



STATE OF NORTH CAROLINA  
DEPARTMENT OF TRANSPORTATION

BEVERLY EAVES PERDUE  
GOVERNOR

EUGENE A. CONTI, JR.  
SECRETARY

April 6, 2011

**Addendum No. 1**

RE: Contract ID C202598

WBS # 34871.3.3

F.A. # NHS-0052(32)

**Forsyth County (U-2826B)**

US-52 from Greyhound Ct. to SR-2264 (Akron Dr.) including Martin Luther King Jr. Drive in Winston-Salem

**April 19, 2011 Letting**

To Whom It May Concern:

Reference is made to the plans and proposal furnished to you on this project.

The following revision has been made to the plans:

Sheet No. 3 (1 of 2) has been revised to reflect the quantity changes shown below. Please void Sheet No. 3 (1 of 2) in your plans and staple the revised Sheet No. 3 (1 of 2) thereto.

The following revision has been made to the proposal form:

On Page No. 231 the project special provision entitled "Spread Spectrum Wireless Radio" was revised. Please void Page Nos. 231 through 242 in your proposal and staple the revised Page Nos. 231 through 242 thereto.

On Page No. 303 the project special provision entitled "DMS Assemblies" was revised and sheet Nos. 306-A through 306-D have been added. Please void Page Nos. 303 through 307 in your proposal and staple the revised Page Nos. 303 through 307 thereto.

On the item sheets the following pay item quantities have been revised.

<u>Item</u>	<u>Description</u>	<u>Old Quantity</u>	<u>New Quantity</u>
22-1489000000-E-610	Asphalt Concrete Base Course, Type B25.0B	8,680 TON	3,370 TON
28-1560000000-E-620	Asphalt Binder for Plant Mix, Grade PG 64-22	1,190 TON	960 TON

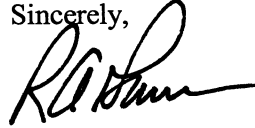
**MAILING ADDRESS:**  
NC DEPARTMENT OF TRANSPORTATION  
CONTRACT STANDARDS AND DEVELOPMENT UNIT  
1591 MAIL SERVICE CENTER  
RALEIGH NC 27699-1591

TELEPHONE: 919-250-4128  
FAX: 919-250-4119  
WEBSITE: [WWW.NCDOT.ORG](http://WWW.NCDOT.ORG)

**LOCATION:**  
CENTURY CENTER COMPLEX  
ENTRANCE B-2  
1020 BIRCH RIDGE DRIVE  
RALEIGH NC 27610

The Expedite File has been updated to reflect this revision. Please download the Expedite Addendum File and follow the instructions for applying the addendum. Bid Express will not accept your bid unless the addendum has been applied.

Sincerely,



R. A. Garriss, PE  
Contract Officer

RAG/jjr  
Attachments

cc: Mr. Jon Nance, PE  
Mr. Ron Hancock, PE  
Mr. Pat Ivey, PE  
Ms. D. M. Barbour, PE  
Mr. Art McMillan, PE  
Mr. J. V Barbour, PE  
Mr. Greg Fuller, PE  
Ms. Lori Strickland

Mr. R.E. Davenport, PE  
Ms. Natalie Roskam, PE  
Mr. Larry Strickland  
Ms. Penny Higgins  
Ms. Jaci Kincaid  
Mr. Ronnie Higgins  
Project File (2)

## 14. SPREAD SPECTRUM WIRELESS RADIO

### 14.1. DESCRIPTION

Furnish and install a spread spectrum wireless Ethernet radio system with all necessary hardware and signage in accordance with the Plans and Project Special Provisions to provide a data link between field devices. Provide a radio system with a bi-directional, full duplex communications channel between multiple “line-of-sight” antennas to the fiber optic network using license free, spread spectrum technology. Radio systems for digital data-only devices shall operate at the 900 MHz frequency and radio systems for transmission of compressed digital video shall operate at the 2.4 / 5.8 GHz frequency.

Furnish material and workmanship conforming to the *National Electrical Code* (NEC), the *National Electrical Safety Code* (NESC), Underwriter’s Laboratories (UL) or a third-party listing agency accredited by the North Carolina Department of Insurance, and all local safety codes in effect on the date of advertisement. Comply with all regulations and codes imposed by the owner of affected utility poles.

### 14.2. MATERIALS

#### A. 900MHz Wireless Radio System:

Furnish license free 902 – 928 MHz radio modem with antennas, coaxial cable and mounting hardware, and configuration software. Design radio modem to work in “point-to-point”, “point-to-multipoint”, “multipoint-to-point”, and “multipoint-to-multipoint” configurations. Ensure the spread spectrum wireless radio meets the following minimum requirements:

- License free (ISM) Spread Spectrum radio band (902 – 928 MHz)
- Frequency Hopping Technology (Direct Sequence Spread Spectrum Technology is not acceptable)
- Bi-Directional, Full Duplex
- Programmable Radio Frequency (RF) output levels of 1 mW, 10 mW, 100 mW, or 1 Watt
- A minimum of 139 user-selectable radio frequency channels, with 62 available hopping sequences (2 non-overlapping)
- 10/100 BaseT Ethernet interface that complies with IEEE 802.3 and is capable of operating from 1200 bps up to 1.1 Mbps when deployed in the configuration and installed conditions of this project
- RJ-45 connector for Ethernet port
- Maximum of 8 mSec. end-to-end latency
- 16 bit Cyclic Redundancy Check (CRC) error checking with auto re-transmit
- Built-in store-and-forward (single radio repeater – back to back radio set-ups are not allowed to accomplish this function)
- 32 Bit encryption
- Receiver Sensitivity of  $-110$  dBm @  $10^{-6}$  BER
- Antenna port: Reverse Polarity - Threaded Normalized Connector-Female (RP TNC-F) antenna connector
- Front Panel LED indicators
  - Power

