

PROJECT SPECIAL PROVISIONS

FINAL

TIP U-4711

PREPARED BY:

KIMLEY-HORN AND ASSOCIATES, INC.


POST OFFICE BOX 33068

RALEIGH, NORTH CAROLINA, 27636-3068

PREPARED FOR:

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

INTELLIGENT TRANSPORTATION SYSTEMS & SIGNALS UNIT

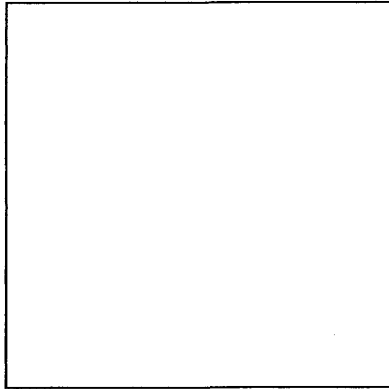

Mark Dunzo
Signature _____ Date: 3/3/08

Prepared by: MWD/KWS

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U-4711 Greensboro Signal System

Intelligent Transportation Systems & Signals Unit



Project Special Provisions

Intelligent Transportation Systems & Signals Unit

Prepared By: MWD / KWS

3-Mar-08

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1. GENERAL REQUIREMENTS**1.1. DESCRIPTION****A. General**

Furnish, install, and integrate a new distributed processing traffic signal system for the City of Greensboro in North Carolina using new fiber optic communications cable, existing fiber optic communications cable, existing copper twisted pair cable, new wireless communications links, new traffic signal controllers and cabinets, existing dynamic message sign (DMS) units, and new and existing closed-circuit television units and control cabinets.

Furnish, install, and integrate new central signal system software, new central video software, and modified regional video software on existing computer hardware and new computer hardware being provided by the City of Greensboro Management Information System (MIS) Department to form a new traffic operations center (TOC) to be housed at the Melvin Municipal Office Building located at 300 West Washington Street in Greensboro. Fully integrate remote system access at the NCDOT Piedmont Triad Regional Transportation Management Center (PTRTMC) located at 201 South Chimney Rock Road in Greensboro, the Greensboro Emergency Management Center located in the Justice Complex at 1201 Coliseum Boulevard in Greensboro, and the City of Greensboro Signal Shop located at 401 Patton Avenue in Greensboro. Perform all building modifications at these facilities as shown in the Plans. And described in these Project Special Provisions.

Furnish and install new 2070L traffic signal controllers and new model 332 and 336 style cabinets to replace existing controllers and cabinets at locations shown in the Plans. Where shown in the plans, integrate signal controllers using wireless radio communications. Furnish, install, and fully integrate local controller software on all new and existing 2070L signal controllers. Furnish local software that is fully compatible and operable with the central software using Ethernet/IP-based communication protocols.

Furnish, install, and integrate new fiber optic communications cable for traffic signal system as shown on the Plans by lashing to existing twisted pair cable, lashing to new messenger cable installed under this project, utilizing existing conduit systems, and utilizing new conduit systems installed under this project.

Furnish, install, and integrate new closed-circuit television (CCTV) camera assemblies and new Wi-Fi mesh access points at locations shown in the Plans. Furnish, install, and fully integrate closed-circuit television (CCTV) control software at the TOC and remote locations as shown in the block

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diagrams.

Furnish, install, and integrate new Ethernet hardware on the new communications infrastructure to form a mesh-based, fully redundant communications network with 10-gigabit (also referred to herein as “10 GIG-E”) Ethernet hubs forming a Layer 3 network “Core” and managed Layer 2 10/100/1000 (also referred to herein as “gigabit” and “GIG-E”) Ethernet edge devices.

Modify buildings, route conduit and/or fiber optic cable into NCDOT, City of Greensboro facilities as called for in the Plans and these Project Special Provisions. Coordinate all work at, near, or inside buildings with the Engineer. Do no work on buildings or enter buildings without prior, written authorization from the Engineer.

At various locations in the Plans, certain items have been identified as “MIS” items such as “MIS Messenger Cable”. Unless other specified, these items shall be identical to their like standard item, but shall be accounted for separately for purposes of inspection and invoicing.

B. Standard Specifications

Conform to these Project Special Provisions, the Plans, and the NCDOT 2006 Standard Specifications for Roads and Structures (also referred to as the “Standard Specifications”). Also conform to the regulations and codes described in Section 1700 of the 2006 Standard Specifications for Roads and Structures.

In the event of a conflict between these Project Special Provisions and the Standard Specifications, these Project Special Provisions shall govern.

1.2. MATERIAL**A. Qualified Products**

Furnish new equipment, materials, and hardware unless otherwise required. Inscribe manufacturer’s name, model number, serial number, and any additional information needed for proper identification on each piece of equipment housed in a case or housing.

Signal Equipment Qualified Products List (QPL) is available on the Department’s website. The QPL website is:

<http://www.ncdot.org/doh/preconstruct/traffic/TMSSU/SMS/qpl/>

Certain signal and communications equipment, material, and hardware shall be pre-approved on the QPL by the date of installation. Equipment, material, and hardware not pre-approved when required will not be allowed for use on the project. Consult the QPL website to obtain pre-approval procedures.

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B. Observation Period

Warrant workmanship and Contractor-furnished equipment for a 120-day observation period under the payment and performance bond from date of acceptance.

If workmanship or equipment fails during the 120-day observation period, repair or replace with new equipment and begin a new 120-day observation period.

All project documentation shall be submitted to the Engineer prior to completion of the 120-day observation period.

The observation period for this work will be part of the work to be completed by the project completion date.

C. Warranties

Unless otherwise required herein, provide manufacturer's warranties on Contractor-furnished equipment for material and workmanship that are customarily issued by the equipment manufacturer and that are at least two years in length from successful completion of the 120-day observation period. Include unconditional coverage for all parts and labor necessary or incidental to repair of defective equipment or workmanship and malfunctions that arise during warranty period.

Ensure all contractor-furnished equipment, including pieces and components of equipment, hardware, firmware, software, middleware, internal components, and subroutines which perform any date or time data recognition function, calculation, or sequencing will support a four digit year format for a period of at least 50 years.

Upon successful completion of the 120-day observation period, transfer manufacturer's warranties with proper validation by the manufacturer to the Department or its designated maintaining agency.

D. Firmware Licensing and Upgrades

Provide the Department with a license to duplicate all programmable devices in equipment for maintenance and software upgrades. Provide binary or hexadecimal format files for each device that may be programmed by the Department. Ensure files are provided on PC compatible compact disks or other approved media.

Ensure firmware performance upgrades that occur during the contract period are available to the Department at no additional cost.

Make firmware upgrades that are developed to correct operating characteristics available to the Department at no additional cost until the warranty period expires.

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E. Wire and Cable

Furnish wire and cable on reels. When requested by the Department, furnish samples of wire and cable to the Department at no additional cost.

Provide either 0.05" x 0.30" aluminum wrapping tape or 0.06" stainless steel lashing wire for lashing cables to messenger cable. Use 0.045" stainless steel lashing wire to lash fiber-optic communications cable to messenger cable.

Except for grounding conductors, provide signal cable conductors of size Number 16 AWG that are fabricated from stranded copper. Number 16 AWG cable can only be used with an all LED traffic signal intersection. Repairs to a non-LED traffic signal intersection must use Number 14 AWG cable.

F. Painting

Where painting of signal equipment cabinets, signal heads, signal poles, and pedestals is required, apply paint at the factory. No field painting will be allowed except when paint has been scratched or marred. In such cases, apply two field coats of the same color and grade enamel as the original paint to the scratched or marred portions.

1.3. CONSTRUCTION METHODS**A. General**

Before beginning signal work, verify all existing signal equipment is in satisfactory working order. Report all defective signal equipment to the Engineer so as not to be held responsible for defects.

Do not remove and replace more than one controller and cabinet per day, unless otherwise approved by the Engineer. Once controller and cabinet replacement has begun at a given location, complete the removal and replacement work at that location before beginning removal and replacement of a controller and cabinet at another location.

Locate existing conduit, cable runs, inductive detection loops, lead-in, junction boxes, and detection equipment before installing or using equipment that can damage or interfere with such facilities. The locations of existing inductive detection loops shown are approximate.

Locate all underground utilities before beginning drilling, digging, or trenching operations.

Immediately cease work and notify the Engineer and affected owners if damage to existing utilities, cables, or equipment occurs. Make all required repairs and replacements at no additional cost to the Department.

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Utilize IMSA Level II Technicians to perform all cabinet placement, cabinet wiring and controller programming. Program the controllers and wire the cabinets so that the phasing, type of operation (time-based, volume density, or special sequences), loop to phase assignments, and phase numbering assignments match the existing assignments, unless otherwise directed by the Engineer.

At the end of each workday, clean and clear the work site of excess excavation, waste packing material, wire, and all other debris that results from traffic signal system work. Haul and dispose of all waste as required by Section 802 of the Standard Specifications.

B. Regulations and Codes

Furnish material and workmanship conforming to the NEC, NESC, UL, and all local safety codes in effect on the date of advertisement. Comply with Article 4, Chapter 87 of the *North Carolina General Statutes* (Licensing of Electrical Contractors). Comply with all regulations and codes imposed by the owner of affected utility poles. In the event of a conflict between the NEC, NESC, UL, local safety codes in effect on the date of advertisement and these Specifications, the cited documents will govern.

Where required, conform to ITE, IEEE, AASHTO, and ASTM in effect on the date of advertisement.

Notify the Engineer, local traffic enforcement agency, local utility company, and affected railroad companies seven business days before operational shutdowns to coordinate connection or disconnection to an existing utility or system.

Install standoffs, meter bases, and service disconnects as required by the NESC, NEC, local utility companies, and local ordinances.

C. Utility Services

Coordinate all work to ensure electrical power of proper voltage, phase, frequency, and ampacity is available to complete the work. Use electrical services cables with THW insulation.

When electrical, telephone, and telecommunication service is not furnished by the Department and is required, contact the utility company and make application to ensure all work can be completed. Obtain authorization for service in the Department's name and make application for service in the Department's name.

The Department will be responsible for direct payment of monthly utility company usage charges. The Contractor will be responsible for all expenses associated with utility installation costs, hookups, etc.

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D. Maintenance and Repair of Material

Furnish the Engineer with the name, office telephone number, cellular (mobile) telephone number, and pager number of the supervisory employee who will be responsible for maintenance and repair of equipment during all hours. An up to date list of these names and phone numbers shall be given to the Engineer. Any changes in personnel affecting this list shall be immediately communicated to the Engineer in writing.

Maintain and repair all signal and communications related equipment within the project construction limits until completion of the observation period and receipt of written notification of final acceptance of the project.

For all failures, malfunctions, or damages to equipment, begin necessary repairs within two hours of notification. Complete repairs within four hours of notification. Comply with Section 150 of the Standard Specifications for maintenance of traffic flow. The inability to contact the supervisory employee or prearranged alternate will not extend repair time requirements.

Remove and replace all signal and communications related equipment that fails. The Department will furnish the Contractor replacement equipment for Department-furnished equipment that fails.

Except for damages and malfunctions caused by the Contractor's work activities, the Contractor will not be held responsible for pre-existing conditions reported to the Engineer before starting traffic signal work at the specific intersection. The Contractor will assume responsibility for all maintenance and emergency services necessary once traffic signal work has begun at the specific intersection and for all damages and malfunctions caused either directly or indirectly by the Contractor's work activities. Repair scratches, dents, or other damage to the cabinet that occur while the cabinet is in under the Contractor's responsibility.

In the event the Contractor fails to perform in accordance with the plans and Specifications within the time frame specified, the Department reserves the right to perform maintenance and emergency service necessary to ensure continuous traffic signal operation. Further, all expenses incurred by the Department in implementing this option will be deducted from payment due the Contractor, plus \$2,500 liquidated damage per occasion, per day, or any portion thereof, until corrected.

Perform yearly maintenance on all Traffic Signal Conflict Monitors. The year shall be defined from the date of installation of the controller and cabinet at an intersection. Use the Signal Monitor Tester described in **Section 34**. Ensure that the Signal Monitor Tester is maintained and calibrated per the manufacturer's recommendation. Provide to the Engineer a copy of the manufacturer's

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certification that the Signal Monitor Tester has been certified before testing any Traffic Signal Conflict Monitors. Perform the test on each Traffic Signal Conflict Monitor per the manufacturer's recommendation. Provide one (1) copy of the Traffic Signal Conflict Monitor test results to the Engineer. Place one (1) copy in the Traffic Signal Cabinet. Perform these yearly tests for the life of the project.

Items reused (that are unmodified), such as signal heads, signal cable, local detector loops and lead-in cable, will be maintained by others. Maintain traffic signal system equipment until completion of the 120-day Observation Period and written notification of final acceptance of the project has been received from the Engineer.

E. Inspections

The Department may access the Contractor's equipment to perform railroad, signal, and preventative maintenance inspections, or conflict monitor certification as necessary. The Contractor shall be present for these inspections.

F. Removal of Existing Equipment and Material

Remove all Department-owned signals and communications related equipment and material that will not be used. Assume ownership of the removed poles, cabinet foundations, messenger cable, guy assemblies, interconnect cable, communications cable, and supporting hardware. Return all other traffic signal equipment and material between 8:00 a.m. and 12:00 p.m., Monday through Thursday, to the Division 7 Traffic Services Office, located at 1584 Yanceyville Street in Greensboro, or at a time mutually agreed to by the Contractor and Engineer. Replace or repair all material lost or damaged during its removal and transit. Label all returned equipment and material to indicate the location from which it was removed.

Remove all City of Greensboro owned signals and communications related equipment and material that will not be reused. Assume ownership of the removed poles, cabinet foundations, messenger cable, guy assemblies, interconnect cable, communications cable, and supporting hardware. Return all other traffic signal equipment and material to the City of Greensboro Signal Shop, located at 401 Patton Avenue in Greensboro, between 8:00 AM and 12:00 PM, Monday through Thursday, or at a time mutually agreed to by the Contractor and the City Signal Section Manager. Replace or repair all material lost or damaged during its removal and transit. Label all returned equipment and material to indicate the location from which it was removed.

The Department will deduct the cost of Department-owned or City-owned equipment damaged by the Contractor from money due to the Contractor.

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G. Railroad Preemption

Where railroad preemption is required, coordinate all work with the railroad company. Do not place signals into operation until signal equipment has been interconnected with required railroad-highway crossing devices and railroad preemption is working properly. Ensure preemption sequences begin immediately after activation of train detection.

Contact and coordinate with the railroad company to schedule interconnection of the signal to the railroad controller cabinet. Install lead-in cable from the signal controller cabinet to a railroad company furnished and installed lockable junction box. Interconnection will be made by the railroad company.

Provide fail-safe operation such that removal of voltage from the railroad side of the isolation relay will initiate the railroad preemption sequence.

H. Emergency Vehicle Preemption Systems

Where required, implement and install emergency vehicle preemption systems. Coordinate emergency vehicle preemption work with the proper operating authority. Contact the proper operating authority and schedule installation of emergency vehicle preemption equipment. Detailed information regarding the installation of new and reuse of existing emergency vehicle preemption systems is given in **Section 23**.

I. Timing of Signals

Implement timing values for signal controllers. Extract all parameters necessary to implement coordinated signal operations from the existing controllers and remote controller units (RCUs). Where applicable, request coordinated timing parameters from the Engineer. Make any modifications to the cycle, split, and offset information extracted from the existing controllers that are necessary to implement the timing plans into the new 2070 controllers and system database. The Engineer may, at his/her option, observe the loading of the timing plans.

Reinstall all existing time-based coordination. As directed, make modifications to existing coordination to account for changes in signal phasing.

The Department reserves the right to make, or have the Contractor make, field timing changes necessary for pattern optimization and to eliminate identifiable, potential hazards to the motoring public. The Engineer will notify the Contractor of timing changes made.

J. Wire and Cable

For installation in a conduit system, lubricate cable and wires before installing in conduit. Use lubricant that will not physically or chemically harm cable jacket, wire insulation, and conduit.

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Splice all electrical wire and cable at recessed-screw, barrier type terminal blocks, in junction boxes, or in condulets. Unless specifically allowed, connect no more than two conductors to the same terminal screw.

Maintain color coding of wires through splices.

Protect ends of wire and cable from water and moisture.

Install all wire and cable with necessary hardware including, but not limited to shoulder eyebolts, washers, nuts, thimbleyelets, three-bolt clamps, J-hooks, split bolt connectors, grounding clamps, and lashing material.

K. Grounding

Provide a grounding system at all new and revised electrical service points unless otherwise specified.

In addition to NEC requirements, test grounding electrode resistance at connection point to electrical service ground bus for a maximum of 20 ohms. Furnish and install additional ground rods to grounding electrode system as necessary to meet test requirements. Submit a completed Inductive Detection Loop & Grounding Test Results form. The form is located on the Department's website.

Provide a length of marker tape 6 to 12 inches below finished grade directly over grounding electrodes and conductors.

L. Contractor's Office

Throughout the project until final acceptance, the Contractor shall maintain full-time staffed office with storage and testing facilities within the Greensboro City Limits.

M. Related Projects

The Plans and these Project Special Provisions assume that the GDOT roadway project to extend Isaacson Boulevard from Horse Pen Creek Road to Fleming Road and the NCDOT roadway widening project on Groometown Road will be completed prior to construction of this project. In addition, the City has general maintenance backlog work for public safety that will need to be continued throughout the duration of this project. Coordinate with Engineer if construction is not complete for actions to be taken until construction is complete.

N. Sequence of Construction

Perform construction of the project in the sequence called for in these Project Special Provisions and as shown in the Plans. All work not performed in accord with the sequence of construction must be approved by the Engineer. Adherence to the sequence of construction must be reflected in the

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Contractor's project schedule and all updates to the project schedule. As new intersections are installed but are not under monitoring and supervision of the new central system, maintain common controller clock time. Insure clock time is in synch with clock time of existing central software until it is removed. All clocks that are updated shall be updated from a single clock source. Review each intersection that has been installed but is not online on a weekly basis in the form of a field visit and review the controller clock for drift against the common time source. Reset clock to common time source if it has drifted. Record time and date of each visit, activity performed, and person performing visit. Maintain of clock maintenance activity in a single document and furnish to the Engineer for review upon request. Failure to visit each intersection that is not online to check and update clocks will result in a liquidated damage of \$1,500 per visit not performed.

For work that involves the removal of operation of existing City of Greensboro CCTV units, schedule work and activities such that ability to view CCTV units from all current central and Internet locations and the ability to control the CCTV unit with at least the current level of functionality from each current access point shall be disabled for no more than two business days.

The project has been divided into four construction zones (A, B, C, and D) and is shown in the sequence of construction detail in the Plans. Each zone and the work to be performed within that zone are described below.

Zone A is geographically defined as a grouping of central business district (CBD) traffic controller cabinets that will be interconnected largely by utilizing existing twisted pair copper cable with small runs of new twisted pair copper cable and new fiber optic cable. The work in this zone will consist of removing existing and installing new signal controller cabinets, reusing and installing new system detectors, splicing existing and new twisted pair copper cable, splicing existing and new fiber optic cable, and installing new messenger cable, junction boxes, and conduit as required. All existing communications channels not disrupted by the installation of new cabinets within Zone A must remain operational and communicate with the existing City of Greensboro signal system server to continue to operate as a real-time central signal system. Also, Zone A shall consist of the installation of field communication hub cabinets and the routing and termination of new fiber optic cable to the communication hubs at the PTRTMC, City of Greensboro Fire Station 9 located at 4302 W. Friendly Ave. (MIS Facility # 539), City of Greensboro Fire Station 12 located at 1805 Pisgah Church Rd. (MIS Facility # 527), and the Sanford Smith Building located at 514 Yanceyville St. (MIS Facility #563). The work shall also consist of the cross connection of existing and/or new fibers at the communication hubs at the PTRTMC, TOC, Signal Shop, and Emergency Management Center. The work in Zone A shall consist of the installation, splicing, and cross-connection of fiber to complete the physical fault tolerant fiber optic communications topology called for in the Plans

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and the installation and integration of hub switches furnished by the City of Greensboro via the Engineer. Work under zone A shall also consist of integrating the Signal System Hardware and furnishing, installing, and integrating the Signal system Software such that operation of the intersections identified as part of Zone A may be fully accessible and operable under the new system software and a client seat of the signal system software installed on the TOC Computer Room Workstation..

Zone B is defined as signals, cable, and devices that are currently not under system interconnection and control, not in Zone A, and not anticipated to be within roadway construction projects within 18 months of the beginning of this project.

Zone C is defined as signals, cable, and devices in areas of current roadway construction projects that are scheduled to be completed within 18 months of the beginning of this project.

Zone D is defined as signals, cable, and devices that are currently interconnected and under the control of the existing signal system. Once a cabinet in an existing communications channel of the existing signal system is taken off-line, the entire channel must be taken off-line and all cabinets and controllers replaced.

The sequence of construction shall be as follows. Work in Zone A shall be completed, prior to commencing any work in Zone D. Work in Zone C may not commence until the roadway construction projects in that area are complete. Work in Zone B may begin at any time.

The Engineer shall provide signal plans with electrical details for each signal intersection to be included in the system. The Contractor may not perform any signal work at a location without receipt of the updated signal plan from the Engineer. The Engineer shall submit signal plans in groups according to the following schedule and in accord with the sequence of construction detailed above.

