>Requirement</b>
Attenuation (dB per 100 ft) @ 900 MHz	3.9 dB
Power Rating @ 900 Mhz	0.58 kW
Center Conductor	0.108" Copper Clad Aluminum
Dielectric: Cellular PE	0.285"
Shield (approx.)	Aluminum Tape - 0.291" Tinned Copper Braid - 0.320"
Jacket	Black UV protected polyethylene
Bend Radius	1"
Impedance	50 Ω
Capacitance	23.9 pf/ft
Water Blocking	Yes
Supply Coaxial Cable on 500 ft Reel	Yes

**G. Standard N-Type Male Connector**

Furnish Standard N-Type Male Connector(s) of proper sizing to mate with the 400 series coaxial cable and use a crimping method to secure the connector to the coaxial cable. Furnish a connector that complies with the following Table.

<b>REQUIREMENTS OF STANDARD N-TYPE MALE CONNECTOR</b>	
<b>Description</b>	<b>Requirement</b>
Center Contact	Gold Plated Beryllium Copper (spring loaded – Non-solder)
Outer Contact	Silver Plated Brass
Body	Silver Plated Brass
Crimp Sleeve	Silver Plated Copper
Dielectric	Teflon PTFE
Water Proofing Sleeve	Adhesive Lined Polyolefin – Heat Shrink
Attachment Size	Crimp Size 0.429" (minimum) hex
<b>Electrical Property</b>	<b>Requirement</b>
Impedance	50 Ω
Working Voltage	Yes
Insertion loss	Yes
VSWR	

**H. Coaxial Cable Shield Grounding and Weatherproofing Kits**

- (1) Furnish a Coaxial Cable Shield Grounding Kit containing components that will adequately bond and ground the cable shield to the pole ground. Ensure the grounding kit complies with MIL-STD-188-124A for coaxial cable and protects the cable from lightning currents of at least 200kA. Ensure each kit is supplied, as a minimum, with the following:
  - (a) Preformed Strap: 24 Gauge copper strap that is at least 1 5/8 inch long and is sized to mate with the 400 series coaxial cable
  - (b) Tensioning Hardware: Copper nuts and lock washers
  - (c) Grounding Lead Cable: #6 AWG, stranded, insulated copper wire
- (2) Furnish a Weatherproofing Kit containing components that will protect the coaxial cable shield grounding system against the ingress of moisture and prevent vibrations from loosening the connections. Ensure the weatherproofing kit is supplied, as a minimum, with the following:
  - (a) Butyl Mastic Tape: 3 3/4 inches wide by 24 inches long (approximately)
  - (b) Electrical Tape: 2 inches wide by 20 inches long (approximately)

**I. Lightning Arrestor**

Furnish a lightning arrestor installed in line between each antenna and its designated radio modem inside the equipment cabinet in accordance with the following Table. Furnish lightning arrestor with multistrike capability, low strike throughput energy, flange mount and bulkhead mount options and a standard N-Type female connector on both the surge-side and protected-side connectors.

<b>PROPERTIES OF LIGHTNING ARRESTOR</b>	
<b>Property</b>	<b>Requirement</b>
Surge (8/20µs Waveform) Maximum Strike Multiple Strike	40kA Max 20kA Multiple
Frequency Range	698MHz to 2.7GHz
Return Loss/VSWR	≤-26dB (VSWR≤ 1.11:1)
Insertion Loss	≤0.1 dB over frequency range
Continuous Power	500 w @ 920MHz (750 W at 122° F)
Let Through Voltage	≤± 200m Volts for 3kA @ 8/20 µs Waveform
Throughput Energy	≤0.5 nJ for 3kA @ 8/20 µs Waveform
Temperature	-40 to 185° F Storage/Operating 122° F
Vibration	1G at 5 Hz up to 100Hz
Unit Impedance	50 Ω
Standard N-Type Female Connector	On both the surge side and protected side connectors
Installation	Bi-Directional
Mounting	Bulkhead bracket with O-Ring, Lock Washer and Nut

**J. Coaxial Cable – Power Divider (Splitter)**

Furnish a coaxial cable power divider for repeater radio sites in accordance with the following Table. Ensure the power divider accommodates a single primary input RF source and divides/splits the signal (power) equally between 2 output ports.



<b>PROPERTIES OF COAXIAL CABLE - POWER DIVIDER</b>	
<b>Property</b>	<b>Requirement</b>
Power Division	2 - Way
Frequency	900 - 1100 MHz
Insertion Loss	0.22 dB
Impedance	50 $\Omega$
VSWR ref. to 50 Ohm (max)	1.3:1
Max. Input Power	500 Watts
Connectors	Standard N-Type Female

**K. Disconnect Switch**

Furnish a double pole, single throw snap switch in a weatherproof outlet box with cover, suitable for use in wet locations. Ensure outlet box and cover supports a lockout tag device. Ensure outlet box includes one 1/2 inch diameter hole in back of box. Furnish mounting hardware, sealing gaskets and lockout tag.