- Transmit Data
- Receive Data
- Data Port Indicator
- Operating temperature of -40 to +176 degrees F at 0 to 95% Humidity
- Power supply requirements:
  - Wall Adapter: 120 VAC UL/CSA wall cube plug-in module with 12 VDC, 1 Amp, nominal output.
  - Typical current draw of no greater than 355 mA when powered with 12 VDC input, and transmitting 1 Watt of RF output power.
  - Radio Sleep mode with a maximum current draw of <1 $\mu$ A.
- Shelf mounted design not to exceed 9" long x 2" wide x 5" high

Furnish a Radio Frequency Signal Jumper constructed of an RG-58 Coaxial Cable with Reverse Polarity - Threaded Normalized Connector-Male (RP TNC-M) on one end for connection to a radio unit and a Standard N-Type Male Connector on the other end for connection to the lightning arrester. Provide the jumper in 6 foot lengths.

Ensure that installing the wireless radio system with a fully functional field device (i.e. controller) does not require any field device modifications with regards to hardware or software.

**B. 2.4/5.8 GHz Wireless Radio System:**

Furnish license free 2.4/5.8 GHz wireless broadband Ethernet radio system with antennas, cabling and mounting hardware, and configuration software. Design radio modem to work in "point-to-point", "point-to-multipoint", "multipoint-to-point", and "multipoint-to-multipoint" configurations. Ensure the wireless broadband Ethernet radio meets the following minimum requirements:

- Frequency – 2.4 GHz ISM & 5.8 GHz ISM, Dynamic Frequency Selection (DFS)
- Wireless Technology – OFDM and DSSS
- Range – greater than 20 Miles (LOS)
- Receiver Sensitivity (dBm) – -70 to -93
- Bandwidth – minimum of 6 Mbps at -94 dBm, capable of 54 Mbps at -74 dBm
- Interface – 10/100 Base-T Ethernet with RJ-45 connector
- Networking – STP, DHCP, NTP, Firewall and NAT, Routing, QOS, VPN, VLAN, SNMP
- Standards Compliance – 802.3, 802.11i, 802.11a
- Security – AES-CCM encryption, 64 bit and 128 bit WEP encryption, WPA, WPA2, , MAC address authentication
- Transmit Power – 23 dB, 600 mW
- Power System – Power-over-Ethernet  
 Input: 100-240 AC, 50-60 Hz, Output: 18V, .4A.
- Operating Temperature – -20°F to 140°F
- Operating Humidity – Max 95% non-condensing
- Shelf mounted design

**C. Wireless Repeater Standalone Radio System:****B.1 General:**

Furnish an operational wireless repeater radio system installed in a NEMA Type 3R enclosure for pole mounting. As a minimum, ensure the Wireless repeater radio meets the specifications provided above.

**B.2 Cabinet:**

Furnish the cabinet shell constructed from unpainted, natural aluminum. Ensure that all non-aluminum hardware on the cabinet is stainless steel or an approved non-corrosive alternate. Ensure that each exterior cabinet plane surface is constructed of a single sheet of aluminum and is seamless. Provide continuous welds made from the inside wherever possible. On the exterior, provide joints that are smooth and flush. Ensure that no screws, bolts, or rivets protrude to the outside of the cabinet shell.

Ensure that all components are arranged for easy access during servicing.

Provide sufficient size so the installed equipment will not occupy more than 60 percent of the total cabinet volume.

Provide a handle and three point latching mechanism designed to be disassembled using hand tools. Provide a shaft connecting the latching plate to the door handle by passing through the door within a bushing, bearing, or equivalent device. Provide a latching plate at least 1/8 inch thick and that mates securely with the lock bolt. Provide a lock bolt with a flat end (no bevel) and that has at least 1/4 inch of length in contact with the latching plate.

Ensure that the handle and lock are positioned so that the lock does not lie in the path of the rotating handle as the door is unlatched and that the handle points down in the latched position.

Provide a main door opening that encompasses the full frontal area of the cabinet shell. Ensure that the cabinet shell is sturdy and does not exhibit noticeable flexing, bending or distortion under normal conditions, except that a minor amount of flexing is permitted in the main door when the cabinet is open. In such case, the flexing must not result in permanent deformation of the door.

A police panel door is not required for this cabinet.

Provide a roof with a slope from front to back at a minimum ratio of 1 inch drop per 2 feet. Ensure the cabinet is vented at the top and in the door. Supply a cabinet door assembly with a louvered air vent and standard-sized fiberglass air filter.

Provide one equipment shelf in the cabinet that extends the practical width of the cabinet. Ensure that the shelf can be moved up and down within the cabinet. Do not locate permanently mounted equipment in such a way that will restrict access to terminals.

**B.3 Cabinet Electrical:**

Furnish a cabinet with two 15 Amp, single pole circuit breakers for power distribution. Ensure one 15 Amp auxiliary breaker provides the electrical circuit to accommodate a thermostatically controlled cabinet exhaust fan, door activated fluorescent light, and one GFCI convenience receptacle.

Ensure the second 15 Amp equipment breaker provides the electrical circuit to accommodate the electrical equipment installed in the cabinet with a minimum of two duplex receptacles.