Group 1

GBO-150 (Eugene & McGee), GBO-171 (Elm & McGee), GBO-148 (Eugene & Washington), GBO-096 (Greene & Washington), GBO-168 (Elm & Washington), GBO-194 (Davie & Washington), GBO-097 (February One & Greene), GBO-178 (Elm & February One), GBO-198 (Davie & February One), 07-0663 (Eugene & Market), GBO-084 (Greene & Market), GBO-049 (Lindsay & Summit), GBO-082 (Elm & Market), GBO-081 (Davie & Market), GBO-078 (Church & Market), GBO-183 (Eugene & Friendly), GBO-070 (Commerce & Friendly), GBO-069 (Friendly & Greene), GBO-068 (Elm & Friendly), GBO-067 (Davie & Friendly), GBO-066 (Church & Friendly), GBO-273 (Bellemeade & Eugene), GBO-272 (Bellemeade & Greene), GBO-274

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(Bellemeade/Summit & Elm), GBO-195 (Davie & Summit), GBO-152 (Eugene & Lindsay), GBO-101 (Greene & Lindsay), GBO-173 (Elm & Lindsay), GBO-226 (Church & Lindsay), GBO-222 (Church & Summit),

Group 2

07-1543 (Burnt Poplar & Chimney Rock), GBO-212 (Dolley Madison & Friendly), 07-0538 (Battleground & Pisgah Church), GBO-155 (Bessemer & Summit), 07-1969 (Elm-Eugene & I-85 SB Ramp), 07-1512 (Hilltop & Stanley), GBO-166 (Benjamin & Green Valley), 07-1820 (Battleground & Edney Ridge)

Group 3

07-2001 (Bryan & Regional Rd.), 07-2033 (NC-68 & Regional Road), 07-0199 (Burnt Poplar & Regional), 07-0251 (Albert Pick/I-40 EB Ramp & NC-68), 07-0968 (NC-68 & Pleasant Ridge Rd.), 07-1029 (Bently & Regional Rd.), 07-1044 (Albert Pick & Regional), 07-1163 (I-40 WB Ramp & NC-68), 07-1449 (NC-68 & Triad Center Dr.), 07-1459 (Edgefield & NC-68), 07-1601 (I-40 WB Ramp & Sandy Ridge), 07-1648 (I-40 EB Ramp & Sandy Ridge), 07-1649 (Sandy Ridge Rd. & Triad Dr.), 07-1772 (NC-68 & Thorndike), 07-1894 (Boulder & Chimney Rock), 07-1978 (Market & PPG), 07-2008 (Friendly Ave & Urban Loop), 07-2044 (Coble Farm/Friendway & Friendly), 07-0962 (Chimney Rock & Market), 07-0978 (Gallimore Dairy & Market), 07-1186 (Friendly & Market), 07-1235 (Friendly & Stage Coach), 07-1436 (Boeing & Market), 07-1458 (Friendly & King George), 07-1513 (Friendly & Old Friendly), 07-1611 (Friendly & Friends Home), 07-1773 (Adams Farm & Hilltop), 07-1774 (Bridford & Hilltop), 07-1776 (Chimney Rock & Friendly)

Group 4

07-2045 (Drawbridge & Horsepen Creek), 07-0221 (Guilford College Prvt Drv & New Garden), 07-0408 (Fleming & Old Oak Ridge), 07-0703 (College/New Garden & Friendly), 07-1018 (Ballinger/New Garden & Fleming), 07-1209 (Bryan WB Ramp/Horsepen Creek & New Garden), 07-1241 (Arcadia & New Garden), 07-1621 (College & Hunt Club Dr.), 07-1831 (Bryan EB Ramp & New Garden), 07-XXX3 (Fleming Rd & Bryan Blvd Ramp), GBO-108 (Garden Lake/Hobbs & New Garden), GBO-122 (Hobbs & Jefferson), GBO-141 (Highwoods Circle & New Garden), 07-1941 (Carlson Dairy & Horsepen Creek), 07-2112 (Horse Pen Creek & Hanberry/YMCA), 07-1016 (Battleground & Horsepen Creek Rd.), 07-1210 (Bryan EB Ramp/Friendly Acres & Westridge), 07-1211 (Bryan WB Ramp & Westridge), 07-1610 (Battleground & Drawbridge Pkwy), FUT-001 (Battleground & Shopping Center/Office Park), GBO-006 (Cotswold & Old Battleground), GBO-007 (Lake Brandt & Old Battleground), GBO-079 (Hobbs & Westridge), GBO-390 (Westridge & Whitehurst)

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Group 5

07-1930 (Air Harbor & Lake Brandt Rd.), 07-1984 (Elm & Old Lake Jeanette), 07-0377 (Church & Lees Chapel/Pisgah Church), GBO-001 (Lawndale & Martinsville), GBO-002 (Lake Jeanette & Lawndale), GBO-003 (Cottage & Lawndale), GBO-005 (Lake Brandt & Lawndale), GBO-010 (Cotswold & Lawndale), GBO-020 (Martinsville & Pisgah Church), GBO-021 (Pisgah Church & Willoughby), GBO-025 (Lawndale & Pisgah Church), GBO-041 (Lawndale & Regents Park Ln.), GBO-128 (Elm & Pisgah Church), GBO-131 (Lees Chapel & Yanceyville), GBO-218 (Elm Village & Pisgah Church), GBO-483 (Corporate Center & Elm), GBO-486 (Pisgah Church & Pisgah Place), 07-2050 (Church & Denny), 07-0193 (Cone & US-29 Ramps), 07-0194 (Cone & Summit), 07-0195 (Cone & Sands), 07-0679 (Sixteenth & Summit), 07-1739 (Church & Electra), 07-1763 (Phillips & Summit), 07-1884 (Rankin & Summit), GBO-015 (Sixteenth & Yanceyville), GBO-209 (Cone & Yanceyville), GBO-213 (Cone & Marston), GBO-215 (Cone & Elm), GBO-217 (Rankin & Yanceyville), GBO-304 (Alma Pinnix & Cone), GBO-381 (Cone & 16th), GBO-489 (Cone & Orange)

Group 6

07-0490 (Cridland/Parkway & Wendover), 07-0613 (Hill & Wendover), GBO-052 (Bessemer & Church), GBO-170 (Elm & Northwood), GBO-182 (Elm & Tankersley), GBO-207 (Cornwallis & Golden Gate), GBO-208 (Cornwallis & Elm), GBO-250 (Bessemer & Yanceyville), GBO-255 (Bessemer & Eugene/Parkway), GBO-257 (Bessemer & Elm), GBO-305 (Elm & Sunset), 07-2034 (Bessemer & Burlington/Franklin), 07-0378 (Sykes & Wendover), 07-0399 (Bessemer & Huffine Mill), 07-0566 (Waugh & Wendover), 07-0579 (Lindsay & Wendover), 07-0583 (Summit & Textile), 07-0714 (Gatewood & Wendover), 07-0715 (English & Wendover), 07-0716 (Elwell & Wendover), 07-0879 (Fourth & Summit), 07-1428 (Burlington/Perry & Wendover), GBO-092 (Sullivan & Summit), GBO-251 (Bessemer & Huffman/Winston), GBO-253 (Bessemer & Lindsay), GBO-256 (Bessemer & English)

Group 7

07-2076 (Market St & Holts Chapel Rd), 07-0870 (Gillespie & Market), 07-0986 (English & Market), 07-1836 (Booker & Market), GBO-009 (Bluford & Dudley), GBO-050 (Lindsay & Sullivan), GBO-065 (Friendly & Murrow), GBO-077 (Market & Murrow), GBO-088 (Lindsay & Murrow), GBO-091 (Summit & Yanceyville), GBO-098 (Dudley & Market), GBO-100 (Laurel & Market), GBO-103 (Benbow & Market), GBO-175 (Benbow & Sullivan), GBO-191 (Dudley/Yanceyville & Lindsay), GBO-312 (Benbow & Bluford), 07-2028 (Lee & Moody), 07-0438 (Lee & Lincoln), 07-0472 (Eugene & Lee), 07-0560 (Bennett & Lee), 07-0567 (Lee &

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Murrow), 07-0648 (Lee & Willow), 07-0649 (Benbow & Lee), 07-0651 (Arlington & Lee), 07-0652 (Elm & Lee), 07-1009 (English & Lee), GBO-104 (English & McConnell), GBO-105 (McConnell & Willow), GBO-134 (Florida & Willow), GBO-260 (Bennett & Gorrell), GBO-261 (Bennett & Dudley/Washington), GBO-268 (Benbow & McConnell/Washington)

Group 8

07-2014 (Alamance Church & Rotherwood), 07-0722 (I-85/US-29 Ramps & Martin Luther King), 07-0851 (Alamance Church/Patton & MLK), 07-0983 (Alamance Church & Willow), GBO-087 (Florida & Martin Luther King), GBO-118 (Benbow & Martin Luther King Jr), GBO-135 (Florida & Randolph), GBO-167 (Elm-Eugene & Florida), GBO-179 (Elm & Elm-Eugene), GBO-271 (Benbow & Florida), GBO-334 (Eugene & Whittington), 07-1970 (Elm-Eugene & I-85 NB Ramp), 07-2055 (Elm-Eugene & Elmsley), 07-2058 (Elmsley & Walmart Driveway), 07-0555 (Pleasant Garden & US-421), 07-1219 (Pleasant Garden & Vandalia), 07-XXX4 (Pleasant Garden Rd & Industrial Ave), GBO-156 (Elm-Eugene & J.J. Drive), 07-1927 (Nestleway/Old Treybrooke & Randleman), 07-2030 (High Point & Guilford College), 07-0749 (Randleman & Vandalia), 07-1284 (High Point & Millis), 07-1379 (Glendale & Randleman), 07-1600 (Adams Farm & Mackay), 07-XXX2 (Vandalia & Wiley Davis)

Group 9

07-0563 (High Point & Pinecroft), 07-0596 (High Point & Meadowview), 07-0623 (High Point & Vanstory), 07-0624 (Florida & High Point), 07-0625 (High Point & Patterson), 07-0987 (Grimsley & High Point), 07-1027 (Holden & I-85 SB Bus. Ramp), 07-1028 (Holden & I-85 NB Bus. Ramp/Campground), 07-1305 (High Point & I-40 WB Ramp), 07-1517 (Holden & Phoenix), 07-1658 (Ellington & High Point), GBO-017 (Holden & Vandalia), GBO-022 (Pinecroft & Vanstory), GBO-024 (Pinecroft & Seawell), GBO-031 (Pinecroft & Vandalia), GBO-072 (Holden & Vanstory), GBO-076 (Holden & McCuiston/Pinecroft), GBO-129 (Four Seasons & Vanstory), GBO-130 (Koury Blvd. & Pinecroft), GBO-142 (Meadowview & Vanstory), GBO-144 (Farmington & Holden), GBO-199 (Darden & Holden), GBO-477 (Centerview & Meadowview), 07-0209 (High Point & Merritt), 07-0450 (High Point & Holden), 07-0621 (Groometown/Hilltop & High Point), 07-1171 (Farmington & High Point), 07-1302 (High Point & Romaine), 07-1320 (Fairfax & Merritt), 07-1376 (Fairfax & Hilltop), 07-1469 (High Point & Veasley), GBO-112 (Eagle & Stanley), GBO-113 (Koger & Stanley), GBO-241 (Cedar Fork & Holden)

Group 10

07-0362 (I-40 WB Ramp & Wendover), 07-0569 (I-40 EB On-Ramp & Wendover), 07-0594 (Guilford College & I-40 WB/Swing), 07-1017 (Guilford College & I-40 EB Ramp), 07-1035

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(Stanley & Wendover), 07-1036 (Landmark Center & Wendover), 07-1324 (Big Tree & Wendover), 07-1518 (Bridford & Wendover), 07-1862 (Guilford College & Hornaday), 07-1863 (Hairston/Sapp & Wendover), 07-1871 (I-40 EB Off-Ramp & Wendover), GBO-138 (Bridford & Wendover Place), GBO-487 (Bridford & Kmart Driveway), 07-1973 (Market & Walker), 07-0242 (Market & United), 07-0375 (Market & Stage Coach), 07-0536 (Market & Montrose), 07-0537 (Market & Westgate), 07-0632 (Market & Muirs Chapel/Spring Garden), 07-0890 (Market & Swing), 07-0911 (Edwardia & Market), 07-1207 (Spring Garden & Wendover WB Ramp), 07-1481 (Spring Garden & Wendover EB Ramp), 07-1495 (Market & Norwalk), GBO-019 (Pomona & Spring Garden), GBO-029 (Muirs Chapel & Tower), GBO-366 (Dolley Madison & Tower), GBO-468 (Dundas & Pomona)

Group 11

07-0444 (Ashland/Wendover & Holden) 07-0447 (Holden & Market), 07-0633 (Green Valley & Market), 07-0634 (Elam & Market), 07-0635 (Chapman & Market), 07-0732 (Lindell & Market), 07-0988 (Holden & Patterson), 07-1240 (Merritt & Patterson WB Ramp), GBO-011 (Hewitt & Merritt), GBO-030 (Merritt & Spring Garden), GBO-064 (Immanuel & Merritt), GBO-071 (Holden & Walker), GBO-074 (Holden & Spring Garden), GBO-137 (Florida & Holden), GBO-220 (Clifton & Merritt), GBO-240 (Center/Meadowview & Holden), GBO-424 (Holden & Madison), 07-1187 (Bryan WB Ramp & Holden), 07-1188 (Bryan EB Ramp & Holden), 07-1271 (Green Valley & Northline/Wendover Ramp), FUT-002 (Friendly Ave & Kemp Rd), GBO-026 (Northline & Pembroke), GBO-063 (Kathleen & Pembroke), GBO-080 (Hobbs & Holden), GBO-193 (Elam & Friendly), GBO-196 (Friendly & Lindell), GBO-197 (Friendly & Green Valley), GBO-200 (Friendly & Pembroke)

Group 12

GBO-201 (Avondale & Friendly), GBO-202 (Friendly & Hobbs), GBO-203 (Friendly & Holden), GBO-204 (Friendly & Lakewood/Westridge), GBO-206 (Cornwallis & Hobbs), GBO-210 (Friendly & Jefferson), GBO-211 (Friendly & Muirs Chapel), GBO-376 (Hobbs & Northline), GBO-388 (Cascade/Cornwallis & Holden), GBO-XX1 (Friendly & Shops at Friendly), 07-2029 (E. Lake/McIver & Market), 07-0636 (Market & Tate), 07-0637 (Market & Mendenhall), 07-0644 (Cedar & Market), 07-0661 (Market & Spring), 07-0662 (Edgeworth & Market), 07-1189 (Benjamin & Bryan Blvd), GBO-053 (Edgeworth & Washington), GBO-056 (Bellemeade & Edgeworth), GBO-090 (Spring & Washington), GBO-117 (Carr & Tate), GBO-161 (Aycock/Westover & Benjamin), GBO-163 (Benjamin & Campus), GBO-165 (Benjamin & Elam), GBO-169 (Benjamin & Pembroke), GBO-172 (Benjamin & Cornwallis), GBO-184 (Edgeworth & Friendly), GBO-185 (Friendly & Spring), GBO-187 (Friendly & Mendenhall), GBO-188 (Friendly & Tate), GBO-189

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(Friendly & Market Crossover), GBO-190 (Friendly & Westover), GBO-192 (Friendly & Radiance)

Group 13

07-1944 (Battleground & Markland), 07-0492 (Battleground & Northwood), 07-0597 (Wendover & Westover Ter.), 07-0610 (Battleground & Cornwallis), 07-0612 (Battleground & Green Valley/Pembroke), 07-0846 (Battleground & Lawndale), 07-1012 (Battleground & Mill), 07-1607 (Battleground & Oakcrest), GBO-023 (Lawndale & Lawndale Crossing), GBO-046 (Battleground & Edgeworth/Fisher), GBO-047 (Battleground & Hill), GBO-048 (Battleground & Benjamin/Smith), GBO-051 (Battleground & Bessemer), GBO-058 (Edgeworth & Smith), GBO-059 (Elm & Fisher), GBO-060 (Elm & Smith), GBO-061 (Eugene & Fisher), GBO-062 (Fisher & Greene), GBO-086 (Benjamin & Holden/Pinedale), GBO-089 (Greene & Smith), GBO-102 (Green Valley & Pembroke/Westover), GBO-124 (Green Valley & Lendew), GBO-127 (Hill & Smith), GBO-133 (Smith & Spring), GBO-136 (Eugene & Smith), GBO-205 (Cornwallis & Lawndale), GBO-214 (Cone & Lawndale), GBO-284 (Battleground & Eugene), GBO-335 (Fernwood & Lawndale), GBO-437 (Campus & Westover)

Group 14

07-0655 (Lee & Silver/Tate), 07-0656 (Glenwood & Lee), 07-0657 (Aycock & Lee), 07-0831 (Chapman/Coliseum & Lee), GBO-004 (Tate & Walker), GBO-012 (Spring Garden & Tate), GBO-033 (Mendenhall & Spring Garden), GBO-034 (Kenilworth & Spring Garden), GBO-083 (Highland & Spring Garden), GBO-093 (Aycock & Walker), GBO-094 (Aycock & Spring Garden), GBO-132 (Forest & Spring Garden), GBO-180 (Elam & Walker), GBO-235 (Chapman & Walker), GBO-236 (Chapman & Spring Garden), GBO-429 (Elam & Spring Garden), GBO-174 (Elm & Lewis),

Group 15

07-2026 (I-85 Bus SB Ramp/Tolar & Rehobeth Church), 07-0568 (Florida & Randleman), 07-0646 (Florida & Freeman Mill), 07-0989 (Rehobeth Church & Vandalia), 07-1316 (Glendale & Rehobeth Church), 07-1505 (Coliseum & Freeman Mill), 07-1887 (Freeman Mill & Garrett/Glenwood), 07-XXX1 (Freeman Mill & Lovett), GBO-013 (Creek Ridge & Four Seasons), GBO-095 (Aycock/Lovett & Florida), GBO-139 (Florida & Hardie), GBO-140 (Florida & Glenwood), GBO-154 (Freeman Mill & Randleman), GBO-239 (Coliseum & Florida), GBO-475 (Four Seasons & Vandalia), 07-0189 (Norwalk & Wendover), 07-0598 (Edwardia & Wendover), 07-0865 (Meadowood & Wendover), 07-0917 (Clifton & Wendover), 07-1870 (Tri-City & Wendover), 07-0285 (Elm-Eugene & I-40 EB Ramp), 07-0428 (I-85 Bus NB Ramp/JJ & Randleman), 07-0430 (I-40 WB Ramp & Randleman), 07-0434 (Meadowview & Randleman), 07-0588 (Elm-Eugene & I-40 WB Ramp), 07-0589 (I-40 EB Ramp/I-85 Bus SB & Randleman), 07-1540 (Randleman &

Terrell), 07-1633 (Corliss & Randleman), GBO-162 (Elm-Eugene & Patton), GBO-164 (Elm-Eugene & Meadowview)

Group 16

07-1921 (Boulder & Burnet Poplar), 07-2000 (Market & Pleasant Ridge), 07-2077 (Airpark East & Gallimore Dairy), 07-1197 (Burnt Poplar & Gallimore Dairy), 07-1429 (Burgess & Market), 07-1439 (Sandy Ridge Rd. & US-421), 07-1491 (Market & NC-68/Thatcher), 07-1689 (Chimney Rock & Gallimore Dairy), 07-1818 (Market & NC-68 NB Ramp), 07-1893 (Gallimore Dairy & I-40), 07-1775 (College & Guida), GBO-107 (Jefferson & New Garden), GBO-XX2 (Fleming Rd & Horse Pen Creek Rd Connector), GBO-XX3 (Horse Pen Creek Rd & Horse Pen Creek Rd Connector), 07-0702 (Battleground & New Garden), 07-0720 (Battleground & Westridge), 07-1145 (Battleground & Brassfield), 07-1484 (Battleground & Cotswold Ave.), GBO-106 (Brassfield & New Garden), 07-0578 (Church & Cone), 07-0984 (Church & Sixteenth), 07-1239 (Church & Golden Gate), 07-0295 (Church & Cornwallis), 07-0826 (Church & Wendover), 07-0992 (Church & Hall Towers), 07-1269 (Church & Northwood), GBO-460 (Cornwallis & Yanceyville), GBO-XX4 (Church & Tankersley)

Group 17

GBO-158 (Creek Ridge/Industrial & Elm-Eugene), GBO-159 (Elm-Eugene & Montcastle), GBO-160 (Elm-Eugene & Vandalia), 07-1928 (Groometown & I-85 NB Ramp), 07-1929 (Groometown & I-85 SB Ramp), 07-2068 (Groomtown Rd & Rose Lake Dr), 07-1041 (Groometown & Vandalia/Wayne), 07-1069 (Alamance & High Point Rd.), 07-1185 (High Point & Mackay), 07-1618 (Grandover/Wiley Davis & Groometown), 07-1964 (Big Tree & Guilford College), GBO-480 (Hecht's Dr/Wendover Place & Hornaday), 07-0725 (College/Guilford College & Market), 07-0867 (Dolley Madison/Meadowood & Market), 07-1073 (Friendway & Market), GBO-186 (Cedar & Friendly), 07-0205 (Battleground & David Caldwell/Martinsville), 07-0609 (Battleground & Benjamin/Cone), GBO-153 (Creek Ridge & Rehobeth Church), 07-0964 (Creek Ridge & Randleman)

O. Electrical Requirements

All electrical equipment shall conform to the applicable standards of the National Electrical Manufacturers Association (NEMA), the Electronic Industries Association (EIA), the International Municipal Signal Association (IMSA), the Rural Electrification Administration (REA), the National Electric Code (NEC), the National Electrical Safety Code (NESC), the Telecommunications Industry Association (TIA), and Underwriters Laboratories (UL).

Furnish materials and workmanship conforming to the latest requirements of the Standards of the

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American Society for Testing and Materials (ASTM); American National Standards Institute (ANSI); and all local ordinances and regulations.

P. Requirements for Cables Crossing Railroads

Copies of all executed railroad agreements and related correspondence may be obtained from the Resident Engineer.

P.1. Railroad Crossings

Do not commence cable routings over or under railroad-owned facilities until notification and coordination with Engineer and the appropriate railroad company has occurred. All affected railroad facilities on this project are listed below and owned by the North Carolina Railroad (NCRR) or Norfolk Southern Railway Company (NSRC). Install fiber optic communications cable as shown on the plans.

	Encroachment	Near	Agency	Route
1	Sandy Ridge Road	Market Street	NSRC	Underground Crossing and Parallel
2	Market Street	NC-68	NSRC	Overhead and Underground Crossing and Parallel
3	Chimney Rock Road	Market Street	NSRC	Overhead Crossing
4	Market Street	Urban Loop	NSRC	Overhead Crossing and Parallel
5	Spring Garden Street	Wendover Avenue	NSRC	Underground Crossing
6	Spring Garden Street	Merritt Drive	NSRC	Overhead Crossing
7	Merritt Drive	Patterson Avenue	NCRR	Underground Crossing
8	Highland Avenue	Lee Street	NCRR	Underground Crossing
9	Elm Street	Burtner Street	NSRC	Underground Crossing
10	Yanceyville Street	Rankin Road	NSRC	Overhead and Underground Crossing

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	Encroachment	Near	Agency	Route
11	Cone Boulevard	Yanceyville Street	NSRC	Underground Crossing
12	Cornwallis Drive	Church Street	NSRC	Overhead Crossing
13	Bessemer Avenue	Church Street	NSRC	Overhead Crossing
14	Summit Avenue	Murrow Boulevard	NSRC	Underground Crossing
15	Gatewood Avenue	Wendover Avenue	NCRR	Underground Crossing
16	Bessemer Avenue	English Street	NCRR	Overhead Crossing
17	Market Street	English Street	NCRR	Overhead Crossing
18	Fernwood Road	Battleground Avenue	NSRC	Overhead Crossing
19	Cornwallis Road	Battleground Avenue	NSRC	Underground Crossing
20	Green Valley Road	Battleground Avenue	NSRC	Underground Parallel
21	Benjamin Boulevard	Battleground Ave	NSRC	Underground Crossing and Parallel
22	Hill Street	Smith Street	NSRC	Overhead Crossing
23	Florida Street	Elm-Eugene Street	NSRC	Underground Crossing
24	Vandalia Road	Pleasant Garden Road	NSRC	Overhead Crossing
25	Dudley Street	Market Street	NCRR	Underground Crossing
26	Lee Street	Eugene Street	NSRC	Underground Crossing
27	Market Street	Cedar Street	NSRC	Underground Crossing

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	Encroachment	Near	Agency	Route
28	Hilltop Road	Outer Loop	NCRR	Underground Crossing
29	Spring Garden	Wendover Avenue	NSRC	Underground Crossing

P.2. Requirements for Insurance

In addition to any other forms of insurance or bonds required under the terms of the contract and specifications, the Prime Contractor will be required to provide coverage conforming to the requirements of the Federal-Aid Policy Guide outlined under 23 CFR 646A for all work to be performed on Railroad right(s) of way by carrying insurance of the following kinds and amounts:

P.2.1. Contractor's Commercial General Liability Insurance

The Contractor shall furnish an original and one copy of the certificate of insurance and one certified copy of the policy to the Department as evidence that, with respect to the operations he performs on railroad right of way, he carries regular Commercial General Liability Insurance having a combined single limit of not less than \$2,000,000 per occurrence for all loss, damage, cost and expense, including attorneys' fees, arising out of bodily injury liability and property damage liability during the policy period. Said policy shall include explosion, collapse, and underground hazard (XCU) coverage, shall be endorsed to name Railroad specified below as an additional insured, and shall include a severability of interests provision.

P.2.2. Railroad Protective Liability Insurance

The Contractor shall furnish to the Department an original and one duplicate of the Railroad Protective Liability Insurance having a combined single limit of not less than \$2,000,000 each occurrence and \$6,000,000 in the aggregate applying separately to each annual period. If the project involves track over which passenger trains operate, the insurance limits required are not less than a combined single limit of \$5,000,000 each occurrence and \$10,000,000 in the aggregate applying separately to each annual period. Said policy shall provide coverage for all loss, damage or expense arising from bodily injury and property damage liability, and physical damage to property attributed to acts or omissions at the job site.

The standards for the Railroad Protective Liability Insurance are as follows:

- a. The insurer must be rated A- or better by A.M. Best Company, Inc.
- b. The policy must be written using one of the following combinations of Insurance Services

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Office (“ISO”) Railroad Protective Liability Insurance Form Numbers:

- (1) CG 00 35 01 96 and CG 28 31 10 93; or
- (2) CG 00 35 07 98 and CG 28 31 07 98; or
- (3) CG 00 35 10 01; or
- (4) CG 00 35 12 04.

c. The named insured shall read:

North Carolina Railroad; and
 Norfolk Southern Railway Company
 Three Commercial Place
 Norfolk, Virginia 23510-2191
 Attn: D. W. Fries, Director Risk Management

d. The description of operations must appear on the Declarations, must match the project description in this agreement, and must include the appropriate Department project and contract identification numbers.