**L. Warning Signs and Decal**

Furnish “RF Warning Sign” and “Decal” at locations called for in the plans. Furnish mounting hardware to secure the sign to either metal or wood poles.”

**2.3. CONSTRUCTION METHODS**

**A. General**

Perform a radio path Site Survey test before installing any equipment. Ensure the test evaluates the signal strength (dBm), fade margin (dB), signal-to-noise ratio, data integrity (poll test) and a complete frequency spectrum scan. Ensure the radio path site survey test is performed using the supplied brand of radio equipment to be deployed. Provide the test results to the Engineer for review and approval. Submit copies of the test results and colored copies of the frequency spectrum scan along with an electronic copy of this information. The Engineer will approve final locations of antennas.

For 900 MHz Serial/Ethernet radios install an Ethernet cable, radio frequency signal jumper, lightning arrestor, coaxial cable, coaxial cable shield grounding and weatherproofing kit, antenna and antenna mounting hardware. If the installation requires a dual antenna configuration to accommodate communications in multiple directions install a power divider/splitter, antenna splitter cables and additional antenna and mounting hardware.

Install the antenna in such a manner that avoids conflicts with other utilities (separation distances in accordance with the guidelines of the NESC) and as specified in the antenna manufacturer’s recommendations. Secure the antenna mounting hardware to the pole and route the coaxial cable such that no strain is placed on the N-Type male coaxial connectors. On wood pole installations, bond the antenna mounting hardware to the pole ground using #6 AWG bare copper wire using split bolt or compression type fitting.

Install the coaxial cable shield grounding system by carefully removing the outer jacket of the coaxial cable without damaging the cable shield. Install the shield grounding system following the

cable manufacturer's recommendations. Install and weatherproof the connection using the appropriate weatherproofing materials and following the manufacturer's recommendations. On wood poles, secure the #6 AWG grounding lead cable to the pole ground using split bolt or compression type fitting or a method approved by the Engineer. On metal poles, secure the #6 AWG grounding lead cable to the pole using a method approved by the Engineer.

Do not exceed the one inch bend radius of the coaxial cable as it traverses from the cabinet to the antenna assembly. Connect the lightning arrestor to the coaxial cable in the equipment cabinet. Properly ground and secure the arrestor in the cabinet. Permanently label all cables entering the cabinet. Ensure the power supply for the radio system is not connected to the GFCI receptacle circuit located in the cabinet. Place a copy of all manufacturer equipment specifications and instruction and maintenance manuals in the equipment cabinet.

At certain locations it may be necessary to integrate the radio system with a fiber optic system. Follow the details shown in the fiber optic splice plans.

### **B. Disconnect Switch**

At all locations, where the antenna is mounted on a joint use pole, install a double pole, snap switch to remove power from the spread spectrum radio system. Do not mount weatherproof box on the traffic signal cabinet door. Drill a hole in the side of the traffic signal cabinet. Mount the outlet box over the hole using a half inch chase nipple and bushings. Ensure sealing gaskets are in place and no water can enter the cabinet. Securely mount the weatherproof outlet box with additional mounting screws. Bond the outlet box to the equipment ground bus. See plans for approximate mounting height. Run the power supply cord of the spread spectrum radio unit into the outlet box and connect to switch. Securely attach power supply cord to equipment rack. Install disconnect switch with lockout tag cover. If the antenna is mounted on a joint use pole, the "disconnect switch" is required.

Do not install power supply for the radio in a GFCI protected outlet.

### **C. Warning Sign(s) and Decal(s)**

At all locations, where the antenna is mounted on a joint use pole, secure a warning sign to pole. Mount warning sign(s) at locations called for in the plans. Ensure there are no conflicts between the warning sign and surrounding utilities. Mount warning sign to be easily viewed. Do not mount warning sign under pole grounds or conduit. If the antenna is mounted on a joint use pole, the RF warning sign is required.

Clean and remove any dirt or oil on traffic cabinet before placing decal. Place decal adjacent to the disconnect switch located on the outside of traffic cabinet. If the antenna is mounted on a joint use pole, the decal is required.

**2.4.MEASURMENT AND PAYMENT**

*900 MHz Serial/Ethernet Spread Spectrum Radio* will be measured and paid as the actual number of 900 MHz serial/Ethernet spread spectrum radios furnished, installed and accepted. This item includes the appropriate sized antenna(s), radio, power supplies, disconnect/snap switch, signs, decals, Ethernet cable, coaxial cable, lightning arrestor, radio frequency signal jumper, coaxial cable power divider (splitter), coaxial cable connectors, coaxial cable shield grounding system with weatherproofing, labeling and any integration between the radio system and a Ethernet switch if necessary, installation materials and configuration software necessary to complete this work, including the radio path Site Survey test and warranties.

Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>
900MHz Serial/Ethernet Spread Spectrum Radio	Each