Provide a two-stage power line surge protector between the electrical equipment receptacles and the 15 Amp equipment breaker. Ensure a maximum continuous current of at least 10A at 120V. Ensure that the device can withstand a minimum of 20 peak surge current occurrences at 20,000A for an 8x20 microsecond waveform. Provide a maximum clamp voltage of 280V at 20,000A with a nominal series inductance of 200 $\mu$ h. Ensure that the voltage does not exceed 280V. Provide devices that comply with the following:

Frequency (Hz)	Minimum Insertion Loss (dB)
60	0
10,000	30
50,000	55
100,000	50
500,000	50
2,000,000	60
5,000,000	40
10,000,000	20
20,000,000	25

Ensure the two-stage power line surge protector will allow connection of a radio frequency interference filter between the two stages of the device. Ensure the radio frequency interference filter minimizes interference generated in the cabinet in both the broadcast and aircraft frequencies. Ensure the filter(s) provide attenuation of at least 50 decibels over a frequency range of 200 kilohertz to 75 megahertz. Furnish a filter that is hermetically sealed in an insulated metal case. Ensure the filter is rated at least at the rated current of the main circuit breaker, 125-volts, 60Hz.

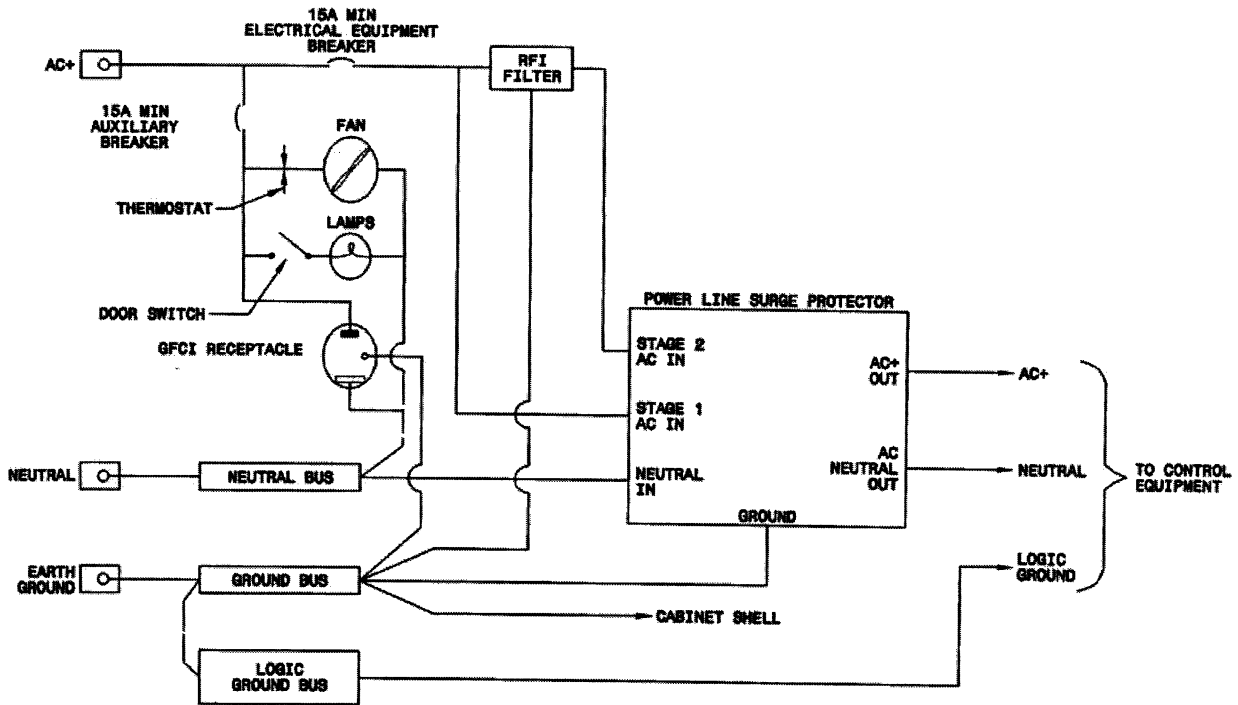
Furnish a fluorescent fixture with lamps mounted above the shelf to light the equipment area.

Fasten all wiring and harness supports to the cabinet with screws or other removable mechanical means. Do not use adhesives.

Do not locate terminals on the underside of the shelf or at other places where they are not readily visible and accessible, or where they may be a hazard to personnel. Provide a clear plastic guard for exposed 120-volt AC terminals on the power panel.

Provide a neutral that is not connected to the earth ground or the logic ground anywhere within the cabinet. Ensure that the earth ground bus and the neutral ground bus each have ten compression type terminals each of which can accommodate wires ranging from number 14 through number 4.

Furnish a cabinet wiring schematic to be placed in the cabinet. Reference the cabinet wiring schematic below for additional details:



**D. Software:**

Furnish units with a Window Based™ software program that uses a GUI (Graphical User Interface) to provide “remote programming, radio configuration, remote maintenance, diagnostics and spectrum analyzer” features. Ensure the software will operate on Microsoft® Windows Operating Platforms: Windows XP at a minimum or latest available version. Provide configuration software that can be upgraded in the future at no additional charge.

Ensure the radio modem is configurable from a single location (i.e. master radio location) via supplied software (no extra cost). Furnish software supplied with drivers to allow easy set-up with all industry standard traffic signal controllers, including 2070 controllers containing custom software written specifically for the North Carolina Department of Transportation. Ensure the supplied software contains pre-written drivers for industry standard radar packages, Dynamic Message Sign controllers, and Closed Circuit Television camera controllers that will be utilized on this project.

**E. Directional Antenna (Yagi):**

For 900 MHz radio systems, furnish a 8.5 dBd Gain or 13 dBd Gain directional antenna that will allow the system to function as designed.

For 2.4 / 5.8 GHz radio systems, furnish a 13 dBd Gain directional antenna that will allow the system to function as designed.