The Description and Designation shall read:

Installation of fiber optic cable over/under tracks in Guilford County, North Carolina, U-4711.

e. The job location must appear on the Declarations and must include the city, state, and appropriate highway name/number.

f. The name and address of the prime contractor must appear on the Declarations.

g. The name and address of the Department must be identified on the Declarations as the “Involved Governmental Authority or Other Contracting Party.”

h. Other endorsements/forms that will be accepted are:

- (1) Broad Form Nuclear Exclusion – Form IL 00 21
- (2) 30-day Advance Notice of Non-renewal or cancellation
- (3) 60- day written notice be given the Department prior to cancellation or change
- (4) Quick Reference or Index Form CL/IL 240

i. Endorsements/forms that are NOT acceptable are:

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- (1) Any Pollution Exclusion Endorsement except CG 28 31
- (2) Any Punitive or Exemplary Damages Exclusion
- (3) Known injury or Damage Exclusion form CG 00 59
- (4) Any Common Policy Conditions form
- (5) Any other endorsement/form not specifically authorized in item no. h above.

If any part of the work is sublet, similar insurance, and evidence thereof as specified above, shall be provided by or on behalf of the subcontractor to cover its operations on Railroad's right of way. As an alternative, the Prime Contractor may provide insurance for the subcontractor by means of separate and individual policies.

Prior to entry on Railroad right-of-way, the original and one duplicate copy of the Railroad Protective Liability Insurance Policy shall be submitted by the Prime Contractor to the Department at the address below for its review and transmittal to the Railroad. In addition, certificates of insurance evidencing the Prime Contractor's and any subcontractors' Commercial General Liability Insurance shall be issued to the Railroad and the Department at the addresses below, and one certified copy of the Prime Contractor and any Subcontractors policy is to be forwarded to the Department for its review and transmittal to the Railroad. All policies and certificates of insurance shall state that the insurance coverage will not be suspended, voided, canceled, or reduced in coverage or limits without (30) days advance written notice to Railroad and the Department. No work will be permitted by Railroad on its right-of-way until it has reviewed and approved the evidence of insurance required herein.

DEPARTMENT:

Department of Transportation
 Utilities Coordination Unit
 c/o Mr. David Hinnant, State Railroad Agent
 1555 Mail Service Center
 Raleigh, NC 27699-1555

RAILROAD:

Mr. D. W. Fries, ARM
 Director Risk Management
 Norfolk Southern Railway Company
 Three Commercial Place
 Norfolk, Virginia 23510-2191

The insurance required herein shall not limit the obligations of Department or its Contractors under the terms of this agreement.

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All insurance herein before specified shall be carried until the final inspection and acceptance of the project, or that portion of the project within railroad right of way, by the Department or, in the case of subcontractors, until the Contractor furnishes a letter to the Engineer stating that the subcontractor has completed his subcontracted work within railroad right of way to the satisfaction of the Contractor and that the Contractor will accomplish any additional work necessary on railroad right of way with his own forces. It is understood that the amounts specified are minimum amounts and that the Contractor may carry insurance in larger amounts if he so desires. As to "aggregate limits", if the insurer establishes loss reserves equal to or in excess of the aggregate limit specified in any of the required insurance policies, Contractor shall immediately notify the Department of Transportation and shall cease all operations until the aggregate limit is reinstated. If the insurer establishes loss reserves equal to or in excess of one/half of the aggregate limit, Contractor shall arrange to restore the aggregate limit to at least the minimum amount stated in these requirements. Any insurance policies and certificates taken out and furnished due to these requirements shall be approved by the Department and the Railroad Company as to form and amount prior to beginning work on railroad right of way.

No separate payment will be made for any extra cost incurred on account of compliance with these special provisions. All such cost shall be included in prices bid for other items of the work as specified in the payment items.

Furnish evidence of insurance as required above for review to the Department of Transportation at the address shown below after which it will be forwarded by the Department of Transportation to the Railroad.

Send to Department:

Department of Transportation

Utilities Coordination Unit

c/o Mr. David Hinnant, State Railroad Agent

1546 Mail Service Center

Raleigh, NC 27699-1546

P.3. Failure to Comply

In the event the Contractor violates or fails to comply with any of the requirements of these Special Provisions:

- (1) The Railroad Engineer may require that the Contractor vacate Railroad property.
- (2) The Engineer may withhold all monies due the Contractor on monthly statements.

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Any such orders shall remain in effect until the Contractor has remedied the situation to the satisfaction of the Railroad Engineer and the Engineer.

P.4. Delays Caused By Operations of Others

Neither the Department of Transportation nor the Railroad Company assumes any responsibility for any work performed by others in connection with the construction of the project, and the Contractor shall have no claim whatsoever against the Department of Transportation, or the Railroad Company for any inconvenience, delay, or additional cost incurred by him on account of such operations by others.

P.5. Cooperation with Others

Cooperate with others participating in the construction of the project to the end that all work may be carried on to the best advantage.

P.6. Authority of Railroad Engineer

The authorized representative of the Railroad Company hereinafter referred to as the Railroad Engineer, shall have the final authority in all matters affecting the safe maintenance of railroad traffic of his company.

P.7. Interference with Railroad Operations

Arrange and conduct work so that there will be no interference with railroad operations, including train, signal, telephone and telegraphic services, or damage to the property of the Railroad Company or to the poles, wire, and other facilities of tenants on the rights of way of the Railroad Company. Wherever work is liable to affect the operations or safety of trains, the method of doing such work shall first be submitted to the Railroad Engineer for approval, but such approval shall not relieve the Contractor from liability.

Should conditions arising from or in connection with the work, require that immediate and unusual provisions be made to protect train operations and property of the Railroad Company, it shall be a part of the required services by the Contractor to make such provisions and if, in the judgment of the Railroad Engineer such provisions is insufficient, the Railroad Engineer or the Department of Transportation, may at the expense of the Contractor, require or provide such provisions as may be deemed necessary.

P.8. Storage of Materials

Materials and equipment shall not be stored where they will interfere with railroad operations, nor on the rights of way of the Railroad Company without first having obtained permission from the Railroad Engineer, and such permission will be with the understanding that the Railroad Company

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will not be liable for damage to such material and equipment from any cause and that the Railroad Engineer may move or require the Contractor to move, at the Contractor's expense, such material and equipment.

P.9. Flagging Protection or Watchman Service

The Contractor shall give 72 hours advance notice to the Railroad Company in order that flagging service can be arranged and provided. No work shall be undertaken until the flagman is at the job site.

P.10. Completion and Acceptance of Work

Upon completion of the work, remove from within the limits of the railroad right of way all machinery, equipment, surplus materials, or rubbish and leave said rights of way in a neat and orderly condition. After the final inspection has been made and work found to be completed in a satisfactory manner acceptable to the Department of Transportation and the Railroad Company, the Department of Transportation will be notified of the Railroad Company's acceptance in writing by the Railroad Company.

Q. Requirements for Historic Areas

As shown in the Plans, some work will be conducted within areas determined to contain properties with documented historic significance. If it is necessary to deviate from the Plans in these areas, alert the Engineer to contact Project Development And Environmental Analysis Branch-Historic Architecture Group of the North Carolina Department of Transportation for an effects determination before proceeding.

1.4. MEASUREMENT AND PAYMENT

There will be no direct payment for work covered in this section. Payment at the contract unit prices for the various items in the contract will be full compensation for all work covered by this section.

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2. MOBILIZATION

2.1. DESCRIPTION

This work consists of preparatory work and operations to mobilize personnel, materials and equipment to the project site.

2.2. MEASUREMENT AND PAYMENT

Mobilization will be paid for as contract lump sum price.

Partial payments for mobilization will be made with the first and second partial pay estimates paid on the contract, and will be made at the rate of 50% lump sum price on each of these partial pay estimates, provided the amount bid for mobilization does not exceed 5 percent of the total amount bid for the contract. Where the amount bid for the item of mobilization exceeds 5 percent of the total amount bid for the contract, 2 1/2 percent of the total amount bid will be paid on each of the first two partial pay estimates, and that portion exceeding 5 percent will be paid on the last partial pay estimate.

Such price and payment includes but is not limited to the movement of personnel, equipment, supplies, and incidentals to the project site, for the establishment of offices, buildings, and other facilities necessary for work on the project; the removal and disbandment of those personnel, equipment, supplies, incidentals, or other facilities that were established for the prosecution of work on the project; and for all other work and operations that shall be performed for costs incurred prior to beginning work on the various items on the project site.

Payment will be made under:

Mobilization.....Lump Sum

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3. SIGNAL AND MESSENGER CABLE**3.1. DESCRIPTION**

Furnish and install signal cable and messenger cable (spanwire) with cable clamps, machine bolts, eyebolts, 3-bolt clamps, eye nuts, split-bolt connectors, and all necessary hardware.

3.2. MATERIAL**A. General**

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

B. Signal Cable

Furnish 16-4 and 16-7 signal cable that complies with IMSA specification 20-1 except provide the following conductor insulation colors:

- For 16-4 cable: white, yellow, red, and green
- For 16-7 cable: white, yellow, red, green, yellow with black stripe tracer, red with black stripe tracer, and green with black stripe tracer. Apply continuous stripe tracer on conductor insulation with a longitudinal or spiral pattern.

Provide a ripcord to allow the cable jacket to be opened without using a cutter. Provide a cable jacket labeled with the IMSA specification number and provide conductors constructed of stranded copper.

C. Messenger Cable

Comply with ASTM A 475 for extra high strength grade wire strand, Class A zinc coating. Fabricate messenger cable from seven steel wires twisted into a single concentric strand.

Provide universal grade strandvises used for extra high strength steel messenger cable. Provide other pole line hardware constructed of hot-dipped galvanized steel. Provide machine bolts, eyebolts, and thimbleye bolts with minimum tensile strength of 12,400 lbs. Provide galvanized nuts, washers, and thimbleyelets.

3.3. CONSTRUCTION METHODS**A. Signal Cable**

Install signal cable in continuous lengths between signal controller cabinets and signal heads. Route signal cable to minimize the length of cable installed, and the number of cables and

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conductors in each run. Pull 36 inches of additional signal cable into controller cabinets.

Wrap signal cable to messenger cable with at least four turns of wrapping tape spaced at intervals less than 15 inches or lash signal cable to messenger cable with one 360 degree spiral of lashing wire per 12 inches.

Make electrical connections inside each signal head, signal controller cabinet, and termination compartment in metal poles. Do not splice cable at any other point between signal heads and controller cabinet.

Coil sufficient signal cable beside each vehicle signal head to accommodate head shifts during various construction phases. For final signal head locations, coil 36 inches on each side of signal head if signal cable comes from both directions. If signal cable terminates at the signal head, coil 36 inches of signal cable on the same side as the cable run

B. Messenger Cable

Install guy assemblies before installing messenger cable.

Use 1/4-inch messenger cable for spans supporting only cables unless otherwise specified.

Use 3/8-inch messenger cable for spans supporting signal heads.

For messenger cable crossing over railroad tracks, provide a minimum of 30 feet of vertical clearance, unless otherwise shown on the Plans.

For permanent installation, install messenger cable in continuous lengths with no splices except where an insulator is required. With prior approval, existing messenger for temporary installations may be extended instead of installing new messenger cable.

Tension messenger cable to eliminate appreciable sag and to match the sag of surrounding utilities. Otherwise, allow 3 to 4 percent sag of the span length between poles. Use crossover clamps to maintain proper vertical and horizontal alignment of adjoining cable runs.

Provide 3-bolt clamp assemblies consisting of 5/8 inch diameter machine bolts, j-hooks, washers, and square nuts to attach messenger cable to wood poles. Provide machine bolts that are 3 inches longer than the pole diameter.

Attach messenger cable to poles using three bolt cable clamps with J-hooks in mid-runs and deadend strandvises at termination poles.

Maintain electrical continuity at all splices.

For messenger cable for signal heads or loop lead-in cable attached to joint use poles, install a

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new grounding system that complies with Article 1720-3 for bonding messenger cable. If a pole ground exists on the joint use pole, bond new pole grounding system to existing pole ground using number 6 AWG minimum solid bare copper grounding wire terminated with split bolt connectors or Burndy clamps (UCG25RS) at each end.

For messenger cable for communications cable attached to joint use poles, bond messenger cable to existing pole ground using Burndy clamps (UCG25RS) at ends and at 1300-foot intervals. If existing poles do not have a grounding system, install new grounding system that complies with Article 1720-3 for bonding messenger cable.

On multiple messenger cable arrangements, connect all messenger cable ends with number 6 AWG minimum solid bare copper wire and bond with split bolt connectors or Burndy clamps (UCG25RS) or equivalent and terminate to pole ground.

3.4. MEASUREMENT AND PAYMENT

Signal cable will be measured and paid for as actual linear feet of signal cable furnished, installed, and accepted. Measurement will be point to point with no allowance for sag. Twenty-five feet will be allowed for vertical segments up or down poles.

Messenger cable (_____) will be measured and paid for as actual horizontal linear feet of messenger cable furnished, installed, and accepted. Measurement will be point to point with no allowance for sag.

MIS messenger cable (_____) will be measured and paid for as actual horizontal linear feet of messenger cable furnished, installed, and accepted. Measurement will be point to point with no allowance for sag.

No measurement will be made of cable clamps, machine bolts, eyebolts, strandvises, 3 bolt assemblies, eyenuts, split bolt connectors, messenger cable bonding, or pole grounding system as these will be considered incidental to furnishing and installing messenger cable.

Payment will be made under:

Signal Cable	Linear Foot
Messenger Cable (1/4")	Linear Foot
MIS Messenger Cable (1/4")	Linear Foot
Messenger Cable (3/8")	Linear Foot

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4. UNDERGROUND CONDUIT**4.1. DESCRIPTION**

Furnish and install conduit for underground installation with tracer wire, miscellaneous fittings, all necessary hardware, marker tape, backfill, graded stone, paving materials, and seeding and mulching.

4.2. MATERIAL**A. General**

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

Comply with the Standard Specification Article 1018-2 for backfill and Articles 545-2 and 545-3 for graded stone.

B. Rigid Metallic Conduit

Provide rigid hot dipped galvanized steel conduit that meets UL Standard 6 Electrical Rigid Metal Conduit-Steel with rigid full weight sherardized or galvanized threaded fittings.

C. Polyvinyl Chloride (PVC)

Provide non-metallic conduit and duct including associated couplings, approved for above and below ground use with or without concrete encasement in accordance with UL Standard 651A *Type EB and A Rigid PVC Conduit*. Provide Schedule 40 conduit unless otherwise specified.

D. Liquid-Tight Metallic Flexible Conduit

Provide conduit that meets UL Standard 360 *Liquid-Tight Flexible Steel Conduit* that is acceptable for equipment grounding in accordance with the NEC. Ensure conduit has insulated throat and malleable iron watertight fittings.

E. High Density Polyethylene Conduit (HDPE)

Provide HDPE conduit with an outer diameter to minimum wall thickness ratio that complies with ASTM D 3035, Standard Dimension Ratio (SDR) 13.6. Provide conduit that meets UL Standard 651B *Continuous Length HDPE Conduit*.

Provide conduit that meets the following:

ASTM D 638	Tensile Strength – 3,000 psi, min; Elongation – 400 percent, min
ASTM D 1238	Melt Index – 0.4 maximum

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ASTM D 1505	Density – (0.941-0.955g/cc)
ASTM D 1693	Condition B – 20 percent failure, maximum
ASTM D 2444	Impact – NEMA Standards Publication Number TC7
ASTM D 3350	Cell Classification – 334420 or 344420

Ensure HDPE conduit is resistant to benzene, calcium chloride, ethyl alcohol, fuel oil, gasoline, lubricating oil, potassium chloride, sodium chloride, sodium nitrate, and transformer oil, and is protected against degradation due to oxidation and general corrosion. Furnish conduit with a coefficient of friction of 0.09 or less in accordance with Telcordia GR-356.

Furnish factory lubricated, low friction, coilable, conduit constructed of HDPE. Furnish conduit with nominal diameter as required. Provide conduit with smooth outer wall and ribbed inner wall. Ensure conduit is capable of being coiled on reels in continuous lengths, transported, stored outdoors, and subsequently uncoiled for installation without affecting its properties or performance.

Furnish conduit that is suitable for underground use in an ambient temperature range of -30 to 130 degrees F without degradation of material properties.

Dependent upon the number of conduits required, furnish conduits in black, orange, blue and white colors. Provide conduits that are factory extruded with the appropriate colors.

Furnish conduit organizers at all points where multiple conduits enter and exit a junction box or cabinet. Furnish conduit organizers that are appropriately sized with regards to the conduits. Provide conduit organizers that are removable.

F. Conduit Plugs, Pull Line, and Tracer Wire

Furnish duct plugs that provide a watertight barrier when installed in conduit. Furnish duct plugs sized in accordance with conduit. Ensure duct plug provides a means to secure a pull line to the end of the plug. Provide removable and reusable duct plugs.

Furnish mechanical sealing devices that provide a watertight barrier between conduit and cables in conduit. Furnish mechanical sealing devices sized in accordance with conduit and with appropriately sized holes to accommodate and seal cables. Provide removable and re-usable mechanical sealing devices.

Furnish conduit spacers to bind the individual conduits together when installed in a common trench. Furnish conduit spacers that are appropriately sized with regards to the conduits.

Furnish 1/2", pre-lubricated, woven polyester tape, pull line with minimum rated tensile strength

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of 2,500 lb.

Provide green insulated number 14 AWG, THW, stranded copper wire to serve as tracer wire.

Comply with Subarticle 1400-2(H) Duct and Conduit Sealer.

Furnish non-detectable underground marker tape with the wording "WARNING – Fiber Optic Cable" in all trenches.

4.3. CONSTRUCTION METHODS**A. General**

Ensure conduit is free of moisture and debris before pulling cables.

Following installation of conduit where cable is not immediately installed, or conduit is for future use (spare), seal the ends of the conduit with a duct plug. Secure a pull line to the duct plug in such a manner that it will not interfere with installation of the duct plug and provides a watertight seal.

Extend ends of conduit 2 to 4 inches above concrete surfaces and 4 inches above crushed stone bases. For metallic conduit, install metallic bushings and bond conduits.

A.1. Conduit Entering Junction Boxes

Terminate conduits installed for communications cables in oversized junction boxes. Do not install other conduits in the oversized junction box unless otherwise specified.

Terminate conduits installed for signal wiring, including loop lead-in cable, in standard size junction boxes unless otherwise specified.

For all conduits entering junction boxes, seal spare conduits with approved duct plugs. Seal conduits containing fiber-optic communications cable with mechanical sealing devices. Seal conduits containing signal cable and loop lead-in wire with moldable duct seal.

A.2. Tracer Wire

Install tracer wire in all conduits containing fiber-optic cable. Pull tracer wire simultaneously in a continuous length with the fiber-optic cable. Where multiple pulls of fiber-optic cable are required and conduit is placed in the same trench, only one tracer wire is required. Where multiple pulls of fiber optic cable are required and conduits may separate into individual trenches, install a tracer wire in each conduit run. Provide waterproof butt splices where tracer wire is spliced. Splicing is allowed only in cabinets and junction boxes. Label all tracer wires entering the equipment cabinet.

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A.3. Plan of Record Drawings

Upon completion of the conduit system for communications, furnish the Engineer with a plan of record drawing detailing the horizontal and vertical locations of the conduit system.

B. Trenching

In certain cases the Contractor may use an alternate material and method of installation between trenching and plowing based on existing field conduits and preferences. Obtain approval before proceeding.

B.1. General

Install PVC, HDPE, or rigid metallic conduit for all underground runs. Install metallic conduit at all locations where conduits cross beneath railroad tracks. Clean existing underground conduit to be incorporated into a new system. Bond all metallic conduit.

If more than one conduit is required between the same points, install conduit in one common trench. Install non-detectable marker tape.

Install longitudinal runs of conduit a minimum of 1 foot from back of curb or 6 feet from edge of pavement in the absence of curb.

Maintain a minimum trench depth of 30 inches below finished grade or 6 inches below roadway subgrade, whichever is deeper.

Extend the ends of the conduits such that upon completion of the installation the conduits will extend a minimum of 2 inches above concrete surfaces and 4 inches above crushed stone bases.

Upon completion, restore surface to like-original condition within seven calendar days of occurrence of damage. Remove all rock and debris from backfill material. Remove excess material from site and compact area according to Article 300-7. Backfill with excavated material and compact to 95% of original density.

Backfill trench at locations along the trench path where non-movable objects, such as rocks and boulders, cannot be avoided. The purpose of the backfill is to provide a gradual change in elevation of the trench, so that excessive bending and stress will not be transferred to conduits once underground conduit system is installed.

After installation of conduits and upon completion of tamping and backfilling, perform a mandrel test on each conduit to ensure no conduit has been damaged. Furnish a non-metallic mandrel having a diameter of approximately 50% of the inside diameter of the conduit in which it is to be pulled through. If damage has occurred, replace the entire length of conduit. Ensure pull line is

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re-installed.

B.2. Unpaved Trenching

Install conduit in all unpaved areas. Rake smooth the top 1 1/2 inches seed with same type of grass as surrounding area. Finish unpaved areas flush with surrounding natural ground.

B.3. Paved Trenching

On concrete surfaces, replace the entire joint of concrete unless otherwise specified. On all other surfaces, neatly cut and replace the width of trench with like material.

Finish paved areas with materials matching damaged areas. For conduit installed under roadways, cut neatly and replace the width of paved area damaged by trenching. For conduit installed under sidewalks and walkways, remove entire section of slab from joint to joint and replace. Place graded stone material to temporarily maintain traffic where repairs cannot be performed immediately. Comply with Article 545-4.

C. Plowing (HDPE Conduit Only)

Direct plow HDPE ducts simultaneously using chute plow method. Direct plow ducts at a minimum depth so the top of the highest duct is 30 inches deep unless otherwise approved.

Provide sufficient personnel to feed chute, operate prime mover and equipment carrying reels (if separate equipment is used), observe chute feeding, observe plowing, and observe reel payout. Use chute with adequate dimensions to allow for passage of duct without damage. During plow operation, continuously check chute opening and path to be sure there are no obstructions and monitor payout reels to be sure reels are turning at a steady rate.

With prior approval, install a junction box at locations where splicing or coupling of the underground polyethylene conduits is necessary. Otherwise, splicing or joining of underground polyethylene conduit is prohibited.

D. Directional Drilling**D.1. Pre-Approvals and Minimum Depth Requirements**

Obtain approval before beginning drilling operations.

At all points where HDPE conduit will traverse under roadways, driveways, sidewalks, or Controlled Access Areas including entrance/exit ramps, maintain a minimum depth of 4 feet or 8 times the back reamer's diameter, whichever is deeper. For an installation that runs parallel to a controlled access area or entrance/exit ramps maintain a minimum depth of 30 inches below finished grade. Maintain a minimum clearance of 30 inches below finished grade when crossing ditch lines.

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For the following structures, the minimum clearance requirements are:

Man-made Structure	Minimum Clearance Requirement
Bridge foundation	5' horizontal & 4' vertical (clearances greater than minimum horizontal should continue to use the 4V:5H ratio, i.e., 10' horizontal should be no deeper than 8')
Drainage pipes less than 60"	1' above or below [while maintaining a minimum depth of 30" below grade]
Drainage pipes greater than 60"	1' above or 4' below [while maintaining a minimum depth of 30" below grade]
Box Culverts	1' above or 4' below [while maintaining a minimum depth of 30" below grade]
Slope protection	2' below
Slope protection foundation footing	5' below

Guarantee the drill rig operator and digital walkover locating system operator are factory-trained to operate the make and model of equipment provided and have a minimum of one year experience operating the make and model of drill rig. Submit documentation of the operators' training and experience for review at least two weeks before start of directional drilling operations.

Provide a means of collecting and containing drilling fluid/slurry that returns to the surface such as a slurry pit. Provide measures to prevent drilling fluids from entering drainage ditches and storm sewer systems. Prevent drilling fluid/slurry from accumulating on or flowing onto pedestrian walkways, driveways, and streets. Immediately remove all drilling fluids/slurry that are accidentally spilled.