All antennas furnished shall meet the following minimum specifications:

Lightning Protection	DC Ground
Termination	Coaxial pigtail with a Standard N-Type Female Connector
Rated Wind Velocity	125 mph
Rated Wind Velocity (with 0.5 inch radial ice)	100 mph
Allows for Vertical or Horizontal polarization	
Minimum separation distance from persons installing and using an active device	9"
Minimum separation distance from other RF sources including radios and antennas	6.5'
Welded construction	

Furnish mounting hardware with the antenna that will secure the antenna to a mounting pipe that has a 1.5" Nominal Pipe Size (approximately 2" OD pipe diameter), as recommended by the manufacturer of the antenna and as approved by the Engineer.

**F. Omni Directional Antenna:**

For 900 MHz radio systems, furnish a 3 dBd Gain or 6 dBd Gain omni directional antenna that will allow the system to function as designed.

For 2.4 / 5.8 GHz radio systems, furnish a 7.5 dBd Gain omni directional antenna that will allow the system to function as designed.

All antennas furnished shall meet the following minimum specifications:

Lightning Protection	DC Ground
Termination	Coaxial pigtail with a Standard N-Type Female Connector
Rated Wind Velocity	125 mph
Rated Wind Velocity (with 0.5 inch radial ice)	100 mph
Allows for Vertical or Horizontal polarization	
Minimum separation distance from persons installing and using an active device	9"
Minimum separation distance from other RF sources including radios and antennas	6.5'
Welded construction	

Furnish mounting hardware with the antenna that will secure the antenna to a mounting pipe that has a 1.5" Nominal Pipe Size (approximately 2" OD pipe diameter), as recommended by the manufacturer of the antenna and as approved by the Engineer.

**G. Antenna Mounting Hardware Kit:**

Furnish an antenna mounting kit to support the antenna when attached to a metal pole, mast arm, or wood pole. Furnish PELCO – "Antenna Mount, Cable Astro-Brac for Yagi Antenna" or an approved equivalent.

Ensure the Antenna Mounting Hardware Kit includes a minimum of a 96" galvanized cable with stainless steel bolt with a nut and lock washer assembly on each end. Ensure the pole base plate accepts a 1 1/2" NPT aluminum pipe, and provides a surface that is a minimum of 6 3/4 inch long by 4



¼” to provide contact with the pole. Ensure the pole base plate is designed to allow both ends of the 96” galvanized cable to be secured and tightened to the base plate. Provide a 90 degree elbow with internal treads on both ends to accommodate 1 ½” NPT aluminum pipes. Provide a 1 ½” \* 18” long aluminum pipe threaded on both ends and a 1 ½” \* 24” aluminum pipe threaded on 1 end with an end cap.

PELCO PART #'s	DESCRIPTION	QUANTITY
AB-3034-96-PNC	Astro-Brac Clamp Kit, 1 ½” NPS, Galv Cable, Alum	1
AB-0260	TUBE CAP, PLASTIC	1
SE-0436-18	NIPPLE, 1 ½” x 18” LONG, ALUM, THREADED ON BOTH ENDS	1
SE-0457-DS-PNC	ELL, SERRATED, 1 ½”, DOUBLE SET SCREW, DIE CAST ALUM	1
SE-0326-24	SUPPORT TUBE, SCH 40, 1 ½” NPS x 24” LONG, ALUM, THREADED ON ONE END	1

**H. Coaxial Cable:**

Furnish 400 Series coaxial cable to provide a link between the antenna and the lightning arrestor that meets the following minimum specifications:

Attenuation (dB per 100 feet) @ 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	Aluminum Tape – 0.291” Tinned Copper Braid – 0.320”
Jacket	Black UV protected polyethylene
Bend Radius	1” with less than 1 ohm impedance change at bend
Impedance	50 ohms
Capacitance per foot	23.9 pf/ft
End Connectors	Standard N-Type Male Connectors on both ends

**I. Standard N-Type Male Connector:**

Furnish Standard N-Type Male Connector(s) of proper sizing to mate with the 400 series coaxial cable and utilize a crimping method to secure the connector to the coaxial cable. Furnish a connector that meets the following minimum specifications:

- 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

Electrical Properties:

- Impedance: 50 ohms
- Working Voltage: 1000 vrms (max)
- Insertion loss:  $0.1 \times \sqrt{F}$ ghz
- VSWR. 1.25:1 (max) up to 3GHz

Provide instructions on properly installing the connector.

#### J. Coaxial Cable Shield Grounding and Weatherproofing Kits:

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 Specifications “Military Standard for Grounding, Bonding and Shielding” for coaxial cable and protects the cable from lightning currents in excess of 200kA. Ensure each kit is supplied, as a minimum, with the following:

- Preformed Strap: 24 Gauge copper strap that is a minimum of 1 5/8 inch long and is sized to mate with the 400 series coaxial cable
- Tensioning Hardware: Copper nuts and lock washers
- Grounding Lead Cable: #6 AWG, stranded, insulated copper wire
- Instructions on properly installing the shield grounding system

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:

- Butyl Mastic Tape: 3 3/4 inches wide by 24 inches long (approximately)
- Electrical Tape: 2 inch wide by 20 inches long (approximately)
- Instructions on properly installing the weatherproofing system

#### K. Lightning Arrestor:

Furnish a lightning arrestor installed in line between each antenna and its designated radio modem inside the equipment cabinet. Furnish a Polyphaser Model # DSXL-BF lightning arrestor or an approved equivalent that meets the following minimum specifications:

- Filter Type – DC Block (None gas tube design)
- Surge: 20kA, 800MHz to 2.0GHz  $\leq 1.1 : 1$  VSWR  
18kA, 800MHz to 2.3GHz  $\leq 1.1 : 1$  VSWR  
700MHz to 2.7GHz  $\leq 1.2 : 1$  VSWR
- Insertion Loss:  $\leq 0.1$  dB over frequency range
- Max Power: 500 w @ 920MHz (750 W @ at 122° F)
- RF Power: 300 Watts
- Let Through Voltage:  $\leq \pm 3$  Volts for 3kA @ 8/20  $\mu$ s Waveform
- Throughput energy:  $\leq 0.5$   $\mu$ J for 3kA @ 8/20  $\mu$ s Waveform
- Temperature: -40 to 185° F Storage/Operating 122° F
- Vibration: 1G at 5 Hz up to 100Hz
- Unit Impedance: 50 $\Omega$
- VSWR: 1.1:1
- Frequency Range: 800 MHz to 2200 MHz

- Multistrike capability
- Low strike throughput energy
- Flange mount and bulkhead mount options
- Standard N-Type Female Connector on both the surge side and protected side connectors

**L. Coaxial Cable – Power Divider (Splitter):**

Furnish a coaxial cable – power divider for repeater radio sites. Ensure the power divider accommodates a single primary input RF source and divides/splits the signal (power) equally between two output ports. Furnish a Telewave Inc., Model ANT-PD29 power divider or an approved equivalent that meets the following minimum specifications.

Power Division	2 – Way
Frequency	900 – 1100 MHz
Insertion Loss	0.22 dB
Impedance	50 Ohm
VSWR ref. to 50 Ohm (max)	1.3:1
Max. Input Power	500 Watts
Connectors	Standard N-Type Female
Dimension	2.5”W x 5”L
Weight	1.5 lbs (approximately)

**M. 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 ½-inch hole in back of box. Furnish mounting hardware, sealing gaskets and lockout tag. (NOTE: On NCDOT owned poles the “Disconnect Switch” can be omitted.)

**N. Warning Signs(s) and Decal(s):**

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. Secure the sign to the pole using ‘Band-It’ brackets or a method approved by the engineer. (NOTE: On NCDOT owned poles the “RF Warning Sign” and “Decal” can be omitted.)

**14.3. CONSTRUCTION METHODS****A. General:**

**Perform a radio path Site Survey test before installing any equipment.** All radio path site surveys shall be completed during full foliage conditions. 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. During the initial radio path signal strength test it may be determined that a repeater station may be necessary to complete the intended link. 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 and any necessary repeater stations. Install a coaxial cable – power divider, antenna splitter cable and additional antenna at locations where it is determined that a dual antenna configuration is necessary to accommodate communications in multiple directions.

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 an Engineer approved method. On metal poles, secure the #6 AWG grounding lead cable to the pole using an Engineer approved method.

Do not exceed the 1-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. Repeater Cabinets:**

Do not obstruct the sight distance of vehicles when locating and installing cabinets.

Install the pole-mounted cabinet approximately five feet from the ground line to the top of the cabinet. Secure the cabinet to the pole using 'Band-It' brackets or a method approved by the Engineer. Leave the RS-232 data interface cable in the cabinet.

### **C. 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 wireless radio system. Do not mount weatherproof box on the field equipment cabinet door. Drill a hole in the side of the field equipment cabinet. Mount the outlet box over the hole using a ½-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. (NOTE: If the antenna is mounted on an NCDOT owned pole the "Disconnect Switch" can be omitted.)

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

**D. 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 on 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. (NOTE: If the antenna is mounted on an NCDOT owned pole the "RF Warning Sign" can be omitted.)

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. (NOTE: If the antenna is mounted on an NCDOT owned pole the "Decal" can be omitted.)

**14.4. WARRANTY**

Provide a minimum two-year warranty with each radio and antenna assembly to ensure the products are free of manufacturing defects in material and workmanship. The warranty commences on the date the radio system is accepted by the Engineer.

**14.5. MEASUREMENT AND PAYMENT**

( ) *wireless radio system* will be measured and paid for as the actual number of wireless radio systems furnished, installed and accepted. A system is defined as a point-to-point or point-to-multipoint configuration of wireless radios that are integrated with the fiber optic network.

This item includes the appropriate sized antennas, radios, power supplies and injectors, disconnect/snap switches, signs, decals, interface cabling, coaxial cabling, lightning arrestors, radio frequency signal jumpers, coaxial cable power dividers (Splitter), coaxial cable connectors, coaxial cable shield grounding systems with weatherproofing, and labeling. Any integration between the wireless radio system and a fiber optic network, installation materials and configuration software necessary to complete this work, including the radio path Site Survey test and warranties, will be incidental.

( ) *wireless repeater standalone radio system* will be measured and paid for as the actual number of wireless repeater standalone radio systems furnished, installed and accepted.

This item includes the appropriate sized NEMA 3R cabinet, conduit, vertical risers, antennas, radios, power supplies and injectors, disconnect/snap switch, signs, decals, interface cabling, coaxial cabling, lightning arrestors, radio frequency signal jumpers, coaxial cable power dividers (Splitter), coaxial cable connectors, coaxial cable shield grounding systems with weatherproofing, and labeling. Any integration, installation materials and configuration software necessary to complete this work, including the radio path Site Survey test and warranties, will be incidental.

Payment will be made under:

900MHz Wireless Radio System .....	Each
2.4/5.8 GHz Wireless Radio System.....	Each
900MHz Wireless Repeater Standalone Radio System .....	Each
2.4/5.8 GHz Wireless Repeater Standalone Radio System .....	Each

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## 23. DMS ASSEMBLIES

### 23.1 DESCRIPTION

This section includes all design, fabrication, furnishing, and erection of the DMS assemblies; ladders and walkways for access to the DMS inspection door and attachment of the DMS enclosures to the structures in accordance with the requirements of these Project Special Provisions and the Plans. Fabricate the supporting DMS assemblies from tubular steel. Furnish pedestal or span type DMS assemblies (walk-in and front access) as shown in the Plans. Mount DMS on four (4) chord (box) truss. Cantilevered and Monotube (horizontal truss) DMS structures will not be allowed.