D.2. Directional Drill Operations

Provide grounding for the drill rig in accordance with the manufacturer's recommendations.

Place excavated material near the top of the working pit and dispose of properly. Backfill pits and trenches to facilitate drilling operations immediately after drilling is completed.

Use drill head suitable for type of material being drilled and sized no more than 2 inches larger than the outer diameter of the conduit. Direct drill to obtain proper depth and desired destination.

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Pressure grout with an approved bentonite/polymer slurry mixture to fill all voids. Do not jet alone or wet bore with water.

During drilling operation, locate drill head every 10 feet along drill path and before traversing underground utilities or structures. Use digital walkover locating system to track drill head during directional drilling operation. Ensure locating system is capable of determining pitch, roll, heading, depth, and horizontal position of the drill head at any point.

Once drill head has reached final location, remove head, and install back reamer of appropriate size (no more than 2 inches larger than outer diameter of conduits) to simultaneously facilitate back reaming of drill hole and installation of conduit. Back reamer is sized larger than actual conduits to ensure conduits are not adversely subjected to deviations caused by the original drill operation and are as straight as practical in their final position.

The intent of these Specifications is to limit the diameter of the actual drill shaft/hole so that it is no more than 2 inches larger than the conduit outer diameter. The 2-inch larger diameter may be accomplished during the original bore or during the back reaming/conduit installation process.

Once installation of conduit has started, continue installation without interruption so as to prevent conduit from becoming firmly set. Apply bentonite/polymer slurry mixture during conduit installation.

Upon completion of conduit installation, perform a mandrel test on conduit system to ensure conduit has not been damaged. Furnish non-metallic mandrel with a diameter of approximately 50% of the inside diameter of the conduit in which it is to be pulled through. If damage has occurred, replace the entire length of conduit and ensure that pull line is re-installed.

D.3. Drilling Fluids

Use lubrication for subsequent removal of material and immediate installation of the conduit. The use of water and other fluids in connection with directional drilling operations will be permitted only to the extent necessary to lubricate cuttings. Do not jet alone or wet bore with water. Use drilling fluid/slurry consisting of at least 10 percent high-grade bentonite/polymer slurry to consolidate excavated material and seal drill hole walls.

Transport waste drilling fluid/slurry from site and dispose of in a method that complies with local, state and federal laws and regulations.

D.4. Conduit Splicing

With prior approval, install a junction box at locations where splicing or coupling of conduit is necessary. Otherwise, splicing or joining of HDPE conduit is prohibited.

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E. Bore and Jack

For bore and jack areas, comply with Subarticles 1540-3 A & B except as follows:

For bore and jack areas, install metallic conduit at a minimum depth of 30 inches below finished grade or 6 inches below roadway sub-grade, whichever is greater. Provide 3 feet clearance to conduit from back of curb or from edge of pavement. Terminate ends of conduit into junction boxes.

Comply with the *NCDOT Policies and Procedures for Accommodating Utilities on Highway Rights-of-Way* in effect on the date of advertisement.

F. Multi-Duct Installation in Outer-Duct

At locations called for jack and bore in the Plans, install multi-duct conduit system in single outer-duct conduit that was installed during jack and bore. Simultaneously install the individual colored conduits in the outer-duct conduit. Install the multi-duct conduits using an approved cable pulling lubricant.

Use a dynamometer (clutch device) so as not to exceed the maximum allowable pulling tension. Do not use a motorized vehicle to generate pulling forces.

Keep tension on the conduit(s) and the pulling line at the start of each pull. Do not release the tension if the pulling operation is halted. Restart the pulling operation by gradually increasing the tension until the multi-ducts are in motion. Once the multi-duct system is installed in the outer-duct, install the duct organizers at the point where the multi-duct system enters or exits outer-duct.

Extend the ends of the multi-duct conduit such that upon completion of the installation, the conduits will extend a minimum of 2 inches above concrete surfaces and 4 inches above crushed stone bases.

After installation of the multi-duct conduits, perform a mandrel test on each individual conduit to ensure that no conduits have been damaged. Furnish a non-metallic mandrel having a diameter of approximately 50% of the inside diameter of the conduit in which it is to be pulled through. If damage has occurred replace the entire length of conduit.

G. Reuse of Existing Conduit

At certain locations, the Plans call for the use of existing communications ducts made available to the City via agreement with Bell South and University of North Carolina – Greensboro (UNCG). Use of this conduit must be in accord with all terms and conditions described in the agreement between Bell South and the City of Greensboro and the agreement between UNCG and the City of Greensboro. Copies of use agreements will be obtained from the City by the Engineer and furnished

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to the Contractor upon request. Only pre-approved Bell South and UNCG Greensboro contractor may be used to work in and to modify this conduit. These conduit locations are shown on the Plans. Prior to commencing work on any segment of Bell South or UNCG conduit, provide Engineer with time, dates, locations, and pre-approved contractor contact information (firm name, location, firm contact name, firm contact address and phone number). Obtain written authorization from the Engineer prior to commencing any work on any segment of the Bell South or UNCG duct. Until final project acceptance, the Contractor shall indemnify and hold harmless NCDOT and the City of Greensboro and be completely and wholly responsible for any claims due to use of the conduit and access points as spelled out in the agreement.

Prior to use of existing conduit, the Contractor shall be responsible for verifying the usability of the conduit for the size cable(s) called for in the Plans. For any locations where new conductors are to be installed where existing cable is present, the Contractor shall not damage nor affect the usability of performance of the existing cable.

4.4. MEASUREMENT AND PAYMENT

Tracer wire will be measured along the horizontal linear feet of tracer wire furnished, installed, and accepted. Measurement will be along the approximate centerline of the conduit system. Payment will be made in linear feet. No payment will be made for excess tracer wire in junction boxes and/or cabinets.

MIS tracer wire will be measured along the horizontal linear feet of tracer wire furnished, installed, and accepted. Measurement will be along the approximate centerline of the conduit system. Payment will be made in linear feet. No payment will be made for excess tracer wire in junction boxes and/or cabinets.

Unpaved trenching (qty)(size) & (qty)(size) will be measured in horizontal linear feet of trenching for underground conduit installation of each type furnished, installed, and accepted. Measurement will be along the approximate centerline of the conduit system. Payment will be in linear feet. No payment will be made for restoring surface to like-original conditions.

MIS unpaved trenching (qty)(size) & (qty)(size) will be measured in horizontal linear feet of trenching for underground conduit installation of each type furnished, installed, and accepted. Measurement will be along the approximate centerline of the conduit system. Payment will be in linear feet. No payment will be made for restoring surface to like-original conditions.

Paved trenching (qty)(size) & (qty)(size) will be measured in horizontal linear feet of trenching for underground conduit installation of each type furnished, installed, and accepted. Measurement

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will be along the approximate centerline of the conduit system. Payment will be in linear feet. No payment will be made for restoring surface to like-original conditions.

MIS paved trenching (qty)(size) & (qty)(size) will be measured in horizontal linear feet of trenching for underground conduit installation of each type furnished, installed, and accepted. Measurement will be along the approximate centerline of the conduit system. Payment will be in linear feet. No payment will be made for restoring surface to like-original conditions.

Directional drill (qty)(size) & (qty)(size) will be measured in horizontal linear feet of directional drill for underground conduit installation furnished, installed, and accepted. Measurement will be along the approximate centerline of the conduit system. Payment will be in linear feet.

MIS directional drill (qty)(size) & (qty)(size) will be measured in horizontal linear feet of directional drill for underground conduit installation furnished, installed, and accepted. Measurement will be along the approximate centerline of the conduit system. Payment will be in linear feet.

Bore and jack (qty)(size) & (qty)(size) will be measured in horizontal linear feet of bore and jack for underground conduit installation furnished, installed, and accepted. Measurement will be along the approximate centerline of the bore from junction box to junction box. Payment will be in linear feet.

MIS bore and jack (qty)(size) & (qty)(size) will be measured in horizontal linear feet of bore and jack for underground conduit installation furnished, installed, and accepted. Measurement will be along the approximate centerline of the bore from junction box to junction box. Payment will be in linear feet

Multi-duct (qty)(size) in outer-duct (qty)(size) will be measured in horizontal linear feet of multi-duct conduit installed and accepted. Measurement will be along the approximate centerline of the conduit system. Payment will be in linear feet.

MIS multi-duct (qty)(size) in outer-duct (qty)(size) will be measured in horizontal linear feet of multi-duct conduit installed and accepted. Measurement will be along the approximate centerline of the conduit system. Payment will be in linear feet.

No measurement will be made of vertical segments, sealing devices, backfill, graded stone, paved materials, miscellaneous fittings, pull lines, marker tape, mechanical sealing devices, duct plugs, conduit organizers, plan of record drawings, and seeding and mulching as these will be considered incidental to conduit installation.

Payment will be made under:

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Tracer Wire	Linear Foot
MIS Tracer Wire	Linear Foot
Unpaved Trenching (1)(2") HDPE Conduit	Linear Foot
Unpaved Trenching (2)(2") HDPE Conduit	Linear Foot
MIS Unpaved Trenching (2)(2") HDPE Conduit	Linear Foot
Unpaved Trenching (2)(2") PVC Conduit	Linear Foot
Paved Trenching (1)(2") HDPE Conduit	Linear Foot
MIS Paved Trenching (1)(2") HDPE Conduit	Linear Foot
Paved Trenching (2)(2") HDPE Conduit	Linear Foot
MIS Paved Trenching (2)(2") HDPE Conduit	Linear Foot
Directional Drill (1)(2")	Linear Foot
Directional Drill (2)(2")	Linear Foot
MIS Directional Drill (2)(2")	Linear Foot
Bore and Jack (1)(5")	Linear Foot
MIS Bore and Jack (1)(5")	Linear Foot
Multi-Duct (2)(2") in Outer-Duct (1)(5")	Linear Foot
MIS Multi-Duct (2)(2") in Outer-Duct (1)(5")	Linear Foot

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5. JUNCTION BOXES**5.1. DESCRIPTION**

Furnish and install junction boxes (pull boxes) with covers, graded stone, grounding systems, and all necessary hardware.

5.2. MATERIAL**A. General**

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

Comply with Section 545 of the Standard Specifications for graded stone.

Comply with Article 1411-2 Electrical Junction Boxes except as follows:

- Provide junction box covers with standard *Traffic Signal* or *GDOT Fiber Optic* logos, pull slots, and stainless steel pins.
- Do not provide sealant compound between junction boxes and covers.

B. Standard Sized Junction Boxes

Provide standard sized junction boxes with minimum inside dimensions of 16"(l) x 10"(w) x 10"(d) that meet or exceed the Tier 15 requirements of ANSI/SCTE 77. Provide certification that testing methods are compliant with ANSI/SCTE 77. Vertical extensions of 6" to 12" shall be available from the junction box manufacturer.

C. Oversized Heavy-Duty Junction Boxes

Provide oversized heavy-duty junction boxes and covers with minimum inside dimensions of 30"(l) x 15"(w) x 24"(d) that meet or exceed the Tier 15 requirements of ANSI/SCTE 77. Provide certification that testing methods are compliant with ANSI/SCTE 77.

D. Special Oversized Heavy-Duty Junction Boxes

Provide oversized heavy-duty junction boxes and covers with minimum inside dimensions of 48"(l) x 48"(w) x 36"(d) that meet or exceed the Tier 15 requirements of ANSI/SCTE 77. Provide certification that testing methods are compliant with ANSI/SCTE 77.

5.3. CONSTRUCTION METHODS

Comply with the Article 1411-3 of the Standard Specifications except as noted herein:

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Install the junction boxes flush with finished grade. Do not install sealant compound between junction boxes and covers.

Install junction boxes at maximum intervals of 250 feet, or where shown on the plans and at locations where underground splicing of lead-in cable is necessary, whichever is less.

At locations where an existing junction box is removed and replaced by a new junction box, the Contractor shall remove the junction box with minimal disruption to the surface of the surrounding area. The Contractor shall seal the existing conduit, protect any existing cables, and replace any surface materials in kind. The junction box should be disposed of by the Contractor in a manner approved by the Engineer.

At certain locations shown in the Plans, reuse existing pull boxes. Precaution shall be taken to prevent damage to the existing conduit or cables. Coil fifteen (15) feet of each new fiber optic cable entering each existing pull box unless otherwise noted. At locations where a new junction box or new conduit is to be connected to an existing junction box, use method to enter existing junction box as approved by the Engineer. Do not damage existing junction box or existing junction box contents. Junction boxes or cable damaged shall be replaced at the Contractor’s expense. At locations where work is called for at manholes, follow all applicable City, State, and Federal requirements regarding work in enclosed spaces.

5.4. MEASUREMENT AND PAYMENT

Junction box (_____) will be measured and paid in actual number of junction boxes of each size and type furnished, installed, and accepted.

MIS junction box (_____) will be measured and paid in actual number of junction boxes of each size and type furnished, installed, and accepted.

No measurement will be made of covers, graded stone, and grounding systems as these will be considered incidental to furnishing and installing junction boxes.

No measurement will be made for the removal and disposal of existing junction boxes as these will be considered incidental to furnishing and installing new junction boxes.

Payment will be made under:

Junction Box (Standard Size).....	Each
Junction Box (Over-Sized Heavy Duty)	Each
MIS Junction Box (Over-Sized Heavy Duty).....	Each

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Junction Box (Special OverSized).....Each

MIS Junction Box (Special OverSized).....Each

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6. WOOD POLES**6.1. DESCRIPTION**

Furnish and install wood poles with grounding systems and all necessary hardware

6.2. MATERIALS

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

Comply with Subarticles 1082-3(F) Treated Timber and Lumber – Poles and 1082-4(G) Preservative Treatment – Poles in the Standard Specifications.

Use treated wood poles meeting the requirements of Section 1082. Unless otherwise required by the contract, use Class 3 or better wood poles that have a minimum length of 40 feet and are of a sufficient length to maintain the minimum required clearances above the roadway, obstructions, and affected railroad tracks. At locations where wood poles will be used for the mounting of CCTV assemblies, use poles with minimum length resulting in installed height of 45 feet.

6.3. CONSTRUCTION METHODS

Mark final pole locations and receive approval before installing poles. Unless otherwise specified, locate poles a minimum of 6 feet behind face of curb or 10 feet from edge of travelway.

Drill or auger a hole for placement of pole and to allow for compacting. Set pole at manufacturer's recommended depth, but at a minimum depth of 5 feet. Ensure the pole is within two degrees of vertical when fully loaded.

Backfill hole with pole installed and tamp backfill in 6 inch lifts with a mechanical tamp until compacted density is at least 95% of original density.

On new Department owned poles, install a grounding system consisting of number 4 or 6 AWG solid bare copper wire that is exothermically welded to a ground rod. Install ground wire so as to minimize damage from vandalism and environmental exposures. Install ground wire up pole to a point adjacent to the uppermost span. Use hot-dipped galvanized wire staples to secure ground wire to pole. Install ground rod at base of pole.

6.4. MEASUREMENT AND PAYMENT

Wood pole will be measured and paid as the actual number of wood poles furnished, installed,

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and accepted.

MIS Wood pole will be measured and paid as the actual number of wood poles furnished, installed, and accepted.

No measurement will be made for installing grounding systems as these will be considered incidental to furnishing and installing wood poles.

Payment will be made under:

Wood Pole.....	Each
MIS Wood Pole.....	Each

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7. METAL POLES**7.1. DESCRIPTION**

Furnish and install metal strain poles, grounding systems, and all necessary hardware. The work covered by this special provision includes requirements for the design, fabrication, and installation of both standard and custom/site specifically designed metal traffic signal supports and associated foundations.

Provide metal support systems that contain no guy assemblies, struts, or stay braces. Provide designs of completed assemblies with hardware that equals or exceeds AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals 4th Edition, 2001 (hereafter called 4th Edition AASHTO), including the latest interim specifications. Provide assemblies with a round or near-round cross-sectional design consisting of no less than six sides. The sides may be straight, convex, or concave.

Standard Drawings for Metal Poles are available that supplement these project special provisions. These drawings are located on the Department's website:

<http://www.ncdot.org/doh/preconstruct/traffic/ITSS/ws/disclaimer.html>

The required drawings are M 1, M 2, M 3 (strain poles), M 6 (strain poles), M 7, and M 8 (standard strain poles).

Comply with Subarticle 1098-1B "General Requirements" of the Standard Specifications for submittal requirements. Furnish shop drawings for approval. Provide triplicate copies of detailed shop drawings for each type of structure. Ensure that shop drawings show materials specifications for each component and identifies welds by type and size. Do not release structures for fabrication until structural drawings have been approved. Provide an itemized bill of materials for all structural components and associated connecting hardware on the drawings.

If plans call for Standard Metal Signal Supports, comply with Subarticle 1098-1A "General Requirements" for QPL submittals.

7.2. MATERIALS

Fabricate monotube shafts with a uniform linear taper of 0.14 in/ft with steel that conforms to ASTM A-595 minimum Grade A or an approved equivalent. Galvanize in accordance with AASHTO M111.

Use the submerged arc process to continuously weld shafts for the entire length. Ground or roll

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smooth exposed welds until flush with the base metal. Ensure shafts have no circumferential welds except at the lower end joining the shaft to the base. Provide welding that conforms to Article 1072-20 of the Standard Specifications, except that no field welding on any part of the pole will be permitted.

Refer to Standard Drawings for Metal Poles M2 for fabrication details. Fabricate anchor bases from plate steel meeting the requirements of ASTM A 36M or cast steel meeting the requirements of ASTM A 27M Grade 485-250, AASHTO M270 grade 36 or an approved equivalent. Conform to the applicable bolt pattern and orientation specified by the design as shown on drawing M2.

Ensure hardware is galvanized steel or stainless steel.

Ensure material used in steel anchor bolts conforms to AASHTO M 314, and yield strength does not exceed 55,000 psi. Unless otherwise required by the design, ensure each anchor bolt is 2" in diameter and 60" in length. Provide 10" minimum thread projection at the top of the bolt, and 8" minimum at the bottom of the bolt. Galvanize each anchor bolt in accordance with AASHTO M232 or M298 from the top of the bolt to a minimum of 2" below the threads.

Provide a circular anchor bolt lock plate that will be secured to the anchor bolts at the embedded end with 2 washers and nuts. Provide a base plate template that matches the bolt circle diameter of the anchor bolt lock plate. Construct plates and templates from ¼" minimum thick steel with a minimum width of 4". Galvanizing is not required.

Provide 4 heavy hex nuts and 4 flat washers for each anchor bolt. For nuts, use AASHTO M291 grade 2H, DH, or DH3 or equivalent material. For flat washers, use AASHTO M293 or equivalent material.

Ensure end caps for poles or mast arms are constructed of cast aluminum conforming to Aluminum Association Alloy 356.0F.

7.3. CONSTRUCTION METHODS**A. General**

Erect signal supports poles only after concrete has attained a minimum allowable compressive strength of 3000 psi. Follow anchor nut-tightening procedures below to complete the installation of the upright. Install metal poles, hardware, and fittings as shown on the manufacturer's installation drawings. Install metal poles so that when the pole is fully loaded it is within 2 degrees of vertical. Install poles with the manufacturer's recommended "rake." Use threaded leveling nuts to establish rake.

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Connect poles to grounding electrodes and the intersection grounding systems.

For holes in the poles used to accommodate cables, install grommets before wiring pole or arm. Do not cut or split grommets.

Attach the terminal compartment cover to the pole by a sturdy chain or cable. Ensure the chain or cable is long enough to permit the cover to hang clear of the compartment opening when the cover is removed, and is strong enough to prevent vandals from being able to disconnect the cover from the pole. Ensure the chain or cable will not interfere with service to the cables in the pole base.

Attach cap to pole with a sturdy chain or cable. Ensure the chain or cable is long enough to permit the cap to hang clear of the opening when the cap is removed.

Perform repair of damaged galvanizing that complies with the Standard Specifications, Article 1076-6 "Repair of Galvanizing."

B. Anchor Nut Tightening Procedure

Compute the required projection of the anchor bolt above the foundation top. Compute the total projection based on the following:

Provide between 3 and 5 threads of anchor bolt projection above the top nut after tightening is complete. Avoid any additional projection, or a normal depth socket torque wrench can not be used on top nuts.

Include the sum of the thickness of top nut, top nut flat washer or top nut beveled washer, base plate, leveling nut flat washer or leveling nut beveled washer, and 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 bolt under service conditions.

Do not use lock washers.

C. Installation Procedure:

Place a leveling nut and washer on each anchor bolt and install a template on top of the leveling nuts to verify that the nuts are level and uniformly contact the template. Use beveled washers if the leveling nuts cannot be brought into firm contact with the template. Verify that the distance between the bottom of the leveling nuts and the top of the concrete is no more than one nut height. Consider how attachments and applied loads may affect the vertical nature of the metal pole after erected and fully loaded. If necessary, induce a rake to the upright in the opposite direction of the anticipated loads during the initial erection by adjusting the leveling nuts accordingly. Failure to consider this could result in the upright being out of the allowable vertical tolerance as specified in the Metal

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Strain Pole Construction Methods of this special provision.

Install the vertical upright on the anchor bolts, and tighten nuts in compliance with steps 3, 4, and 5 below. Do not attach cantilever arms or messenger cable to the vertical post until all of the top nuts and leveling nuts have been properly tightened on the anchor bolts.

Install top nuts and washers. Install flat washers under the top and leveling nuts. Use beveled washers if the nuts cannot be brought into firm contact with the base plate. Lubricate threads of the anchor bolts, nuts, and bearing surface of the nuts and tighten to a snug-tight condition with a spud wrench following a star pattern (using at least two increments). Snug-tight condition is defined as 20% to 30% of the verification torque (600 ft-lbs.). Ensure lubricant is beeswax, stick paraffin, or other approved lubricant.

After the top nuts have been snug tightened, snug tighten the bottom nuts up to the base plate using the same procedure as described above. The base-plate must be in firm contact with both the top and bottom nuts to achieve the proper pretension in the anchor bolts.

Before further turning of the nuts, mark the reference position of the top nut in the snug-tight condition by match marking each nut, bolt shank, and base plate. Use ink or paint that is not water-soluble.

Turn the top nuts in increments using the star pattern (using at least two full tightening cycles) to 1/6 of a turn. Use a torque wrench to verify that at least 600 ft-lbs. is required to further tighten the top nuts. At least 48 hours after the entire structure and any attachments are erected, use a torque wrench again to verify that at least 600 ft-lbs. is still required to tighten the top nuts. Verify that the leveling nuts remain in firm contact with the base plate.

Do not place non-shrink grout between the base plate and foundation. This will allow for future inspection of leveling nuts and for adequate drainage of moisture.

7.4. MEASUREMENT AND PAYMENT

Actual number of metal strain poles without regard to height or load capacity furnished, installed and accepted.

No measurement will be made of foundation designs prepared with metal pole designs, as these will be considered incidental to designing signal support structures.

Payment will be made under:

Metal PoleEach

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8. GUY ASSEMBLIES**8.1. DESCRIPTION**

Furnish and install guy assemblies with all necessary hardware.

8.2. MATERIAL

Material, equipment, and hardware furnished under this section must be pre-approved on the Department's QPL by the date of equipment installation.

Furnish guy assemblies with anchor assemblies, guy cable, and guy cable guard.

Provide anchor assemblies with all miscellaneous hardware consisting of either expanding anchor with rod and tripeye attachment, screw anchor with extension rod and tripeye attachment, or expanding rock anchor with tripeye attachment. Ensure anchor assembly size is adequate for site conditions. Provide rods constructed of hot-dipped galvanized steel sized according to the soil bearing conditions in the area. Provide tripeye guy attachments constructed of hot-dipped galvanized steel. Anchor assemblies with double-strand eyes may be used in lieu of those with the tripeye feature when only one guy cable is to be attached. Ensure anchor assemblies are 7 feet minimum in length.

For the type of anchor assembly furnished, ensure that the following:

- Expanding anchor - provide steel construction with a protective paint or heat shrink of 6 mil plastic to protect the metal during shipping and storage.
- Screw anchor - provide hot-dipped galvanized steel construction.
- Expanding rock anchors - provide malleable iron and rust-resisting paint construction.