Provide the pedestal structure with a minimum of 25 feet and span structure with a minimum of 20 feet clearance from the high point of the road to the bottom of the DMS enclosure. The DMS assembly must allow for field adjustment (horizontal & vertical tilting) of the DMS enclosure to ensure optimum legibility from all travel lanes.

Design the new DMS assemblies and walkway, including footings, and submit shop drawings for approval. Design new walkways for existing DMS structures and submit shop drawings for approval. A Professional Engineer that is registered in the state of North Carolina will prepare such computations and drawings. These must bear his signature, seal, and date of acceptance.

It is the Contractor's responsibility to field verify the S-dimensions and determine the length and height of each DMS assembly.

The provisions of Section 900 of the Standard Specifications apply to all work covered by this section.

### 23.2 MATERIAL

Use materials that meet the following requirements of the Standard Specifications:

Structural Steel	Section 1072
Overhead Structures	Section 1096
Signing Materials	Section 1092
Organic-Zinc Repair Paint	Article 1080-9
Reinforcing Steel	Sub-article 1070
Direct Tension Indicators	Sections 440 and 1072

### 23.3 CONSTRUCTION METHODS

#### A. General

Fabricate the new DMS assemblies, ladders and walkways in accordance with the details shown in the approved shop drawings and the requirements of these Project Special Provisions.

No welding, cutting, or drilling in any manner will be permitted in the field, unless approved by the Engineer.

Drill bolt holes and slots to finished size. Holes may also be punched to finished size, provided the diameter of the punched holes are at least twice the thickness of the metal being punched. Flame cutting of bolt holes and slots is not permitted.

Erect DMSs in accordance with the requirements indicated on the plans and in these Project Special Provisions. Field drill two holes per connection in the Z bars for attaching DMS to structures. Use two bolts at each connection. Provide two (2) U-bolts at each U-bolt connection such as 1) each truss chord to sign hanger, or 2) each truss chord to walkway support. Provide two (2) U-bolts at each U-bolts connection where ends of truss chords are supported. Minimum diameter of all U-bolts is to be ½ inch.

Use two coats of a zinc-rich paint to touch up minor scars on all galvanized materials. See Standard Specifications for Roads and Structures Section 1076-6.

For high strength bolted connections, provide direct tension indicator washer.

## **B. Shop Drawing**

Submit to the Engineer for approval a complete design for the DMS assemblies, including footings, DMS assembly hardware, brackets for supporting the DMS, ladder, access platform, and the maintenance walkway. Base design upon the final structure line drawings, wind load area and the wind speed shown on the plans, and in accordance with the "Standard Specifications for Structural Structures for Highway Signs, Luminaires and Traffic Signals."

The manufacturer of the DMS assembly must ensure that design of each assembly is compatible with the DMSs for mounting and attachment.

Submit six copies of complete detailed shop drawings and one copy of the design computations for the DMS assemblies to the Engineer for approval prior to fabrication. Show in the shop drawings complete design and fabrication details including foundations, provisions for attaching the DMS, ladder, access platform, and maintenance walkway to supporting structures, applicable material specifications, and any other information necessary for procuring and replacing any part of the complete DMS assemblies.

Allow a minimum of 40 working days for shop drawing approval after the Engineer receives them. If revised drawings are necessary, allow appropriate additional time for review and approval of final shop drawings.

Approval of shop drawings by the Engineer will not relieve the Contractor of his responsibility for the correctness of drawings, or for the fit of all shop and field connections and anchors, including but not limited to the installation of new walkways and existing structures.

## **C. Design and Fabrication**

### **1. Dynamic Message Sign Assembly**

The following criteria govern the design of DMS assemblies:

- Design must be in accordance with the Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, 4<sup>th</sup> Edition, 2001, and the latest Interim Specifications.
- The wind pressure map that is developed from the 3-second gust speeds, as provided in Article 3.8, shall be used.



- The natural wind gust speed in North Carolina shall be assumed to be 5 meters per second or 11.6 mph for inland areas, and 7 meters per second or 15.7 mph for coastal areas. The coastal area shall be defined as any area within 2 miles from the waterfront facing the ocean or sound and all area where the design basic wind speed is above 120 mph, as shown in Figure 3-2.
- The fatigue importance category used in the design, for each type of structure, as provided for in Article 11.6, Fatigue Importance Factors, shall be Category II unless otherwise shown on the contract plans.
- Wind drag coefficient for Dynamic Message Sign enclosures shall be 1.7

The following Specification interpretations or criteria shall be used in the design of overhead sign assemblies:

- For design of supporting upright posts or columns, the effective length factor for columns "K", as provided for in Appendix B, Section B.5, shall be taken as the following, unless otherwise approved by the Engineer:
  - Case 1 For a single upright post of span type overhead sign structure, the effective column length factor, "K", shall be taken as 2.0.
  - Case 2 For twin post truss-type upright post with the post connected to one chord of a horizontal truss, the effective column length factor for that column shall be taken as 2.0.
  - Case 3 For twin post truss-type upright post with the post connected to two truss chords of a horizontal tri-chord or box truss, the effective column length factor for that column shall be taken as 1.65.
- For twin post truss-type upright post, the unbraced length shall be from the chord to post connection to the top of base plate.
- For twin post truss-type upright post that is subject to axial compression, bending moment, shear, and torsion the post shall satisfy Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals Equations 5-17, 5-18 and 5-19. To reduce the effects of secondary bending, in lieu of Equation 5-18, the following equation may be used:

$$\frac{f_a}{F_a} + \frac{f_b}{\left(1 - \frac{0.6f_a}{F_c}\right)F_b} + \left(\frac{f_v}{F_v}\right)^2 \leq 1.0$$

Where

fa = Computed axial compression stress at base of post

- The base plate thickness for all uprights and poles shall be a minimum of 2" but not less than that determined by the following criteria and design.

Case 1 Circular or rectangular solid base plates with the upright pole welded to the top surface of base plate with full penetration butt weld, and where no stiffeners are provided. A base plate with a small center hole, which is less than 1/5 of the upright diameter, and located concentrically with the upright pole, may be considered as a solid base plate.

The magnitude of bending moment in the base plate, induced by the anchoring force of each anchor bolt shall be calculated using equation  $M = (P \times D_1) / 2$ .

Case 2 Circular or rectangular base plate with the upright pole socketed into and attached to the base plate with two lines of fillet weld, and where no stiffeners are provided, or any base plate with a center hole that is larger in diameter than 1/5 of the upright diameter.

The magnitude of bending moment induced by the anchoring force of each anchor bolt shall be calculated using equation  $M = P \times D_2$ .

- M, bending moment at the critical section of the base plate induced by one anchor bolt
- P, anchoring force of each anchor bolt
- $D_1$ , horizontal distance between the center of the anchor bolt and the outer face of the upright, or the difference between the radius of the bolt circle and the outside radius of the upright
- $D_2$ , horizontal distance between the face of the upright and the face of the anchor bolt nut

- The critical section shall be located at the face of the anchor bolt and perpendicular to the radius of the bolt circle. The overlapped part of two adjacent critical sections shall be considered ineffective.
- The thickness of base plate of Case 1 shall not be less than that calculated based on formula for Case 2.
- Uprights, foundations, and trusses shall be designed in accordance with the Overhead Sign Foundation Special Provision for the effects of torsion. Torsion shall be considered from dead load eccentricity of these attachments, as well as for attachments such as walkways, supporting brackets, etc., that add to the torsion in the assembly. Truss vertical and horizontal truss diagonals in particular and any other assembly members shall be appropriately sized for these loads.
- Uprights, foundations, and trusses shall be designed for the proposed sign wind area and future wind areas. The design shall consider the effect of torsion induced by the eccentric force location of the center of wind force above (or below) the center of the supporting

truss. Truss vertical and horizontal truss diagonals in particular and any other assembly members shall be appropriately sized for these loads.

Fabricate the supporting structures using tubular members of either aluminum or steel, using only one type of material throughout the project.

Horizontal components of the supporting structures for overhead DMS must be of a truss design to support the DMS. Truss centerline must coincide with centerline of the DMS design area shown on the structure line drawing. Provide permanent camber in addition to dead load camber in accordance with the "Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals." Indicate on the shop drawings the amount of camber provided and the method employed in the fabrication of the support to obtain the camber.

For all U-bolt connections of hanger beams to overhead assembly truss chords, provide all U-bolts with a flat washer, a lock washer and double nuts at each end of the U-bolts. All double nuts that are on any U-bolt shall be the same thickness and weight. When assembled, the double nuts shall be brought tight against each other by the use of two wrenches.

Fabricate attachment assemblies for mounting DMSs in a manner that allows easy removal of the sign.

## 2. DMS Access Platform for Pedestal Structure

Provide an access platform, a minimum of three feet wide with open skid-resistant surface and safety railing on **pedestal structure** for access to the DMS inspection door. Provide platforms with fixed safety railings along both sides from the beginning of the platform to the inspection door.

Ensure the design, fabrication and installation of the access platforms on new DMS structures complies with the following:

1. The top of the platform grading surface is vertically aligned with the bottom of the DMS door.
2. The DMS door will open 90-degrees from its closed position without any obstruction from the platform or safety handrails.
3. The platform is rigidly and directly connected to the walkway brackets and there is no uneven surface between sections.
4. Install a 4" x 4" safety angle parallel to and along both sides of the platform and extend it the entire length of the platform. Design the safety angle to withstand loading equivalent to the platform.
5. Ensure the platform design allows full access to the DMS enclosure inspection door with no interference or obstructions.

## 3. DMS Walkway for Span Structure

Provide a maintenance walkway on **span structures**, a minimum of three feet wide, with open skid-resistant surface and safety railings on the DMS assemblies for access to the DMS inspection door. Provide a maintenance walkway that extends from the DMS inspection door to three feet over the edge of the shoulder. Provide new walkways with fixed safety railings along both sides from the beginning of the walkway to the inspection door.

Ensure the maintenance walkway complies with the following:

1. The top of the walkway grading surface is vertically aligned with the bottom of the DMS door with no gap between the end of the walkway and the DMS door.
2. The DMS door will open 90-degrees from its closed position without any obstruction from the walkway or safety handrails.
3. The walkway is rigidly and directly connected to the walkway brackets and there is no uneven surface between sections.
4. Install a 4" x 4" safety angle parallel to and along both sides of the platform and extend it the entire length of the platform. Design the safety angle to withstand loading equivalent to the platform.
5. Ensure the walkway design allows full access to the DMS enclosure inspection door with no interference or obstructions.

#### 4. DMS Access Ladder

Provide a fixed ladder, of the same material as the **pedestal structure**, leading to the access platform. Equip the ladder with a security cover (ladder guard) and lock to prohibit access by unauthorized persons. Start the first ladder rung no more than 18 inches above finished ground and end it at the access platform. Design the rungs on 12-inch center to center typical spacing. Attach the security cover approximately 6 feet above the finished ground. Design the ladder and security cover as a permanent part of the DMS assembly and include complete design details in the DMS assembly shop drawings. Fabricate the ladder and cover to meet all OSHA requirements and applicable state and local codes, including but not limited to providing a ladder cage. Attached the bottom of the ladder to a concrete pad a minimum of 4 inches deep, 24 inches wide, and 36 inches long.