Provide 3-bolt clamp fabricated from galvanized steel with minimum length of 5 3/4". Ensure clamp has parallel grooves (one on each side of bolt holes) for cable placement. Provide three 1/2" diameter galvanized bolts and nuts to tighten the clamp around the messenger cable. Ensure clamp fits 1/4" to 3/8" messenger cable.

Provide full round guy cable guards that are 8 feet in length and constructed of ultraviolet stabilized, high impact, bright yellow, high density polyethylene.

Provide guy cables consisting of messenger cable of the same size as the largest sized messenger cable to be guyed. Comply with **Section 3** of these Project Special Provisions.

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8.3. CONSTRUCTION METHODS

A. Guy Assemblies for Signal Heads or Loop Lead-in Cable

Install guy assemblies with guy cable, guy guards, anchors, three-bolt clamps and associated fittings. Use two-bolt attachment method where there is adequate room on the pole to comply with the NESC. Attach guy assembly and guy cable to two separate bolts with one bolt for span and one bolt for guy cable.

Where adequate spacing is not available and a violation of the NESC would occur with the two-bolt attachment method, use approved one-bolt attachment method for attaching messenger cable and guy assembly.

Bond guy assembly to new pole grounding system as described in Section 1710-3.

Do not attach to existing guy assemblies unless specifically approved by owner.

B. Guy Assemblies for Communications Cable

When installing messenger cable for supporting only communications cable, use approved one-bolt attachment method for attaching messenger cable and guy assembly. Install mid-span guys in accord with telecommunication standards and as approved by the Engineer.

Bond guy assembly to existing pole ground using Burndy Clamp (UCG25RS) or equivalent. If existing poles do not have a grounding system, install new grounding system for bonding guy assembly that complies with Article 1720-3.

Do not attach to existing guy assemblies unless specifically approved by owner.

8.4. MEASUREMENT AND PAYMENT

Guy assembly will be measured and paid as the actual number of guy assemblies furnished, installed, and accepted.

MIS guy assembly will be measured and paid as the actual number of guy assemblies furnished, installed, and accepted.

No measurement will be made of guy cable, guy guards, anchors, clamps, or fittings as this will be considered incidental to furnishing and installing guy assemblies.

Payment will be made under:

Guy Assembly.....	Each
MIS Guy Assembly.....	Each

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9. RISER ASSEMBLIES**9.1. DESCRIPTION**

Furnish and install riser assemblies with clamp-on, aluminum weatherheads or heat shrink tubing, galvanized pole attachment fittings, and all necessary hardware.

9.2. MATERIAL

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

Provide rigid metallic conduit for risers as called for in these Project Special Provisions.

Provide Tyco™ (Raychem™) part number 066193-000 or equivalent heat shrink tubing for the installation of fiber-optic or coaxial cable in new risers.

Provide Tyco™ (Raychem™) part number FOSC-ACC-CABLE-SEAL-2-NW or equivalent heat shrink tubing retrofit kits for the installation of new fiber-optic or coaxial cable in existing riser with existing fiber-optic or coaxial cables.

9.3. CONSTRUCTION METHODS**A. New Installations**

Install risers with required weatherheads or heat shrink tubing on poles using pole attachment fittings.

Install heat shrink tubing retrofit kits in existing risers as specified.

Use separate 1/2-inch riser with weatherhead for pedestrian pushbutton.

Use separate 1-inch riser with weatherhead for electrical service.

Use separate 2-inch riser with weatherhead for signal cables (bundled). Use separate 2-inch riser with weatherhead for the combination of all lead-in and twisted-pair communications cable. Install conduit on all risers for lead-in cable.

Use separate 2-inch riser with heat shrink tubing for fiber-optic communications cables and coaxial cable. Install risers with heat shrink tubing so that cable can be installed without violating its minimum bending radius. Install cable so it does not share a riser with any other cable.

Install heat shrink tubing in accordance with manufacturer's recommendations. Provide tubing a minimum of 5 inches in length with a minimum of 2.5 inches extended over cables and 2.5 inches

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extended over risers after heat has been applied. Use nylon filler rods with UV protection or equivalent, and sealing spacer clips to separate cables where multiple cables enter a riser. Ensure sealing spacer clips have a heat activated sealing compound with the sealing compound fully encapsulating the space between cables. Ensure heat shrink tubing provides a watertight fit around individual cables and outer walls of risers. Do not use cut sections of cable or any other devices in lieu of filler rods. Use aluminum tape around cables to prevent damage from sealing chemicals. Use a heat source that will provide even heat distribution around tubing. Ensure no damage occurs to any cables.

B. Reuse Existing Risers

At locations shown in the plans, install fiber optic cable in existing riser assemblies. If required, replace existing weatherhead with heat shrink tubing using a method approved by the Engineer.

9.4. MEASUREMENT AND PAYMENT

___" Riser with _____ will be measured and paid as the actual number of risers of each type and size furnished, installed, and accepted.

MIS ___" riser with _____ will be measured and paid as the actual number of risers of each type and size furnished, installed, and accepted.

Heat shrink tubing retrofit kit will be measured and paid for as the actual number of heat shrink tubing retrofit kits furnished, installed, and accepted.

No measurement will be made for replacing weatherhead of existing riser assemblies with heat shrink tubing as this will be considered incidental to the installation of the fiber optic cable.

Payment will be made under:

2" Riser with Weatherhead	Each
2" Riser with Heat Shrink Tubing	Each
MIS 2" Riser with Heat Shrink Tubing	Each
Heat Shrink Tubing Retrofit Kit	Each

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10. INDUCTIVE DETECTION LOOPS**10.1. DESCRIPTION**

Furnish and install inductive detection loops with loop slot sealant, loop wire, conduit with fittings, and all necessary hardware.

10.2. MATERIAL

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

A. Loop Sealant

Provide loop slot sealant that completely encapsulates loop wire when installed according to manufacturer's instructions. Provide loop sealant that does not generate temperatures greater than 220 degrees F. Ensure sealant bonds with asphalt and concrete pavement saw slots so sealant and encapsulated loop wire do not come out of slot. Ensure sealant is self-leveling, but with sufficient viscosity to prevent exit from saw slot when installed along a ten percent grade.

Provide sealant that protects loop wire by preventing the entrance of dirt, water, rocks, sticks, and other debris into saw slot, and is resistant to traffic, water, gasoline, chemical and chemical fumes, mild alkalis, oils, and mild acids. Ensure sealant will not be affected by water and sealant does not chemically interact with pavement and loop wire insulation.

Ensure loop sealant has sufficient flexibility to permit expected pavement expansion and contraction due to weather and to permit pavement movement due to traffic without cracking for a temperature range of -40 to 160 degrees F.

Provide sealant with a usable life of at least ten minutes once mixed, when the ambient temperature is 75 degrees F. Ensure sealant dries to tack free state in less than two hours, and does not flow within or out of saw slot after exposed surface has become tack free. Tack free time will be determined by testing with a cotton ball until no sealant adheres to cotton ball and no cotton adheres to sealant.

Ensure two part sealant cures within 48 hours to attain 95 percent of published properties for the cured material.

Ensure one part sealant cures within 30 days to attain 95 percent of published properties for the cured material.

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B. Loop Wire

Provide loop wire composed of 19-strand conductor insulated by a cross-linked polyethylene compound. Ensure insulated conductors are completely encased in tubes of low density polyethylene compound. Print manufacturer's name, manufacture year, and any applicable part number on encasing tube at intervals of 2 feet or less.

Provide number 14 AWG copper conductors fabricated from 19 strands that comply with ASTM B 3 before insulating. Ensure stranded conductors use either concentric or bunch stranding, and comply with circular mil area and physical requirements of ASTM B 8 or ASTM B 174 for bunch stranding.

Provide insulating compound that is cross-linked thermosetting black polyethylene (ASTM D 2655). Ensure insulation is applied concentrically about conductor. Provide insulation thickness not less than 0.026" at any point and minimum average thickness of 0.030" as measured by UL Standard 62.

Ensure insulation of finished conductor will withstand application of a 60 Hertz or 3000 Hertz, 7500 volt (RMS) essentially sinusoidal spark test potential as specified in UL Standard 83.

Provide insulated conductors that are factory-installed in protective encasing tube that comply with the following:

- Encasing tube fabricated of polyethylene compound conforming to ASTM D 1248 for Type I, Class C, Grade E5.
- Minimum inside diameter of 0.150"
- Wall thickness of 0.040" +/- 0.010"
- Outside diameter of 0.240" +/- 0.010"

C. Conduit

Comply with **Section 4** of these Project Special Provisions for non-metallic conduit.

10.3. CONSTRUCTION METHODS**A. General**

All work performed in this section shall be done in the presence of the Engineer.

Notify Engineer one week before installing inductive detection loops.

Coordinate sawcutting and loop placement with pavement markings. For new construction or for resurfacing, install inductive detection loops before placing final layer of surface course. On

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unmarked pavement, pre-mark locations of stop lines and lane lines before locating inductive detection loops.

Loop locations are shown on the Plans with the distance to the closest stopline in the direction of travel noted. This measurement is an approximation. Before sawcutting, pre-mark inductive detection loop locations and receive approval.

Sawcut pavement at approved pre-marked locations. Do not allow vehicles to travel over unsealed loop slots.

Install conduit with bushings from edge of pavement to junction box. Do not sawcut through curb.

Remove all loose material and wash saw slots with a high-pressure method using an air and water mixture. Dry saw slots with compressed air. Clear saw slots of jagged edges and protrusions. Seat loop conductor at bottom of saw slot without damaging loop wire.

Before sealing loop conductors, test that impedance from the loop wire to ground is at least 100 megohms. For each location with inductive loops, submit a completed Inductive Detection Loop & Grounding Test Results form and place copy in controller cabinet. Ensure all loops are included on form. The form is located on the Department's website and shown here.

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Embed loop conductors in saw slot with loop sealant. Seal saw slot and dispose of excess sealant in an environmentally safe manner. Provide Engineer with Material Safety Data Sheet and manufacturer's test data.

Between corners of loops and junction boxes, twist loop conductor pairs a minimum of 5 turns per foot. Permanently label each twisted pair in the junction box with nylon cable tie using indelible ink. Indicate loop number and loop polarity on the tie.

B. Double Sawcut

At downtown locations shown in the plans, twisted loop conductors shall be of the length required to reach the signal controller cabinet. Twisted loop conductors will be installed in a sawcut to the signal controller cabinet. In this case, double sawcut the route such that there is adequate room for the installation and maintenance of the lead-in cable.

10.4. MEASUREMENT AND PAYMENT

Inductive loop sawcut will be measured and paid as the actual linear feet of inductive loop sawcut furnished, installed, and accepted.

Inductive loop double sawcut will be measured and paid as the actual linear feet of inductive loop sawcut furnished, installed, and accepted.

No measurement will be made of loop slot sealant, loop wire, conduit, and conduit fittings as these will be considered incidental to furnishing and installing inductive detection loops.

Payment will be made under:

Inductive Loop Sawcut	Linear Foot
Inductive Loop Double Sawcut	Linear Foot

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11. LOOP LEAD-IN CABLE**11.1. DESCRIPTION**

Furnish and install loop lead-in cable with all necessary hardware.

11.2. MATERIALS

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

Furnish Type I lead-in cable with conductors of number 14 AWG fabricated from stranded copper that complies with IMSA Specification 50-2 except as follows:

- Provide one pair (2 conductor) insulation pair colors: black and white.
- Ensure one spirally-wrapped Aluminum Mylar tape is applied with aluminum side out to completely cover conductor assembly.
- Provide cable jacket formed from black polyethylene. Ensure finished jacket provides environmental stress resistance, outdoor weatherability, toughness, low temperature performance, and ultraviolet resistance.
- Provide a ripcord to allow the cable jacket to be opened without using a cutter.
- Provide length markings in sequential feet and within one percent of actual cable length. Ensure character height of the markings is approximately 0.10 inches.

11.3. CONSTRUCTION METHODS

For underground runs, install lead-in cable in 2 inch non-metallic conduit. For aerial installation, wrap lead-in cable to messenger cable with at least four turns of wrapping tape spaced at intervals less than 15 inches or lash lead-in cable to messenger cable with one 360 degree spiral of lashing wire per 12 inches.

Where railroad preemption is required, install lead-in cable from the signal controller cabinet to railroad company furnished and installed lockable junction box.

Splicing of lead-in cable will be allowed only for runs in excess of 750 feet. Splice lead-in cable in junction boxes or condulets on poles. Splicing shall be as called for in the Standard Specifications and as shown in the Roadway Standard Drawings.

Test each complete loop system from the controller cabinet by using a megger to verify that impedance from the loop system to the ground is at least 50 megohms. Record and report results

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utilizing "Inductive Loop and Grounding Test Results" form in **Section 10** of these Project Special Provisions. Maintain a single source binder or binders of all results, kept in order by intersection number. After successful completion of megger test, test the loop system resistance using an electronic ohmmeter to verify that loop system resistance is less than 0.00885 ohms per foot. Provide copy of test to the Engineer and place copy of test in the signal cabinet.

11.4. MEASUREMENT AND PAYMENT

Lead-in cable (____) will be measured and paid as the actual linear feet of lead-in cable furnished, installed, and accepted. Measurement will be made by calculating the difference in length markings located on outer jacket from start of run to end of run for each run. Terminate all cables before determining length of cable run.

If markings are not visible, measurement will be point to point with no allowance for sag. Twenty-five feet will be allowed for vertical segments up or down poles.

Payment will be made under:

Lead-In Cable (14-2).....Linear Foot

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12. MICROWAVE VEHICLE DETECTOR**12.1. DESCRIPTION**

Furnish and install a microwave vehicle detection unit and manufacturer recommended cables and hardware in accordance with the plans and specifications.

12.2. MATERIALS**A. Vehicle Detector**

Furnish EIS RTMS Model G4 or approved equivalent that is compatible and interoperable with the wireless controller, providing the following features:

- True vehicle presence detection with a minimum detection zone of 6 x 12 feet at a 20 foot mounting height and an effective range of at least 75 feet from the detector unit to the aim point on the road surface.
- Programmable delay time of up to 25 seconds.
- Self tuning capability to auto-adjust to changing environmental conditions.
- Monitoring circuit for the unit that will put out a constant call in the event of a component failure or loss of power
- 120 (95 to 135) VAC input power, or power supply or step down transformer, if other than 120 VAC.
- Operating temperature from -20 to 150 degrees F.
- Water resistant housing.

If a notebook computer is used to adjust detector settings, ensure that software is licensed for use by the Department and by any other agency responsible for maintaining or operating the microwave detection system. Provide the Department with a license to duplicate and distribute the software as necessary for design and maintenance support.

A.1. Wireless Communication

Each microwave vehicle detector shall have an integrated Digital Spread Spectrum (DSS) radio modem that requires no additional power supply. Each microwave vehicle detector shall have an integrated 9-inch omni-directional whip antenna. DSS radio modem shall have the following characteristics:

- Technology: Frequency Hopping Spread Spectrum Radio
- Frequency Band: 902-928 MHz ISM band
- Hopping Pattern: 64 pseudo-random sequences selectable

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- Transmitter Power: 1mW, 10mW, 100mW, or 1W selectable
- Error Detection: CRC-16
- Interface: Asynchronous, AT Command set, transparent data set
- Licensing: FCC rules Part 15 approval and license free operation in the United States

B. Wireless Controller

Furnish wireless controller unit that is compatible with the DSS radio modem. A single wireless controller shall have the following characteristics:

- Integrated Digital Spread Spectrum radio modem
- Remote programming, monitoring, and data by serial port
- Support for up to eight (8) microwave vehicle detection units
- Support for up to eight (8) contact pairs per microwave vehicle detector
- Support for up to thirty-two (32) isolated contact pairs

Furnish wireless controller unit that is shelf mountable in an equipment cabinet and has a height no greater than 2 inches.

C. Solar Power Supply

Each microwave vehicle detector shall include a solar power supply as recommended by the microwave vehicle detector manufacturer. The solar power supply consists of a solar panel array, solar charge regulator, batteries, pole-mounted enclosure, connection cables, and other required grounding and installation accessories.

The solar panel array shall meet the following minimum requirements:

- Shall be made in North America and have a 20 year factory warranty.
- Shall be a minimum of 75Wp.
- Shall be UL listed, FM Class I, Div II, Group C&D approved.
- Shall be capable of withstanding 125-MPH winds.

The solar charge regulator shall meet the following minimum requirements:

- Shall be UL listed, minimum 10A with solid state, low voltage disconnect.
- Shall be sealed with internal temperature compensation, lightning protection, reverse polarity protection and LED indicators.
- Shall be FM Class I, Div. II, Groups ABCD and have the CE mark.

The batteries shall meet the following minimum requirements and be furnished in the quantity needed to meet the following minimum requirements:

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- Shall be 12V gel electrolyte, non-spillable, maintenance free units.
- Shall have 7 days of Battery autonomy.

The solar power supply enclosure shall meet the following minimum requirements:

- Shall be .125" aluminum with stainless steel hardware.
- Shall have #1 Corbin, Police Lock on an insulated door.
- Shall be separate compartments for the batteries and the electronic equipment.

Power wiring shall be 10-2, stranded copper, double insulated, sunlight resistant, 600V 90C rated cable.

12.3. CONSTRUCTION METHODS

Install the microwave vehicle detector in accordance with the manufacturer's recommendations. The microwave vehicle detector shall be mounted in a side-fired configuration. It shall be mounted on new poles at the specified locations, using the manufacturer -supplied mounting brackets. The detection zones shall be set up using the provided software and a Notebook PC.

Install a wireless controller unit in the signal controller cabinet nearest to the microwave vehicle detector as shown in the Plans. Route the wireless controller unit output to the system detector inputs in the signal controller.

Install solar power supply according to manufacturer's guidelines. Ensure solar power supply has adequate surge protection and grounding. Attach solar panel array to the side of the pole with stainless steel fasteners. The array mount shall be aluminum alloy or stainless steel. Install solar panel array on the pole at a height greater than the microwave vehicle detector unit.

Monitor and maintain the detector unit during construction to ensure microwave vehicle detector is functioning properly and aimed for the detection zone shown in the plans. Refer to Subarticle 1700-3 (D) Maintenance and Repair of Materials of the *Standard Specifications* for failure to maintain the microwave detection system.

12.4. MEASUREMENT AND PAYMENT

Each microwave vehicle detector shall consist of a detector unit, radio modem, radio antenna, cabling, solar assembly, and all other hardware required to install the unit on the pole.

Each wireless controller shall include all cabling, harnesses, antennas, attachment hardware, interface with signal cabinet/signal controller detector inputs, and equipment to provide wireless link to the microwave detector.

Actual number of microwave vehicle detector units furnished, installed, and accepted.

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Actual number of wireless controller units furnished, installed, and accepted.

No measurement will be made of cables or hardware, as these will be considered incidental to furnishing and installing microwave vehicle detectors.

No measurement will be made of any central or local software related to the installation or operation of the microwave vehicle detector unit.

Payment will be made under:

Microwave Vehicle Detector	Each
Wireless Controller Unit	Each

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13. FIBER OPTIC CABLE**13.1. DESCRIPTION**

Furnish and install single mode fiber-optic (SMFO) communications cable and drop cable assemblies with grounding systems, fiber-optic cable storage racks (snow shoes), communications cable identification markers, lashing wire, and all necessary hardware.

13.2. MATERIALS**A. SMFO Communications Cable**

Furnish loose tube fiber-optic cable with required fiber count that complies with RUS CFR 1755.900, single mode with a dielectric central member. Use single mode fiber in cable that does not exceed 0.25 dB/km at 1550 nm and 0.35 dB/km at 1310 nm. Provide cable with all fibers that are useable and with a surface sufficiently free of imperfections and inclusions to meet optical, mechanical, and environmental requirements. Provide cable with minimum of one ripcord under sheath for easy sheath removal and with shipping, storage, installation, and operating temperature of at least -40 to 160 degrees F with a dual layered, UV cured acrylate fiber coating applied by cable manufacturer that may be stripped mechanically or chemically without damaging fiber.

Provide fibers inside a loose buffer tube. Use a doped silica core surrounded by concentric silica cladding for each fiber. Distinguish each fiber and buffer tube from others by means of color coding that meets EIA/TIA-598 *Color Coding of Fiber-Optic Cables*. In buffer tubes containing multiple fibers, ensure that the colors are stable during temperature cycling and not subject to fading, sticking, or smearing into each other or into the gel filling material. Use fillers in cable core if necessary to provide a symmetrical cross-section of cable. Fill buffer tubes with nonhygroscopic, non-nutritive to fungus, electrically non-conductive, homogenous gel. Ensure that gel is free from dirt and foreign matter, and is removable with conventional nontoxic solvents.

Provide a central member consisting of a dielectric glass reinforced plastic rod. Apply binders with sufficient tension to secure buffer tubes and binders to the central member without crushing buffer tubes. Ensure that binders are non-hygroscopic, non-wicking (or rendered so by the flooding compound), and dielectric with low shrinkage.

Provide cable that has cable core interstices filled with super-absorbent, water-blocking compound that is non-conductive and homogenous. Ensure compound is free from dirt and foreign matter, and is removable with conventional nontoxic solvents.

Provide cable with high tensile strength aramid yarns or fiberglass yarns that are helically

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stranded evenly around the cable core.

Provide cable jacket of consistent thickness that is free of holes, splits, and blisters, and containing no metal elements. Provide outer jacket of medium density polyethylene with minimum nominal sheath thickness of 0.050 inch. Ensure polyethylene contains carbon black for ultraviolet light protection and does not promote the growth of fungus.

Provide length markings in sequential feet and within one percent of actual cable length. Ensure that character height of the markings is approximately 0.10 inch.

B. Plenum Rated SMFO Cable

Where called for on the Plans, the SMFO cable shall be an indoor/outdoor Plenum/OFNR-rated cable.

The Plenum/OFNR cable shall comply with Bellcore GR-409-Core, "Generic Requirements for Premises Fiber Optic Cable" and with Bellcore GR-20-Core, "Generic Requirements for Optical Fiber and Fiber Optic Cable". The Plenum rated cable shall meet all other operating characteristics of the SMFO communications cable called for in these Project Special Provisions

C. Drop Cable

Furnish drop cable assemblies to provide communications links between aerial splice enclosures and cabinet interconnect centers. Furnish drop cable assemblies containing a minimum of six individual fibers.

Furnish drop cable assemblies that comply with RUS-CFR 1755.900 and have a minimum bend radius of 5.0 inches for a 6-fiber cable. Ensure drop cable assemblies have the same operating characteristics as the SMFO cable it is to be coupled with.

On one end of cable assemblies, furnish six ST-PC connectors for termination on the connector panel in equipment cabinet. Provide either factory assembled drop cables with ST-PC connectors or field installed connectors. No connectors are required for drop cables running from one splice enclosures directly to another splice enclosure.

Ensure attenuation of drop cable at 1310 nm does not exceed 0.5 dB/km. Ensure attenuation loss for complete drop cable assembly does not exceed a mean value of 1.5 dB.

Provide length markings in sequential feet and within one percent of actual cable length. Ensure that character height of the markings is approximately 0.10 inch.

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D. Communications Cable Identification Markers

Furnish yellow communications cable identification markers that are resistant to fading when exposed to UV sources and changes in weather. Use markers designed to coil around fiber-optic cable, and that do not slide or move along the surface of the cable once installed. Ensure exposure to UV light and weather does not affect the markers natural coiling effect or deteriorate performance. For all fiber optic cables except those indicated on the Plans as MIS, furnish cable wraps containing the following text in black:

WARNING
GDOT FIBER OPTIC CABLE
CONTACT TELEPHONE NUMBER: (336) 373-CITY
WARNING
GDOT FIBER OPTIC CABLE

Overall Marker Dimensions: 7"(l) x 4"(w)

Lettering Height: 3/8 inch for *WARNING*, 1/4" for all other lettering

For all fiber optic cables indicated in the Plans as MIS cable, furnish cable wraps containing the following text in black:

WARNING
CITY OF GREENSBORO FIBER OPTIC CABLE
CONTACT TELEPHONE NUMBER: (336) 373-CITY
WARNING
CITY OF GREENSBORO FIBER OPTIC CABLE

Overall Marker Dimensions: 7(l) x 4 (w) inches

Lettering Height: 3/8 inch for "WARNING", 1/4 inch for all other lettering

Submit a sample of the proposed communications cable identification markers to the Engineer

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for approval before installation.

E. Fiber-Optic Cable Storage Guides

Furnish fiber-optic storage guides (snowshoes) that are non-conductive and resistant to fading when exposed to UV sources and changes in weather. Ensure snowshoes have a captive design such that fiber-optic cable will be supported when installed in the rack and fiber-optic cable's minimum bending radius will not be violated. Provide stainless steel attachment hardware for securing snowshoes to messenger cable and black UV resistant tie-wraps for securing fiber-optic cable to snowshoe. Ensure that snowshoes are stackable so that multiple cable configurations are possible.

13.3. CONSTRUCTION METHODS**A. General**

Provide cable manufacturer's attenuation and Optical Time Domain Reflectometer (OTDR) testing data for each reel of cable prior to installation, in a format approved and accepted by the Engineer.

Install single mode fiber-optic (SMFO) communications cable, snow shoes, communications cable identification markers, lashing wire, and all necessary hardware.

Comply with manufacturer's recommendations. Install communications cable on signal poles, utility poles, messenger cable, and in conduits as required to bring the fiber-optic cable into and, if necessary, out of each splice enclosure.

Take all precautions necessary to ensure that cable is not damaged during storage, handling, and installation. Do not violate the minimum bending radius of 20 times the radius of the cable diameter or the manufacturer's recommendation, whichever is greater. Do not step on cable nor run over cable with vehicles or equipment. Do not pull cable over or around obstructions, or along the ground.

Determine lengths of cable necessary to reach from termination-point to termination point. Install cable in continuous lengths between approved splicing facilities. Additionally, provide a sufficient amount of slack cable to allow for an additional 20 feet of cable to be present after removal of outer sheath for termination. Measure slack cable by extending cable straight out of cabinet door.

Keep cable ends sealed at all times during installation to effectively prevent the ingress of moisture. Use approved heat shrink cable end cap. Do not use tape to seal cable ends.

Before installing cable, provide three copies of the cable manufacturer's recommended and

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maximum pulling tension. Do not exceed the manufacturer's recommended pulling tension. Use pulling grips containing a rotating swivel. Coil cable in a figure-8 configuration whenever cable is unreeled for subsequent pulling.

Install fiber-optic cable in separate 2 inch risers with heat shrink tubing or conduits. Do not share risers or conduits containing fiber-optic cable with other type cable.

B. Aerial Installation

Double lash fiber-optic cable to messenger cable with one 360 degree spiral per foot.

Use pole attachment hardware and roller guides with safety clips to install aerial run cable.

Maintain tension during the pulling process for aerial run cable by using an approved mechanical clutch (dynamometer) device. Do not allow cable to contact the ground or other obstructions between poles during installation. Do not use a motorized vehicle to generate cable pulling forces.

Use a cable suspension clamp when attaching cable tangent to a pole. Select and place cable blocks and corner blocks so as not to exceed the cable's minimum bending radius. Do not pull cable across J-hooks.

Store 100 feet of slack fiber-optic cable over-head on all cable runs that are continuous without splices and are greater than 2,500 feet and as shown on the plans or the amount shown on the Plans. This shall be for each fiber optic cable lashed to the messenger cable. Obtain approval for spare cable storage locations. Store spare fiber-optic cable on fiber-optic cable storage racks (snow shoes) that may be stackable. At aerial splice enclosures, store spare cable of each size. Do not mix MIS and GDOT fiber optic cables on same snowshoe. Locate spare cable storage in the middle of spans between termination points. Do not store spare fiber-optic cable over the roadway or driveways.

Install one communications cable identification marker within 36 inches of pole attachment points and at locations where more than one cable originates or terminates.

Maintain electrical continuity of messenger cable at all poles.

C. Underground Installation

Install fiber-optic cable underground in conduit using cable pulling lubricants recommended by the fiber-optic cable manufacturer.

Obtain approval of cable pulling lubricant and method of pulling before installing underground fiber-optic cable.

Use a dynamometer (clutch device) so as not to exceed the maximum allowable pulling tension if the cable is pulled by mechanical means. Do not use a motorized vehicle to generate cable pulling

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forces.

Keep tension on the cable reel and pulling line at the start of each pull. Do not release tension if the pulling operation is halted. Restart the pulling operation by gradually increasing tension until the cable is in motion.

For pulling cable through manholes, junction boxes, and vaults, feed cable by manually rotating the reel. Do not pull cable through intermediate junction boxes, handholds, or openings in conduit unless otherwise approved.

Install communications cable identification markers on each communications cable entering a junction box or manhole.

D. Installation of Drop Cable Assembly

Determine the length of drop cable needed, including slack, to reach from termination point to termination point.

At aerial splice enclosures, store 100 feet of slack cable on cable storage racks. At below ground splice enclosures, coil 100 feet of slack cable in manhole or junction box where enclosure is located.

At equipment cabinet end of the drop cable assembly, terminate all fibers with ST-PC connectors to the connector panel. Label all connectors, pigtails, and the connector panel. At the aerial splice enclosure location, cap off all unused or designated fibers and label to correspond with the connector panel.

E. Storage at Future Traffic Signals

As shown on the plans, store cable at locations of future traffic signals. Coil drop cable from splice enclosure. Ensure there is sufficient length of cable to route cable from splice enclosure to proposed location of signal controller cabinet.

F. Reuse of Existing Fiber Optic Cable

At several locations, existing fiber optic cable owned by NCDOT and/or the City of Greensboro is called for reuse under this project. Prior to splicing, reconnecting at patch panels, or performing any activity that would otherwise modify the operation of the existing cable, the Contractor shall notify the Engineer in writing of the location of the affected cable, and the duration for which the cable will be affected. The Contractor shall be responsible for testing existing optical fibers intended for reuse from the nearest accessible terminated end to the location points the cable is intended for reuse. The Contractor shall report in writing to the Engineer any fibers proposed for reuse that do not meet the operating standards called for in these Project Special Provisions. The Contractor shall

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verify prior to disruption of any service the nature and character of the use of each optical fiber that may be cut or otherwise affected and report these uses to the Engineer. The Contractor shall not perform work that removes any existing communications or devices from service during the week day commute hours (7AM to 9AM and 4PM to 6PM Monday through Friday) nor during planned special events or other events or activities as called for by the Engineer unless approved by the Engineer.

13.4. MEASUREMENT AND PAYMENT

Communications cable (____-fiber) will be measured and paid as the actual linear feet of fiber-optic cable of each fiber count furnished, installed, and accepted. Measurement will be made by calculating the difference in length markings located on outer jacket from start of run to end of run for each run. Terminate all fibers before determining length of cable run.

MIS communications cable (____-fiber) will be measured and paid as the actual linear feet of fiber-optic cable of each fiber count furnished, installed, and accepted. Measurement will be made by calculating the difference in length markings located on outer jacket from start of run to end of run for each run. Terminate all fibers before determining length of cable run.

MIS plenum rated communications cable (____-fiber) will be measured and paid as the actual linear feet of fiber-optic cable of each fiber count furnished, installed, and accepted. Measurement will be made by calculating the difference in length markings located on outer jacket from start of run to end of run for each run. Terminate all fibers before determining length of cable run.

Drop cable will be measured and paid as linear feet of fiber-optic drop cable assemblies furnished, installed, and accepted. Sag and vertical segments will not be paid for as these distances are considered incidental to the installation of drop cable assemblies.

No measurement will be made for terminating, splicing, and testing of the fiber-optic cable, communications cable identification markers, fiber-optic cable storage racks, and grounding of messenger cable, as these will be considered incidental to the installation of the fiber optic cable.

Payment will be made under:

Communications Cable (12-Fiber)	Linear Foot
Communications Cable (24-Fiber)	Linear Foot
MIS Communications Cable (24-Fiber)	Linear Foot
Communications Cable (36-Fiber)	Linear Foot
Communications Cable (48-Fiber)	Linear Foot

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MIS Communications Cable (48-Fiber)	Linear Foot
Communications Cable (72-Fiber)	Linear Foot
MIS Plenum Rated Communications Cable (24-Fiber).....	Linear Foot
MIS Plenum Rated Communications Cable (96-Fiber).....	Linear Foot
MIS Plenum Rated Communications Cable (144-Fiber).....	Linear Foot
Drop Cable (6-Fiber).....	Linear Foot
Drop Cable (12-Fiber).....	Linear Foot

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14. FIBER-OPTIC SPLICE CENTERS**14.1. DESCRIPTION**

Furnish and install fiber-optic interconnect centers, fiber-optic aerial splice enclosures, and all necessary hardware. Provide aerial splice enclosures that are suitable for aerial, pedestal, buried, junction box, and/or manhole installations.

14.2. MATERIALS**A. General**

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

B. Interconnect Center

Furnish compact, modular interconnect centers designed to mount inside equipment cabinets. Furnish interconnect centers with 12-position modules. Furnish interconnect centers that are rack-mountable. Design and size interconnect centers to accommodate all fibers entering equipment cabinets with additional 50% spare capacity.

Inside buildings, furnish compact, modular interconnect centers designed to be rack mounted in a standard 19" rack cabinet. Furnish interconnect centers with 12-position modules from the Corning LANscape line of equipment, or as approved by the Engineer. Design and size interconnect centers to accommodate all fibers entering interconnect centers with additional 50% spare capacity for future splicing and terminations

Provide splice trays that hold, protect, and organize optical fibers, and secure fibers inside splice tray. Design and size splice trays to be dielectric, to accommodate all fibers entering the splice tray, and to provide sufficient space to prevent microbending of optical fibers. Provide connector panels with ST-type connectors.

Furnish SMFO pigtailed with each interconnect center. Provide pigtailed that are a maximum of 6 feet in length with a factory assembled PC-ST connector on one end. Ensure that the SMFO pigtailed meet the operating characteristics of the SMFO cable with which it is to be coupled.

Furnish SMFO jumpers that are a minimum of 3 feet in length with factory assembled PC-ST connectors on each end. Ensure that SMFO jumpers meet the operating characteristics of the SMFO cable with which it is to be coupled.

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C. Aerial Splice Enclosure

Furnish aerial splice enclosures that are re-enterable using a mechanical dome-to-base seal with a flash test valve, and are impervious to the entry of foreign material (water, dust, etc.). Ensure enclosures are manufactured in such a manner to be suitable for aerial, pedestal, buried, junction box, and manhole installation.

Provide enclosures with a minimum of one over-sized oval port that will accept two cables with a minimum of four round ports (for single cables) that will accommodate all cables entering enclosure. Provide heat shrink cable shields with enclosure to ensure weather tight seal where each cable enters enclosure.

Within enclosures, provide enough hinged mountable splice trays to store the number of splices required, plus the capacity to house six additional splices. Provide a fiber containment basket for storage of loose buffer tubes expressed through the enclosure. Ensure enclosures allow sufficient space to prevent microbending of the buffer tubes when coiled.

Provide splice trays that hold, protect, and organize optical fibers, and that secure fibers inside the splice tray.

Provide splice trays that are dielectric.

14.3. CONSTRUCTION METHODS**A. General**

Install interconnect centers with connector panels, splice trays, storage for slack cable or fibers, mounting and strain relief hardware, and all necessary hardware.

Install aerial splice enclosures with splice trays, basket containment assemblies, racking for slack cable or fibers, mounting and strain relief hardware, and all other necessary hardware.

Fusion splice and secure SMFO cable in splice trays inside the splice enclosure. Ensure all buffer tubes are contained within splice trays so no bare fibers are outside tray.

Do not exceed 0.05 dB of attenuation per splice.

Furnish strain relief so that no tensile force is on the SMFO cable when it is held within the interconnect center or aerial splice enclosure.

Do not damage fiber or violate the minimum bending radius of the fiber.

B. Termination and Splicing within Interconnect Center

Terminate and splice all fibers including unused fibers.

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Label all fiber-optic connectors, whether on jumpers, connector panels, or other equipment, to prevent improper connection. Obtain approval of the fiber-optic connector labeling method.

For all fibers designated for termination to connector panel within the interconnect center, fusion splice the fibers to the pigtails.

For all cut fibers designated to pass through interconnect center, fusion splice fibers.

For all buffer tubes designated to pass through interconnect center, neatly coil the excess tubing inside the interconnect center.

C. Termination and Splicing within Aerial Splice Enclosure

Fusion splice all fibers including fibers designated to be coupled with fibers from a drop cable assembly and cut fibers designated to pass through splice enclosure.

For all buffer tubes designated to pass through splice enclosure, neatly coil the excess tubing inside basket provided with enclosure.

Label all fiber-optic splices. Obtain approval of fiber-optic connector labeling method.

Install heat shrink cable shields using methods recommended by the manufacturer of the enclosure. Perform a pressurization flash test on the enclosure in accordance with the manufacturer's recommended procedures at the conclusion of the splicing procedure and before the final placement of enclosure.

For aerial installations, secure enclosures to messenger cable using manufacturer supplied hardware. Secure SMFO cable and drop cable assemblies to snowshoes.

Install enclosures with enough slack cable to allow enclosure to be lowered to ground level and extended into a splicing vehicle that is located within 10 feet of the equipment cabinet.

For underground, manhole, and junction box facility installations, place the enclosure along with required spare cables in the facility in a neat and workmanship like manner and insure that no standing water remains in junction box. Do not place the splice enclosure in bottom of junction box. Do not damage cable or violate the minimum bending radius of the cable.

D. Testing

Provide written notification a minimum of ten days before beginning OTDR tests. Test whole segments following installation. Test all existing fibers prior to reuse.

After splicing is completed, perform bi-directional OTDR test on each fiber, including unused fibers. Install 1000 foot pre-tested launch cable between the OTDR and fiber optic to be tested.

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Ensure fusion splice losses do not exceed 0.05 dB and connectors have a loss of 0.5 dB or less. If any fiber exceeds maximum allowable attenuation or if fiber properties of the cable have been impaired, take appropriate actions up to and including replacement of the fiber cable. Corrective action will be at no additional cost to the Department.

Clearly label each OTDR trace identifying a starting and ending point for all fibers being tested. Record the attenuation level of each fiber and clearly indicate OTDR trace results in report format. Furnish one hard copy of each of the OTDR trace results and electronic copies of all trace results on a compact disk. Furnish the manufacturer's make, model number, and software version of the OTDR used for testing.

E. Modify Existing Splice Enclosure

At locations shown in the Plans, the Contractor shall reuse an existing splice enclosure or cabinet to facilitate the splicing of an additional communications cable. The Contractor shall ensure that all existing, unmodified splices are functional and operating in their same condition after performing any work in an existing splice enclosure or cabinet. The Contractor shall also ensure that any modifications do not cause downtime of the terminating communication cables during normal business hours.

14.4. MEASUREMENT AND PAYMENT

Interconnect center will be measured and paid as the actual number of fiber-optic interconnect centers furnished, installed, and accepted in accord with the following conditions: 75% of the payment will be made upon acceptance of the installed unit; 25% of the payment for the unit will be made following final acceptance of the integrated system (including completion of the 120 day observation period). In certain locations, such as equipment racks in buildings, interconnect centers are incidental to the building modifications and shall not be paid for separately.

Splice enclosure will be measured and paid as the actual number of fiber-optic splice enclosures furnished, installed, and accepted in accord with the following conditions: 75% of the payment will be made upon acceptance of the installed unit; 25% of the payment for the unit will be made following final acceptance of the integrated system (including completion of the 120 day observation period). No measurement will be made between aerial, underground, manhole, or junction box installation of the fiber-optic splice enclosure.

MIS splice enclosure will be measured and paid as the actual number of fiber-optic splice enclosures furnished, installed, and accepted in accord with the following conditions: 75% of the payment will be made upon acceptance of the installed unit; 25% of the payment for the unit will be

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made following final acceptance of the integrated system (including completion of the 120 day observation period). No measurement will be made between aerial, underground, manhole, or junction box installation of the fiber-optic splice enclosure.

Modify existing splice enclosure will be measured and paid as the actual number of existing splice enclosures or cabinets modified and accepted.

No measurement will be made of splice trays, pigtails, jumpers, connector panels, and testing, as these will be considered incidental to furnishing and installing fiber optic interconnect centers and aerial splice enclosures.

Payment will be made under:

Interconnect Center	Each
Splice Enclosure.....	Each
MIS Splice Enclosure	Each
Modify Existing Splice Enclosure	Each

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15. DELINEATOR MARKERS

15.1. DESCRIPTION

Furnish and install delineator markers with all necessary hardware.

15.2. MATERIALS

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

Furnish tubular delineator markers, approximately 6 feet long, and constructed of a Type III, high density polyethylene material. Provide delineator assemblies that are ultraviolet stabilized to help prevent components from color fading, warping, absorbing water and deterioration with prolonged exposure to the elements. Provide delineators designed to self-erect after being knocked down or pushed over. Provide orange delineators posts.

Provide text, including the division contact number, hot stamped in black on a yellow reflective background material that will not fade or deteriorate over time. Provide delineator markers with a nominal message height of 15 inches and that contain the following text visible from all directions approaching the assembly:

WARNING	FIBER OPTIC CABLES
BEFORE EXCAVATING OR IN AN EMERGENCY CALL (336) 373-CITY	
CITY OF GREENSBORO DEPARTMENT OF TRANSPORTATION	

15.3. CONSTRUCTION METHODS

Install delineator markers using a method that firmly and securely anchors the delineator marker in the ground to prohibit twisting and easy removal.

Install channel post mounted delineator markers using methods approved by the Engineer.

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15.4. MEASUREMENT AND PAYMENT

Delineator marker will be paid for by the actual number furnished, installed, and accepted.

MIS delineator marker will be paid for by the actual number furnished, installed, and accepted.

Payment will be made under:

Delineator MarkerEach

MIS Delineator MarkerEach

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16. TWISTED PAIR CABLE**16.1. DESCRIPTION**

Furnish and install twisted pair communications cable as required when installing new signal controller cabinets to maintain communications for locations that will remain on the existing twisted pair communications network. The communications cable shall be fully operational and interchangeable with the existing twisted pair communications cable in the signal controller cabinet.

16.2. MATERIALS**A. Twisted Pair Cable**

The Contractor shall provide communications cable to be installed underground in conduit that meets the following requirements:

- RUS CFR 1755.390, 6-pair, 19 gauge, shielded, twisted pair communications cable

Have the manufacturer factory test the communications cable on reels for each pair's mutual capacitance, crosstalk loss, insulation resistance, and conductor resistance. Furnish the Engineer with a certified report for each reel showing compliance with the IMSA, ANSI, or RUS specification, the factory test results, and the manufactured date of the cable. The contractor shall not use communications cable manufactured more than one year before the date of installation.

Provide sequential foot markings within one percent of the actual cable length and as required by Section 350G of the National Electrical Safety Code. Provide approximately 1/10-inch (2.5-mm) character height of the markings.

B. Cable Termination Facilities

Use Telecommunications standard Type 66 Punch down blocks for splicing in controller cabinets. All terminations of wires into punch down blocks cable shall be performed using 3M brand 17-24 AWG, gel filled, Butt Connectors or approved equal. Fuse and ground each splice.

16.3. CONSTRUCTION METHODS**A. General**

Install communications cable in continuous lengths with no splices outside the controller cabinet.

Test the integrity of the communications cable before installation based on IMSA 20-4, 19 gauge wire standard. Test the cable insulation for a resistance of more than 500 megaohms for each insulated conductor when measured with all other insulated conductors and the shielded ground

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before installation. Make the measurement with a DC potential of at least 100 volts but not more than 550 volts applied for 1 minute. Furnish the test results to the Engineer.

Wire communications cable into the cabinet. Allow a minimum of 10 feet (3 meters) of cable slack.

The contractor shall not exceed 80 percent of the manufacturer's maximum pulling tension when installing underground communications cable.

Use a clutch device (dynamometer) so as not to exceed the allowable pulling tension if the cable is pulled by mechanical means. Do not use a motorized vehicle to generate cable-pulling forces.

Keep tension on the cable reel and the pulling line at the start of each pull. Do not release the tension in the cable if the pulling operation is halted. Restart the pulling operation by gradually increasing the tension until the cable is in motion.

Set cable reels up on the same side of the junction box as the conduit section in which the cable is to be installed. Place the reel level and align the reel with the conduit section such that the cable will pass from the top of the reel in a smooth bend into the conduit without twisting. Do not pull the cable from the bottom of the reel. Manually feed the cable by rotating the reel. Do not pull the cable through intermediate junction boxes, pull boxes, handholes, or openings in conduit unless otherwise approved by the Engineer.

B. Bonding and Splicing

Terminate all cable pairs in a neatly arranged manner. Clean the terminals before terminating the cable.

Splice communications cable within the signal controller cabinets. Do not splice within pull boxes except for at terminal splice box locations called for in the plans.

Ground the shield of the outgoing cable (going away from the controller) to a ground rod using insulated (green) number 14 AWG standard copper wire at all cabinet locations. Leave the shield of the incoming cable ungrounded. Bond and ground the cable shields as required by REA Standard PC 2.

16.4. MEASUREMENT AND PAYMENT

Twisted Pair (*-Pair*) will be measured and paid as the actual linear feet of twisted pair cable, installed, and accepted that is designated on the plans. Measurement will be made by calculating the difference in length markings located on outer jacket from start of run to end of run for each run. Terminate all fibers before determining length of cable run.

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No measurement will be made for terminating, splicing, storing, grounding, and testing of the twisted pair cable, as these will be considered incidental to the installation of the signal controller cabinets. Twisted pair cable installed as part of the relocation of a cabinet at an intersection from one location to another location on the same corner or from one corner to another corner at the same intersection is considered incidental to the Terminal Splice Box item in **Section 23** of these Project Special Provisions and will not be paid for separately under this item. Twisted pair cable installed as part of the Traffic Operations Center Computer Room Building Modifications in **Section 19** of these Project Special Provisions is considered incidental to the Traffic Operations Center Computer Room Building Modifications and will not be paid for separately under this item.

Payment will be made under:

Twisted Pair Cable (6 Pair)..... Linear Feet

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17. ETHERNET CABLE (OUTDOOR RATED)**17.1. DESCRIPTION**

Furnish and install Ethernet cable to serve as interconnect between Ethernet switches and field devices such as video codec units and Wi-Fi access points routed in outdoor conduit and/or lashed to messenger cable and existing cables. Ethernet cabling installed within equipment cabinets, within rooms, and within buildings are incidental and will not be paid for under this item.

17.2. MATERIALS

Furnish CAT5E Ethernet cable that is suitable for outdoor installation and meets or exceeds the following standards:

- 4-pair shielded twisted pair cable
- 24AWG (minimum) solid bare copper conductor
- Meets or exceeds CAT5E specifications
- High-density polyethylene insulation, PVC jacket
- Compliant with EIA/TIA standards
- UL/CSA listed
- UV Stabilized PE Jacket
- Gel Filled
- Meets TIA/EIA 568B.2 Networking Standard
- Supports 10/100/1000/10,000Mbps
- Mean Power Sum for Equal Level Far End Crosstalk (ELFEXT): 45dB/kft (minimum)
at 772kHz
- Worst Pair Power Sum for ELFEXT: 40dB/kft (minimum) at 772kHz
- Mean Power Sum for Near-end Crosstalk (NEXT): 42dB/kft (minimum) at 772 kHz
- Operating Temperature: Rated from -10 to +60 Celsius
- Average mutual capacitance: 90nf/mile (maximum)

Have the manufacturer factory test the communications cable on reels for each pair's mutual capacitance, crosstalk loss, insulation resistance, and conductor resistance. Furnish the Engineer with

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a certified report for each reel showing compliance with these specifications, the factory test results, and the manufactured date of the cable. The contractor shall not use communications cable manufactured more than one year before the date of installation.

Cables where both ends will terminate in an RJ-45 connector, both ends should be installed with punchdown female jacks at both ends of the factory-manufactured cable, to be connected at both ends with short 3-6' patch cables.