#### 5. Anchor Rod Assembly

Attach the DMS structure to concrete foundations by the use of straight galvanized anchor rods with galvanized heavy hex nuts and flat washers. The rods, nuts and flat washers shall be galvanized in accordance with AASHTO M232. Provide anchor rods that have an anchor plate or flat washers with nut at the end to be embedded in concrete. For pedestal structures, use a minimum of eight anchor rods.

Ensure material used in steel anchor rods conforms to AASHTO M 314 or ASTM F1554, and the specified yield strength does not exceed 55,000 psi. Compute the required projection of the anchor rod above the foundation top. Compute the total projection based on the following:

- Provide between 3 and 5 threads of anchor rod projection above the top nut after tightening is complete. Avoid any additional projection, or a normal depth socket torque wrench shall not be used on top nuts.
- Include the sum of the thickness of top nut, top nut flat washer or top nut beveled washers, base plate, leveling nut flat washer or leveling nut beveled washers, leveling nut.

- Set the maximum distance between the bottom of the leveling nut and the foundation top to one nut height to avoid excessive bending stresses in the anchor rod under service conditions.
- Do not use lock washers.

## **6. Anchor Rod Nut Tightening Requirements for Metal Poles**

### **a. Prior to installation**

Protect the anchor rod threads from damage prior to installation and during installation.

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Prior to installation of the rods in the foundation, turn nuts onto and off the rods, well past the elevation of the bottom of the leveling nuts. Turn by the effort of one worker using an ordinary wrench without a cheater bar. Report any thread damage to the Engineer.

### **b. During installation**

1. Place leveling nuts (bottom nuts) on the anchor rods.
2. Place leveling nut washers on top of the anchor rod leveling nuts.
3. Place a rigid template on top of the leveling nuts to check the level of the nuts. Use beveled washers if the anchor nut and washer cannot be brought into firm contact with the template.
4. Verify that the distance between the bottom of the leveling nut and the top of the concrete foundation is no more than one anchor rod diameter. If an upright is required to be back-raked, then the distance between the bottom of the leveling nut and the top of the concrete foundation should be no more than one anchor rod diameter, averaged over the anchor rod group.
5. Place the base plate and structural element to which it is attached. However, do not attach to the upright element, during tightening of the anchor nuts, cantilever beams or arms with span in excess of 10 feet.
6. Place top nut washers.
7. Do not use lock washers.
8. Lubricate threads and bearing surfaces of top nuts with beeswax, stick paraffin, or other approved lubricant.
9. Place top nuts. Use beveled washers if the anchor nut and washer cannot be brought into firm contact with the base plate.
10. Tighten top nuts to snug tight. A snug-tight condition is defined as the washer and nut being in full contact with the base plate, and the application of the full effort of a workman on a 12-in wrench. Turn top nuts in increments following a star pattern (using at least two full tightening cycles).
11. To ensure proper pre-tensioning, after all top nuts have been brought to snug-tight condition, repeat the procedure on the leveling nuts. Turn leveling nuts in increments following a star pattern (using at least two full tightening cycles).

12. At this point, verify if beveled washers are required. Beveled washers are necessary under the leveling nut or top nut if any face of the base plate has a slope greater than 1:20 and/or any nut can not be brought into firm contact with the base plate.

13 Before further nut turning, make the reference position of the nut in the snug-tight condition with a suitable marking (ink or paint that is not water-soluble). Mark on the corner at the intersection of two flats with a corresponding reference mark on the plate at each nut. After tightening, verify the nut rotation.

14. Achieve pre-tensioning by turn-of-nut method. Turn the top nuts to 1/6 of a turn. Do so in a star pattern using at least two full-tightening cycles.

15. After installation, ensure that firm contact exists between the anchor rod nuts, washers, and base plate on any anchor rod installed.

16. For overhead DMS assemblies: The span type truss may be placed on the uprights or attached to the upright at this time.

17. After a period of no less than 4 days, and no more than 2 weeks, and in the presence of the Engineer, use a torque wrench to verify that a torque at least equal to 600 foot-pounds is provided on each top nut. For DMS pedestal structures, verify the torque after erection of the remainder of the structure and attaching the DMS to the structure.

18. If any top nut torque reveals less than 600 foot-pounds of effort is required to move the nut, then tighten the nut to no less than 600 foot-pounds.

19. Calibrate the torque indicator on the wrench used for tightening the nuts annually if the project construction extends over a 12 month period. Provide the Engineer with certification of the calibration.

20. Do not place grout under the base plate.

**23.4 MEASUREMENT AND PAYMENT**

( ) structure for ( ) DMS will be measured and paid as the actual number of dynamic message sign assemblies furnished, installed, and accepted. Payment includes all design, fabrication, construction, transportation, and attachment of the complete dynamic message sign assemblies, supporting structure, hardware, access platform or walkway, direct tension indicators, preparing and furnishing shop drawings, additional documentation, incidentals, and all other equipment and features necessary to furnish the system described above.

*DMS Access Ladder* will be measured and paid as the actual number of DMS access ladders furnished, installed and accepted. Payment includes design, fabrication, transportation, and attachment to the DMS assembly as described above.

Payment will be made under:

**Pay Item**

Pedestal Type Structure for Walk-In DMS.....	Each
Pedestal Type Structure for Front Access DMS.....	Each

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**U-2826B US 52 Corridor ITS Deployment  
Signals & Intelligent Transportation Systems**

Full Span Overhead Structure for Walk-In DMS .....Each  
DMS Access Ladder .....Each

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