For Ethernet cable used for the WI-FI-Access points, terminate WI-FI Access Unit end into WI-FI Access unit connector as directed by the WI-FI Access point manufacture. Terminate other end (non-WI-FI Access Point end) into an RJ-45 connector as called for above. All cable ends shall be terminated as called for, subject to inspection by the Engineer. No custom connectors shall be used with the exception of cables used for the WI-FI Access Point.

Cable length with end patch connectors shall not exceed 295 feet.

17.3. CONSTRUCTION METHODS

Install Ethernet cable on new or existing messenger cable and in conduits at locations shown in the Plans. Allow a minimum of 10 feet (3 meters) of cable slack.

Ethernet cables shall not be spliced.

All cables shall be labeled with water proof, smear resistant labels that denote the equipment cabinets or housing they are run from and the device and identifier for that device they are connected to (e.g. CCTV Cabinet 31; CODEC at CCTV Cabinet 31).

A. Aerial Installation

Double lash the communications cable to the messenger cable where installed aerially.

Wrap the communications cable to the messenger cable using aluminum ribbon wraps where the wire supports other cables (i.e., traffic signal cable, lead-in cable, etc.).

B. Underground Installation

Install underground communications cable in conduit described in these Special Provisions.

The contractor shall not exceed 80 percent of the manufacturer's maximum pulling tension when installing underground communications cable. Use a clutch device (dynamometer) so as not to exceed the allowable pulling tension if the cable is pulled by mechanical means. Do not use a motorized vehicle to generate cable-pulling forces.

Keep tension on the cable reel and the pulling line at the start of each pull. Do not release the

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tension in the cable if the pulling operation is halted. Restart the pulling operation by gradually increasing the tension until the cable is in motion. Do not pull the cable through intermediate junction boxes, pull boxes, handholes, or openings in conduit unless otherwise approved by the Engineer.

17.4. MEASUREMENT AND PAYMENT

Ethernet cable (Outdoor Rated) will be measured and paid as linear feet of outdoor rated Ethernet cable furnished, installed, and accepted. Sag and vertical segments will not be paid for as these distances are considered incidental to the installation of the cable.

No measurement will be made for terminating and testing of the cable, cable identification markers, and grounding, as these will be considered incidental to the installation of the Ethernet cable.

Payment will be made under:

Ethernet Cable (Outdoor Rated)Linear Foot

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18. CABLE TRANSFERS

18.1. DESCRIPTION

Remove and reinstall communications cable for pole relocations.

18.2. CONSTRUCTION METHODS

During project, transfers of existing communications cable to new poles may be required. Perform such transfers where directed by the Engineer. Remove existing cables from pole to be removed and reinstall these cables and any existing attachment hardware on the new pole. Remove all communications hardware from existing pole. Furnish and install any new attachment hardware as required.

18.3. MEASUREMENT AND PAYMENT

Cable transfer will be measured and paid as the actual number of cable transfers with attachment hardware to new poles furnished, installed, and accepted.

MIS cable transfer will be measured and paid as the actual number of MIS cable transfers with attachment hardware to new poles furnished, installed, and accepted.

Payment will be made under:

Cable Transfer.....	Each
MIS Cable Transfer.....	Each

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19. BUILDING MODIFICATIONS AND FIBER OPTIC CABLE TERMINATION**19.1. DESCRIPTION**

At locations called for in the Plans, route fiber optic cable in new and/or existing conduit and install conduit into buildings as shown. Terminate fiber optic cable into fiber interconnect centers in building as shown in the Plans. Modify rooms and furnish and install cable and cable routing facilities as shown in the Plans.

19.2. MATERIALS

Use risers and conduit materials as called for in the Standard Specifications or these Project Special Provisions.

Use fiber interconnect centers as called for in the Standard Specifications or these Project Special Provisions.

Use caulking and sealing materials for sealing entrances into buildings as approved by the Engineer.

Use new cable raceways, electrical boxes, and metallic conduit as approved by the Engineer. Where called for in the Plans, use thin-walled EMT conduit that complies with the NEC and EIA/TIA Standard 569 and commercial building standards for telecommunications pathways.

A. Rack Cabinets

As called for, furnish equipment cabinets with railings and sockets for mounting of EIA 19" mountable equipment. Furnish units with removable and adjustable shelves and pull out drawers capable of holding 1.5 times the heaviest component required to be placed on shelf or drawer (when fully extended). Furnish Rack cabinets that are modular with removable side panels with open front and back sections. Furnish racks with cable management and raceways to facilitate neat and orderly organization of all cables routed to equipment on the rack. Furnish rack cabinets with accessories to ensure cables are not kinked or pinched and that all minimum bend radii of cables are preserved. Furnish rack cabinet units that may be aggregated into single units of up to four bays wide. Furnish units with ventilation fans audible no more than 46 dba at a distance of 4 feet from the unit. Furnish units with each bay a width of no more than 24" and a minimum of 84" of continuous useable rack space beginning no more than 6" above the floor. Furnish rack cabinets with maximum height of no more than 12" less than the ceiling of the room they are to be installed in. Furnish units made of quality, non-corrosive materials and non-peeling paint. Furnish rack cabinets that are same color and same manufacturer.

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Equip each rack with a rack-mount uninterruptible power supply (UPS) units capable of detecting a power failure and providing back-up power to the components plugged into within twenty (20) milliseconds. The transition to the UPS source from primary power shall occur without loss of data or damage to the equipment being provided with back-up power.

Furnish UPS units that are sized such that each is capable of providing back-up power for the total load of all equipment connected to the UPS plus an additional load of twenty-five percent of the total load for at least ten (10) minutes of operation. Furnish minimum of one UPS unit per newly furnished equipment rack up to the number required to meet the back-up time requirement for the load for the equipment on the rack.

Furnish UPS units that act as surge and power transient suppression devices that meet or exceed the surge suppression requirements of Underwriter's Laboratory standards UL 1449 and UL 1778.

Furnish UPS units that shall be capable of interfacing with management software resident on application servers and computer workstations capable of initiating a device shutdown based on user adjustable parameters. The software shall also be able to interrogate each unit regarding remaining battery load. Furnish UPS units that can be integrated into computing and network devices via a 10Bast-T LAN connection and contain a RJ-45 port and network interface card to facilitate such connection. The UPS shall communicate using TCP/IP unless otherwise approved by the Engineer and shall be IP addressable. Furnish UPS units with a serial RS-232 serial port for direct connection to a computer. All software provided shall operate in a Windows 2000 environment unless otherwise approved by the engineer.

Furnish UPS units with the following characteristics:

- Commercial 115 VAC, 60 Hz power interconnection and power loss sensing and alarm reporting
- Power protection and filtering
- Power conversion for battery charging
- Battery status sensing and low battery alarm reporting
- Battery charging and charge management
- Battery power conversion and filtering as necessary for interface compatibility with installed equipment

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- Compliance with article 645 of the National Electric Code (NEC)
- Operating temperature Range 32 Degrees F to 105 Degrees F
- Humidity 0%-95%, non-condensing
- Size less than 5.25" (3RU) tall
- Surge energy rating greater than 480 joules
- Electrical outlets 6 NEMA 5-15R

19.3. CONSTRUCTION METHODS**A. General**

Contact Engineer prior to entering any building. Coordinate and obtain approval from Engineer regarding allowable working time in buildings.

Prior to core drilling or otherwise creating new entrance into an existing building, obtain approval of methods and materials from the Engineer. In all cases, create entrance that is weatherproof and water tight.

Whenever possible, use existing cable raceways, ducts, raised floors, and drop ceilings to route fiber optic cable.

Perform all work called for in the plans to enter building, install cable conduits and cable raceways, and to route cabling in raised floors, drop ceilings, and new and existing conduits.

Terminate all optical fibers in interconnect centers unless otherwise shown on the Plans.

B. Traffic Operations Center

- Office space for a new Traffic Operations Center on the 3rd floor of the Melvin Municipal Office Building is being upfitted by the City of Greensboro.
- Furnish and Install new 2 bay rack cabinet in new Traffic Operations Center as shown in the Plans
- Furnish video monitor framing system to hold eight (8) 50" video monitors of the size and weight called for in these specifications and a 100" diagonal large screen for projection of the large screen display system. Furnish video framing system that is constructed of wood or other approved material and is finished with scratch resistant paint or other approved surface. Furnish system that permits full view of all contained monitor units and full access to all knobs, buttons, and dials on front and sides of monitor

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units. Furnish system that allows a minimum of 12” between the bottom of the large screen and the floor. Furnish system that allows for the placement and removal of monitor units without use of tools. Furnish system that is free standing and secured to the floor. Furnish system that has slots, grommet holes, and cable raceways, for the discrete placement of cabling such that no cabling is visible from the front or sides of the system. Furnish unit that fits into the TOC operator room. Furnish system that allow for the addition of at least 4 additional units video monitors of the size and weight of those being provided under this project. Prior to construction of the video monitor framing system, develop shop drawings and submit to Engineer for approval prior to commencement of construction of the system.

- Furnish furniture as called for in the Plans. Furnish furniture items with cable storage and openings for routing of cables. All furniture provided at the TOC shall be approved by the Engineer.

C. Traffic Operations Center Computer Room

The City’s existing Signal System Computer Room shall serve as the computer room for this project. Under this item, the Contractor shall:

- Furnish and Install 3 bay rack cabinet in existing Signal System Computer room as shown in the Plans.
- Using raised floor and drop ceiling, route existing twisted pair conductors servicing existing communications channels servicing the following intersections to new DSL Switch:

○ GBO-049	GBO-066
○ GBO-067	GBO-068
○ GBO-069	GBO-070
○ GBO-078	GBO-081
○ GBO-082	GBO-084
○ GBO-096	GBO-097
○ GBO-101	GBO-150
○ GBO-152	GBO-148
○ GBO-168	GBO-171
○ GBO-173	GBO-178

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○ GBO-183	GBO-194
○ GBO-195	GBO-198
○ GBO-222	GBO-226
○ GBO-272	GBO-273
○ GBO-274	07-0663

- Using raised floor and drop ceiling and new raceways as approved by the Engineer, route existing, terminated optical fibers in Computer Room to new Fiber Optic Patch Panel
- Perform all work such that the existing signal system hardware remains operable until all intersections monitored and controlled by the existing system are monitored by the new system.
- Cross-connect existing fiber optic cables and terminate as shown in the Plans.
- Route cabling from signal system computer room to new Traffic Operations Center using drop ceiling, raised floor, and new risers and raceways as approved by the Engineer.

D. NCDOT PTRTMC

Install equipment and route cables as shown in the Plans.

Furnish and Install a single bay rack cabinet to house new equipment. Match size, make, and model of existing rack in PTRTMC.

No activity at the PTRTMC facility done under this project shall result in the PTRTMC system operations being unavailable between the hours of 6:00 AM and 6:00 PM on weekdays.

E. Greensboro Emergency Management Center (Justice Building)

Cross-connect existing fiber optic cables as shown in the Plans. Furnish and Install a single bay rack cabinet to house new equipment and system furniture as shown in the Plans. Furnish rack cabinet detail to the Engineer for approval prior to beginning work.

F. Greensboro Signal Shop

Install equipment and route cables as shown in the Plans. Route cabling from telecommunications room to test cabinets, video monitors, using drop ceilings and new raceways as approved by the Engineer. Route cabling through interior walls using methods approved by the Engineer. Route cable from pole line into Telecommunications Room using existing riser. Furnish and Install a single bay rack cabinet to house new equipment.

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19.4. MEASUREMENT AND PAYMENT

Each building modification shall be measured on a lump sum basis and shall include all work required to route and terminate the fiber optic and twisted pair cable into and within the buildings. Furnish and install rack cabinets as shown as well as any other work not called for under other items but required to accomplish the building modifications.

No separate payment will be made for interconnect centers in buildings, patch panels in buildings, new rack cabinets, new furniture, wall sockets and outlets, splicing, conduit, cable routing within building, and telephone service costs for permits and installation fees, as this will be considered incidental to building modifications.

All payments for the building modification items will be made in accord with the following conditions: 75% of the payment will be made upon acceptance of the building modifications; 25% of the payment will be made following final acceptance of the integrated system (including completion of the 120 day observation period).

Payment will be made under:

Traffic Operations Center Building Modifications	Lump Sum
Traffic Operations Center Computer Room Building Modifications	Lump Sum
NCDOT PTRTMC Building Modifications	Lump Sum
Greensboro Emergency Management Center Building Modifications.....	Lump Sum
Greensboro Signal Shop Building Modifications.....	Lump Sum

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20. MIS BUILDING MODIFICATIONS**20.1. DESCRIPTION**

At MIS building locations called for in the Plans, provide means of accessing City of Greensboro buildings with telecommunications equipment managed by the City of Greensboro Department of Management Information Systems (MIS) for the routing and termination of fiber optic cable by others. At MIS building locations housing 10 GIG-E Layer 3 Ethernet Hubs, provide access means to building, route fiber optic cable into building to telecommunications room or closet, terminate cable into new fiber optic cable interconnect center and integrate fiber optic network with 10 GIG-E layer 3 Switch. This work may include attaching risers to buildings, routing risers into ceilings or crawl spaces, attaching messenger cable to buildings to support fiber optic cable, routing conduit into buildings, or other work to provide path into the building. For building where fibers is to be routed within buildings, this work shall include risers, cable raceways, rack cabinets, and all other equipment and hardware required to route and terminate the cable within the building. No work shall be performed at MIS buildings without prior, written authorization from the Engineer. Coordinate all work with contact persons identified by the Engineer.

Locations where work is to occur to enter a building are discussed in this section. A complete list of all facilities where work will occur at or near as part of this project is located on Sheet 3Z of the Plans.

20.2. MATERIALS

Use risers and conduit materials as called for in the Standard Specifications or these Project Special Provisions.

Use fiber interconnect centers as called for in the Standard Specifications or these Project Special Provisions.

Use caulking and sealing materials for sealing entrances into buildings as approved by the Engineer.

Use new cable raceways, electrical boxes, and metallic conduit as approved by the Engineer. Where called for in the Plans, use thin-walled EMT conduit that complies with the NEC and EIA/TIA Standard 569 and commercial building standards for telecommunications pathways.

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20.3. CONSTRUCTION METHODS**A. General**

Contact Engineer prior to entering any building. Coordinate and obtain approval from Engineer regarding allowable working time in buildings.

Prior to core drilling or otherwise creating new entrance into an existing building, obtain approval of methods and materials from the Engineer. In all cases, create entrance that is weatherproof and water tight.

Whenever possible, use existing cable raceways, ducts, raised floors, and drop ceilings to route fiber optic cable.

Perform all work called for in the plans to enter building, install cable conduits and cable raceways, and to route cabling in raised floors, drop ceilings, and new and existing conduits.

Terminate all optical fibers in interconnect centers unless otherwise shown on the Plans.

At locations where Hub switches are to be installed, provide a 220 VAC, 20 amp electrical outlet for the 10 Gig-E hub switch. Perform all work to furnish and install the 220 V outlet in accord with the NEC. Provide electrical service that conforms to all requirements of the switch manufacturer. Provide grounding, electrical isolation, electrical transient and surge protection in accord with the 10 Gig-E hub switch manufacturer recommendations and the Network Equipment Building System (NEBS) requirements.

The table following describes the work to be performed at each building.

ID	Facility Name	Address	Work to be Performed
513	Benjamin Library	1530 Benjamin Pkwy	Install conduit stub from new junction box. Core drill into building wall. Attached galvanized elbow to stub and connect to building at new hole entrance. Provide weatherproof, watertight seal.
518	Coliseum	1921 W Lee St	Install conduit stub from new junction box. Core drill into building wall. Attached galvanized elbow to stub and connect to building at new hole entrance. Provide weatherproof, watertight seal.
519	Cone Building	1101 4th St	Route new riser from new junction box, up wall to ceiling. Strap to wall as shown on the plans using methods approved by the Engineer. Core drill into building and route riser into building. Provide weatherproof, watertight seal.
524	Fire Station 1	1514 N Church St	Route new riser from new junction box, up wall to ceiling. Strap to wall as shown on the plans

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ID	Facility Name	Address	Work to be Performed
			using methods approved by the Engineer. Core drill into building and route riser into building. Provide weatherproof, watertight seal.
525	Fire Station 10	4208 High Point Rd	Route new riser from new junction box, up wall to ceiling. Strap to wall as shown on the plans using methods approved by the Engineer. Core drill into building and route riser into building. Provide weatherproof, watertight seal.
527	Fire Station 12	1805 Pisgah Church Rd	Route new riser from new junction box, up wall to ceiling. Strap to wall as shown on the plans using methods approved by the Engineer. Core drill into building and route riser into building. Provide weatherproof, watertight seal. Route plenum rated fiber optic cable to telecommunications closet in building as identified by the Engineer. Install new fiber optic interconnect center in telecommunications closet. Terminate plenum rated fiber optic cable in new fiber optic interconnect center. Integrate fiber optic interconnect center with new Layer 3 Hub Switch furnished by the City. This location shall house Hub C.
528	Fire Station 14	3622 Summit Ave	Route new riser from new junction box, up wall to ceiling. Strap to wall as shown on the plans using methods approved by the Engineer. Core drill into building and route riser into building. Provide weatherproof, watertight seal.
529	Fire Station 15	1400 W. Vandalia Rd	Route new riser from new junction box, up wall to ceiling. Strap to wall as shown on the plans using methods approved by the Engineer. Core drill into building and route riser into building. Provide weatherproof, watertight seal.
530	Fire Station 16	1000 Meadwood St	Install conduit stub from new junction box. Core drill into building wall. Attached galvanized elbow to stub and connect to building at new hole entrance. Provide weatherproof, watertight seal.
531	Fire Station 6	4504 Lake Brandt Rd	Install conduit stub from new junction box. Core drill into building wall. Attached galvanized elbow to stub and connect to building at new hole entrance. Provide weatherproof, watertight seal.
532	Fire Station 18	5903 Ballinger Rd	Route new riser from new junction box, up wall to ceiling. Strap to wall as shown on the plans using methods approved by the Engineer. Core drill into building and route riser into building. Provide weatherproof, watertight seal.
533	Fire Station 19	6900 Downwind Rd	Route new riser from new junction box, up wall to ceiling. Strap to wall as shown on the plans using methods approved by the Engineer. Core drill into building and route riser into building. Provide weatherproof, watertight seal.

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ID	Facility Name	Address	Work to be Performed
534	Fire Station 20	8404 W. market St	Route new riser from new junction box, up wall to ceiling. Strap to wall as shown on the plans using methods approved by the Engineer. Core drill into building and route riser into building. Provide weatherproof, watertight seal.
535	Fire Station 4	401 Gorrell St	Route new riser from new junction box, up wall to ceiling. Strap to wall as shown on the plans using methods approved by the Engineer. Core drill into building and route riser into building. Provide weatherproof, watertight seal.
536	Fire Station 5	1401 Westover Ter	Route new riser from new junction box, up wall to ceiling. Strap to wall as shown on the plans using methods approved by the Engineer. Core drill into building and route riser into building. Provide weatherproof, watertight seal.
537	Fire Station 7	1064 Gatewood Ave	Route new riser from new junction box, up wall to ceiling. Strap to wall as shown on the plans using methods approved by the Engineer. Core drill into building and route riser into building. Provide weatherproof, watertight seal.
538	Fire Station 8	2201 Coliseum Blvd	Route new riser from new junction box, up wall to ceiling. Strap to wall as shown on the plans using methods approved by the Engineer. Core drill into building and route riser into building. Provide weatherproof, watertight seal.
539	Fire Station 9	4302 W. Friendly Ave	Route new riser from new junction box, up wall to ceiling. Strap to wall as shown on the plans using methods approved by the Engineer. Core drill into building and route riser into building. Provide weatherproof, watertight seal. Route plenum rated fiber optic cable to telecommunications closet in building as identified by the Engineer. Install new fiber optic interconnect center in telecommunications closet. Terminate plenum rated fiber optic cable in new fiber optic interconnect center. Integrate fiber optic interconnect center with new Layer 3 Hub Switch furnished by the City. This location shall house Hub B.
542	Glenwood Library	1901 W. Florida St	Route new riser from new junction box, up wall to ceiling. Strap to wall as shown on the plans using methods approved by the Engineer. Core drill into building and route riser into building. Provide weatherproof, watertight seal.
546	Landfill offices	2503 White St	Route new riser from new junction box, up wall to ceiling. Strap to wall as shown on the plans using methods approved by the Engineer. Core drill into building and route riser into building. Provide weatherproof, watertight seal.
552	McGirt-Horton Library	2509 Phillips St	Route new riser from new junction box, up wall to ceiling. Strap to wall as shown on the plans using methods approved by the Engineer. Core drill into building and route riser into building.

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ID	Facility Name	Address	Work to be Performed
			Provide weatherproof, watertight seal.
557	P&R Maintenance	316 E. Florida St	Route new riser from new junction box, up wall to ceiling. Strap to wall as shown on the plans using methods approved by the Engineer. Core drill into building and route riser into building. Provide weatherproof, watertight seal.
563	Sanford Smith	514 Yanceyville St	Using eye-bolt, attached new messenger strand to side of building. Core drill hole into side of building for use by other to route fiber optic cable into building. Size hole for fiber optic cable. Route plenum rated fiber optic cable to telecommunications closet in building as identified by the Engineer. Install new fiber optic interconnect center in telecommunications closet. Terminate plenum rated fiber optic cable in new fiber optic interconnect center. Integrate fiber optic interconnect center with new Layer 3 Hub Switch furnished by the City. This location shall house Hub E.
565	Tannenbaum	2200 New Garden Road	Route new riser from new junction box, up wall to ceiling. Strap to wall as shown on the plans using methods approved by the Engineer. Core drill into building and route riser into building. Provide weatherproof, watertight seal.
566	Vance Chanvis Library	900 S Benbow Rd	Install conduit stub from new junction box. Core drill into building wall. Attached galvanized elbow to stub and connect to building at new hole entrance. Provide weatherproof, watertight seal.
569	Historical Museum	130 Summit Ave	Install conduit stub from new junction box. Core drill into building wall. Attached galvanized elbow to stub and connect to building at new hole entrance. Provide weatherproof, watertight seal.
571	Central Library	219 N Church St	Install conduit stub from new junction box. Core drill into building wall. Attached galvanized elbow to stub and connect to building at new hole entrance. Provide weatherproof, watertight seal.
590	Curb Market	501 Yanceyville Rd	Using eye-bolt, attached new messenger strand to side of building. Core drill hole into side of building for use by other to route fiber optic cable into building. Provide weatherproof, watertight seal for newly drilled hole that may be removed by other for routing of fiber optic cable into building. Size hole for fiber optic cable.
603	Kathleen Clay Edwards Family branch library	1420 Price Park Rd	Route new riser from new junction box, up wall to ceiling. Strap to wall as shown on the plans using methods approved by the Engineer. Core drill into building and route riser into building. Provide weatherproof, watertight seal.
606	Swing Road	300 Swing Rd	Using eye-bolt, attached new messenger strand

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ID	Facility Name	Address	Work to be Performed
	Station		to side of building. Core drill hole into side of building for use by other to route fiber optic cable into building. Provide weatherproof, water tight seal for newly drilled hole that may be removed by other for routing of fiber optic cable into building. Size hole for fiber optic cable.
901	SportsPlex	2400 16th Street	Install conduit stub from new junction box. Core drill into building wall. Attached galvanized elbow to stub and connect to building at new hole entrance. Provide weatherproof, watertight seal.
902	Fire 56	820 Franklin Blvd	Install conduit stub from new junction box. Core drill into building wall. Attached galvanized elbow to stub and connect to building at new hole entrance. Provide weatherproof, watertight seal.
903	Trotter Rec/Hester	3906 Betula Street	Route new riser from new junction box, up wall to ceiling. Strap to wall as shown on the plans using methods approved by the Engineer. Core drill into building and route riser into building. Provide weatherproof, watertight seal.
904	Burmill Park	5834 Bur-Mil Club Road	Route new riser from new junction box, up wall to ceiling. Strap to wall as shown on the plans using methods approved by the Engineer. Core drill into building and route riser into building. Provide weatherproof, watertight seal.
1415	Fire Station 21	2870 Horsepen Creek Rd	Route new riser from new junction box, up wall to ceiling. Strap to wall as shown on the plans using methods approved by the Engineer. Core drill into building and route riser into building. Provide weatherproof, watertight seal.

20.4. MEASUREMENT AND PAYMENT

Each building modification shall be measured on a lump sum basis and shall include all work required to provide an entrance for fiber optic cable to be installed into the buildings, including all labor and materials to create entrances into building, and to affix risers, utility elbows and messenger cable to buildings. At MIS locations where 10 Gig-E Layer 3 Ethernet Hubs are called to be installed, this work includes furnishing and routing plenum rated fiber optic cable within the building, the installation of riser, cable raceways, and other hardware approved by the Engineer to route the cable within the building, furnishing and installing single bay EIA 19" equipment rack cabinets, furnishing and installing fiber interconnect centers, fiber interconnect patch panels, and Ethernet cable (CAT 5E) patch panels, and the provision of 220V electrical outlets, grounding, surge protection, and electrical transient protection to service the 10 Gig-E Layer 3 Ethernet Hub.

No separate payment will be made for rack cabinets, interconnect centers, patch panels, risers

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within buildings, raceways, modifications to provide 220V service, equipment grounding, equipment electrical transient and surge protection, wall sockets and outlets, splicing at interconnect centers, splicing to extend cable runs within buildings, plenum rated cable runs within the building, or any other labor or materials to route and terminate the cable with the buildings as this will be considered incidental to building modifications.

All payments for the building modification items will be made in accord with the following conditions: At locations without 10 Gig-E Layer 3 Ethernet Hubs, 100% of the payment will be made upon acceptance of the building modifications. At locations with 10 Gig-E Layer 3 Ethernet Hubs (Fire Station 9 (MIS ID 539), Fire Station 12 (MIS ID 527), and the Sanford Smith Building (MIS ID 563)), 75% of the payment will be made upon acceptance of the building modifications; 25% of the payment will be made following final acceptance of the integrated system (including completion of the 120 day observation period).

Payment will be made under:

Benjamin Library Building Modifications.....	Lump Sum
Coliseum Building Modifications.....	Lump Sum
Cone Building Building Modifications.....	Lump Sum
Fire Station 1 Building Modifications	Lump Sum
Fire Station 10 Building Modifications	Lump Sum
Fire Station 12 Building Modifications	Lump Sum
Fire Station 14 Building Modifications	Lump Sum
Fire Station 15 Building Modifications	Lump Sum
Fire Station 16 Building Modifications	Lump Sum
Fire Station 6 Building Modifications	Lump Sum
Fire Station 18 Building Modifications	Lump Sum
Fire Station 19 Building Modifications	Lump Sum
Fire Station 20 Building Modifications	Lump Sum
Fire Station 4 Building Modifications	Lump Sum
Fire Station 5 Building Modifications	Lump Sum
Fire Station 7 Building Modifications	Lump Sum

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Fire Station 8 Building Modifications	Lump Sum
Fire Station 9 Building Modifications	Lump Sum
Glenwood Library Building Modifications	Lump Sum
Landfill offices Building Modifications	Lump Sum
McGirt-Horton Library Building Modifications.....	Lump Sum
P&R Maintenance Building Modifications	Lump Sum
Sanford Smith Building Modifications	Lump Sum
Tannenbaum Building Modifications	Lump Sum
Vance Chanvis Library Building Modifications	Lump Sum
Historical Museum Building Modifications	Lump Sum
Central Library Building Modifications	Lump Sum
Curb Market Building Modifications	Lump Sum
KCEF Library Building Modifications	Lump Sum
Swing Road Station Building Modifications	Lump Sum
SportsPlex Building Modifications	Lump Sum
Fire Station 56 Building Modifications	Lump Sum
Trotter Rec/Hester Building Modifications	Lump Sum
Burmill Park Building Modifications	Lump Sum
Fire Station 21 Building Modifications	Lump Sum

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21. SIGNAL CABINET FOUNDATIONS**21.1. DESCRIPTION**

Furnish and install signal cabinet foundations and all necessary hardware.

Furnish either poured concrete foundations or preformed cabinet pad foundations and all necessary hardware. Obtain approval of foundation type.

Where approved by the Engineer, install conduit entrances into existing foundations in accordance with the plans and specifications.

Modify existing foundations in accordance with the Plans and Project Special Provisions. At locations with where sidewalk, decorative brick pavers, or surface treatments or landscaping treatments are removed or damaged as part of the cabinet foundation installation, replace and restore to pre-construction condition using same material.

21.2. MATERIALS

Preformed cabinet pad foundation material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

Comply with Article 1000-4 Portland Cement Concrete.

Provide foundations with a minimum pad area that extends 24 inches from the front and back of the cabinet, and 3 inches from the sides of the cabinet.

Furnish cabinet foundations with chamfered top edges. Provide minimum Class B concrete.

Provide preformed cabinet pad foundations with 7" (l) x 18" (w) minimum opening for the entrance of conduits. Ensure that no more than four 3/4 inch holes are cast or drilled in each pad.

Comply with the provisions of section 1750-2 of the Standard Specifications.

Replacement sidewalk where required to restore locations to preconstruction condition shall be replaced in whole panels and shall meet the requirements of Section 848 of the Standard Specifications.

Replacement brick pavers where required to restore locations to preconstruction condition shall be of the same color and materials of the damaged or modified items

Replacement of other special pavement treatments or landscaping required to restore locations to preconstruction condition shall be the same materials of the damaged or modified items

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21.3. CONSTRUCTION METHODS

Comply with Section 825 of the 2006 Standard Specifications for Roads and Structures regarding Incidental Concrete Construction.

Obtain approval for final cabinet foundation locations before pouring the concrete base. Locate new cabinets so as not to obstruct sight distance of vehicles turning on red or create any ADA violations or pedestrian conflicts.

Do not install foundations over uncompacted fill or muck.

Use procedures, equipment, and hardware as follows:

- Hand tamp soil before placing the concrete.
- Maintain 12 inches minimum from service pole to the closest point on foundation unless otherwise approved.
- Use a minimum of four 1/2 inch diameter expanding type anchor bolts to secure the cabinet to foundation.
- Install minimum 4 inches above and 4 inches below finished grade.
- Locate external stubbed out conduit at the cabinet foundation so conduit is in middle of cabinet. Provide service conduit as the rightmost conduit coming into cabinet. Provide two spare conduits stubbed out; one pointed toward service pole and the other toward direction of lead-in cable. Inscribe an identification arrow in foundation indicating direction of spare conduits.
- Give cabinet foundation a broom finish.
- Seal space between cabinet base and foundation with permanent, flexible, waterproof sealing material.
- If using preformed cabinet pad, ensure ground is level before installation.

A. Install Conduit Entrance into Existing Foundation

Install Conduit Entrances into existing cabinet foundations by core drilling foundations to install additional conduit.

Maintain a minimum of 3 inches of cover between new conduit and edge of foundation. Maintain

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minimum clearances of 1 inch from the flange of the base adapter and 2 inches from existing conduits. Avoid damaging existing conduit, conductors, and anchor bolts. Repair all such damages. Where approved by the Engineer, the foundation may be chipped instead of drilled for conduit entrance. When possible, maintain traffic signal operations while drilling is performed.

Bond new metallic conduit to the cabinet grounding system.

After installation of conduit, place grout to seal around conduit, and return the foundation to normal appearance.

B. Modify Foundation

Enlarge existing cabinet foundations to accommodate the new cabinet and/or to provide a maintenance technician pad(s).

Excavate the ground around the existing foundation to a depth sufficient to expose a minimum of 4 inches of the foundation below existing grade.

Rough the sides of the existing foundation from the top to a point 4 inches below grade by means of a chisel or other method approved by the Engineer.

Wash the sides of the foundation with water pressurized at 50 psi and thoroughly dry with compressed air.

Drill holes approximately 12 inches deep on 12-inch centers into the existing foundation. Install #4 dowels and epoxy into place. Provide dowels of the following lengths:

Foundation Extension	Length of Dowel
>16"	24"
>6" and <16"	17"
=6"	14"

Use concrete to install the maintenance technician pad.

Form the sides of the modified foundation to a minimum depth of four inches below grade.

Position forms so that all existing exposed foundation surfaces at or above grade level will be matched.

Apply a coating of approved epoxy bonding agent to all exposed roughened concrete surfaces as recommended by the manufacturer.

Enlarge the foundation to the distance specified for new cabinet foundations. Provide a 1-inch

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chamfer on all new outside edges.

Maintenance technician pads should be added to the foundation to provide a minimum work area of 24 inches (length) x 30 inches (width) from both the front and rear doors of the cabinet.

C. Remove Foundation, Cabinet, Controller

At locations where a new signal controller and cabinet is installed in a different site than the existing signal controller and cabinet, the Contractor shall remove the existing controller, cabinet, and foundation and restore the surface to the condition of the surrounding area. If the removed foundation is in the sidewalk, this shall include filling in the entire concrete panel in kind with new sidewalk, using the same type of concrete. If the removed foundation is in a bricked sidewalk, this shall include filling in the area with brick pavers that match the surrounding area, as approved by the Engineer. The controller, cabinet, and foundation should be disposed of by the Contractor in a manner approved by the Engineer. Comply with the requirements for the removal of existing material in Section 1 of these Project Special Provisions.

21.4. MEASUREMENT AND PAYMENT

Signal cabinet foundation will be measured and paid as the actual number furnished, installed, and accepted.

Conduit Entrance into Existing Foundation will be measured and paid as the actual number installed and accepted.

Modify Foundation for Controller Cabinet will be measured and paid as the actual number installed and accepted.

Concrete Sidewalk will be measured and paid as the actual square yards of concrete installed and accepted.

Brick pavers will be measured and paid as the actual square footage of pavers installed and accepted.

Payment will be made under:

Signal Cabinet Foundation.....	Each
Conduit Entrance into Existing Foundation.....	Each
Modify Foundation for Controller Cabinet.....	Each
4" Concrete Sidewalk	Square Yard
Brick Pavers	Square Foot

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22. CABINET BASE ADAPTER/EXTENDER**22.1. DESCRIPTION**

Furnish and install cabinet base adapters and extenders with all necessary hardware.

22.2. MATERIALS

Fabricate base adapters and extenders from the same materials and with the same finish as cabinet housing. Fabricate base adapter and extender in the same manner as controller cabinets, meeting all applicable specifications called for in Section 7.5 of CALTRANS TEES (11/19/99). Provide base adapters and extenders a minimum height of 12 inches.

22.3. CONSTRUCTION METHODS**A. General**

Install cabinet base adapter at locations requiring a new Model 332A cabinet on existing/modified foundation.

Install cabinet base extender at locations requiring a new Model 332A cabinet on new foundation or existing Model 332A cabinet that does not have cabinet base extender.

Where Model 336 cabinet is used as base mount cabinet, install adapter or extender, as required.

Use permanent, flexible waterproof sealing material to:

- Seal between cabinet base and cabinet base adapter/extender,
- Seal two-piece cabinet base adapter/extender seams, and
- Seal space between cabinet base adapter/extender and foundation.

B. Integrated Base Adapter

Install base adapter with integrated electrical service meter and disconnect at locations requiring a new Model 336S cabinet to be base mounted on a new or modified foundation. The adapter and electrical service equipment shall be a single, solid, integrated piece. All electrical service equipment shall conform to the provisions in **Section 24**.

22.4. MEASUREMENT AND PAYMENT

Cabinet base adapters will be measured and paid as the actual number furnished, installed, and accepted.

Integrated cabinet base adapters will be measured and paid as the actual number furnished,

installed, and accepted. No separate measurement or payment will be made for electrical service meters, disconnects, and associated wiring, as this will be considered incidental to the integrated cabinet base adapter.

Cabinet base extenders will be measured and paid as the actual number furnished, installed, and accepted.

Payment will be made under:

Cabinet Base Adapter	Each
Integrated Cabinet Base Adapter	Each
Cabinet Base Extender	Each

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23. CONTROLLERS WITH CABINETS**23.1. DESCRIPTION**

Furnish and install controllers with cabinets and all necessary hardware. Furnish all pole or foundation mounting hardware, detector sensor cards, external electrical service disconnects, one Corbin Number 2 cabinet key, one police panel key, conflict monitors or malfunction management units, surge protection, grounding systems, AC/DC isolator cards, and all necessary hardware.

Hold three identical controller training sessions for maintenance personnel. Each of the identical training sessions shall consist of five (5) consecutive days, beginning on a Monday. **Conduct one of these training sessions prior to the installation of any new controllers and cabinets on the project.**

These three sessions include training for NCDOT and City traffic engineering, signal timing, and maintenance personnel on controller and cabinet assemblies as called for in **Section 36** of these Project Special Provisions.

23.2. MATERIALS**A. General**

Material, equipment, and hardware furnished under this section must be pre-approved on the Department's QPL by the date of equipment installation.

B. Cabinet Prototype

The Contractor shall develop cabinet prototypes for each configuration of controller and equipment cabinet to show how all hardware (controller, detectors, Ethernet switches, video codec units, etc.) and associated cabling called for in these Project Special Provisions will be installed and configured in the field. The cabinet prototypes shall be approved by the Engineer prior to the installation of that cabinet configuration.

C. Type 2070L Controllers

Conform to CALTRANS *Transportation Electrical Equipment Specifications (TEES)* (11-19-2002) except as required herein.

Furnish Model 2070L controllers. Ensure that removal of the CPU module from the controller will place the intersection into flash.

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Provide model 2070L controllers with the latest version of OS9 operating software and device drivers, composed of the unit chassis and at a minimum the following modules and assemblies:

- MODEL 2070 1B, CPU Module, Single Board
- MODEL 2070-2A, Field I/O Module (FI/O)
- MODEL 2070-3B, Front Panel Module (FP), Display B (8x40)
- MODEL 2070-4A, Power Supply Module, 10 AMP
- MODEL 2070-7A, Async Serial Com Module (9-pin RS-232)

Furnish one removable data key with each 2070L controller unit.

D. Type 170E Cabinets**D.1. General**

Conform to the CALTRANS *Transportation Electrical Equipment Specifications* (TEES) (11-19-99) except as required herein.

Furnish CALTRANS Model 336S pole mounted cabinets configured for 8 vehicle phases with power distribution assemblies (PDAs) # 2, and 4 pedestrian phases or overlaps.

Furnish CALTRANS Model 332A base mounted cabinets with PDAs #2 and configured for 8 vehicle phases, 4 pedestrian phases, and 4 overlaps. When overlaps are required, provide auxiliary output files for the overlaps. Do not reassign load switches to accommodate overlaps unless shown on electrical details.

D.2. Cabinet Electrical Requirements

Provide a cabinet assembly designed to ensure that upon leaving any cabinet switch or conflict monitor initiated flashing operation, the controller starts up in the programmed start up phases and start up interval.

Furnish two sets of non-fading cabinet wiring diagrams and schematics in a paper envelope or container and placed in the cabinet drawer.

Provide surge suppression in the cabinet for each type of cabinet device. Provide surge protection for the full capacity of the cabinet input file.

All AC+ power is subject to radio frequency signal suppression.

If additional surge protected power outlets are needed to accommodate field Ethernet switches, modems, etc.; install a UL listed, industrial, heavy-duty type power outlet strip with a maximum

rating of 15 A / 125 VAC, 60 Hz. Provide a strip that has a minimum of 3 grounded outlets. Ensure the power outlet strip plugs into one of the controller unit receptacles located on the rear of the PDA. Ensure power outlet strip is mounted securely; provide strain relief if necessary.

Connect detector test switches for cabinets as follows:

336S Cabinet		332A Cabinet	
Detector Call Switches	Terminals	Detector Call Switches	Terminals
Phase 1	I1-F	Phase 1	I1-W
Phase 2	I2-F	Phase 2	I4-W
Phase 3	I3-F	Phase 3	I5-W
Phase 4	I4-F	Phase 4	I8-W
Phase 5	I5-F	Phase 5	J1-W
Phase 6	I6-F	Phase 6	J4-W
Phase 7	I7-F	Phase 7	J5-W
Phase 8	I8-F	Phase 8	J8-W

Provide a terminal mounted loop surge suppresser device for each set of loop terminals in the cabinet. For a 10x700 microsecond waveform, ensure that the device can withstand a minimum of 25 peak surge current occurrences at 100A, in both differential and common modes. Ensure that the maximum breakover voltage is 170V and the maximum on-state clamping voltage is 30V. Provide a maximum response time less than 5 nanoseconds. Ensure that off-state leakage current is less than 10 µA. Provide a nominal capacitance less than 220pf for both differential and common modes.

Provide surge suppression on each communications line entering or leaving a cabinet. Ensure that the communications surge suppresser can withstand at least 80 occurrences of an 8x20 microsecond wave form at 2000A and a 10x700 microsecond waveform at 400A. Ensure that the maximum clamping voltage is suited to the protected equipment. Provide a maximum response time less than 1 nanosecond. Provide a nominal capacitance less than 1500pf and a series resistance less than 15 Ω.

Provide surge suppression on each DC input channel in the cabinet. Ensure that the DC input

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channel surge suppresser can withstand a peak surge current of at least 10,000 amperes in the form of an 8x20 microsecond waveform and at least 100 occurrences of an 8x20 microsecond wave form at 2000 A. Ensure that the maximum clamping voltage is 30V. Provide a maximum response time less than 1 nanosecond and a series resistance less than 15 Ω per line.

Provide protection for each preemption or 120 Vrms single phase signal input by an external stud mounted surge protector. Ensure that a minimum stud size of 1/3 inch, and Number 14 AWG minimum sized wire leads with 1 foot minimum lengths. Ensure that a peak surge trip point less than 890 volts nominal for a 600 volt rise per microsecond impulse, and 950 volts nominal for a 3000 volt per microsecond rise impulse. Provide a maximum surge response time less than 200 nanoseconds at 10 kV per microsecond. Ensure that the AC isolation channel surge suppresser can withstand at least 25 occurrences of a 8x20 waveform of 10,000 amperes and a peak single pulse 8x20 microsecond wave form of 20,000 amperes. Provide a maximum clamping voltage of 30V. Provide a maximum response time less than 1 nanosecond. Ensure that the discharge voltage is under 200 volts at 1000 amperes and the insulation resistance is 100 megaohms. Provide an absolute maximum operating line current of one ampere at 120 Vrms.

Provide conductors for surge protection wiring that are of sufficient size (ampacity) to withstand maximum overcurrents which could occur before protective device thresholds are attained and current flow is interrupted.

Furnish a fluorescent fixture in the rear across the top of the cabinet and another fluorescent fixture in the front across the top of the cabinet at a minimum. Ensure that the fixtures provide sufficient light to illuminate all terminals, labels, switches, and devices in the cabinet. Conveniently locate the fixtures so as not to interfere with a technician's ability to perform work on any devices or terminals in the cabinet. Provide a protective diffuser to cover exposed bulbs. Furnish all bulbs with the cabinet. Provide door switch actuation for the fixtures.

Furnish a police panel with a police panel door. Ensure that the police panel door permits access to the police panel when the main door is closed. Ensure that no rainwater can enter the cabinet even with the police panel door open. Provide a police panel door hinged on the right side as viewed from the front. Provide a police panel door lock that is keyed to a standard police/fire call box key. In addition to CALTRANS Specifications, provide the police panel with a toggle switch connected to switch the intersection operation between normal stop-and-go operation (AUTO) and manual operation (MANUAL). Ensure that manual control can be implemented using inputs and software such that the controller provides full programmed clearance times for the yellow clearance and red clearance for each phase while under manual control.

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Provide a 1/4-inch locking phone jack in the police panel for a hand control to manually control the intersection. Provide sufficient room in the police panel for storage of a hand control and cord.

Provide detector test switches inside the cabinet on the door or other convenient location which may be used to place a call on each of eight phases based on standard CALTRANS input file designation for detector racks. Provide three positions for each switch: On (place call), Off (normal detector operation), and Momentary On (place momentary call and return to normal detector operation after switch is released). Ensure that the switches are located such that the technician can read the controller display and observe the intersection.

Equip cabinet with a connector and terminal assembly designated as P20 (Magnum P/N 722120 or equivalent) for monitoring the absence of any valid AC+ signal display (defined here as red, yellow, or green) input on any channel of the conflict monitor. Connect the terminal through a 3 1/2 feet 20 wire ribbon cable which mates on the other end to a connector (3M-3428-5302 or equivalent) installed in the front of the Type 2010 enhanced conflict monitor. Ensure that the female connector which mates with the connector on the conflict monitor has keys to ensure that proper connection. Ensure that the cabinet enters the flash mode if the ribbon cable is not properly connected. Provide a P20 connector and terminal assembly that conforms to Los Angeles City DOT "Traffic Signal Specification DOT 170 ATSAC Universal and Related Equipment #54-053-02".

Terminate ribbon cable at the P20 connector and terminal assembly. Ensure the P20 connector and mating ribbon cable connector is keyed to prevent cable from being improperly installed. Wire the P20 connector to the traffic signal red displays to provide inputs to conflict monitor as shown:

Pin #	Function	Pin #	Function
1	Channel 15 Red	11	Channel 9 Red
2	Channel 16 Red	12	Channel 8 Red
3	Channel 14 Red	13	Channel 7 Red
4	GND	14	Channel 6 Red
5	Channel 13 Red	15	Channel 5 Red
6	Special Function 2	16	Channel 4 Red
7	Channel 12 Red	17	Channel 3 Red
8	Special Function 1	18	Channel 2 Red
9	Channel 10 Red	19	Channel 1 Red

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10	Channel 11 Red	20	Red Enable
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Provide a convenient means to jumper 120 VAC from the signal load switch AC+ supply bus to any channel Red input to the P20 connector in order to tie unused red inputs high. Ensure that easy access is provided to the jumper connecting terminals on the back side of cabinet. Locate the jumper terminals connecting to all 16 channel Red inputs in the same terminal block. For each channel Red input terminal, provide a companion terminal supplying AC+ from the signal bus. Provide one of the following two methods for providing Signal AC+ to the channel red input:

- Place a commercially available jumper plug between the channel Red input and its companion Signal Bus AC+ terminal.
- Place a jumper wire between a channel red input screw terminal and its companion Signal Bus AC+ screw terminal.

Connection between channel Red input terminal and its companion Signal Bus AC+ terminal must not require a wire greater than 1/2 inch in length.

Conform to the following Department wiring requirements:

- Wire the Red Enable monitor input to the Signal Bus AC+ terminal TB01-1.
- Do not connect either the special function 1 or the special function 2 monitor input to the red monitor card.
- Ensure that removal of the P-20 ribbon cable will cause the monitor to recognize a latching fault condition and place the cabinet into flashing operation and that this is implemented in the conflict monitor software.

Ensure that removal of the conflict monitor from the cabinet will cause the cabinet to revert to flashing operation.

Provide Model 200 load switches and Model 204 flashers.

D.3. Cabinet Physical Requirements

Provide a surge protection panel with 16 loop protection devices and designed to allow sufficient free space for wire connection/disconnection and surge protection device replacement. Provide an additional three slots protected with six AC+ interconnect surge devices and two protected by four DC surge protection devices. Provide no protection devices on slot 14. Attach flash sense and stop time to the upper and lower slot as required.

i) For pole mounted cabinets, mount surge protection devices for the AC+ interconnect cable inputs, inductive loop detector inputs, and low voltage DC inputs on a fold down panel assembly on the rear side of the input files. Fabricate the surge protection devices from sturdy aluminum and incorporate a swing down back panel to which the surge protection devices are attached. Attach the swing down panel to the assembly using thumb screws. Have the surge protection devices mounted horizontally on the panel and soldered to the feed through terminals of four 14 position terminal blocks with #8 screws mounted on the other side.

ii) For base mounted cabinets, attach separate surge protection termination panels to each side of the cabinet rack assembly. Mount the surge protection termination panel for AC isolation devices on the same side of the cabinet as the AC service inputs. Install the surge protection termination panel for DC terminals and loop detector terminals on the opposite side of the cabinet from the AC service inputs. Attach each panel to the rack assembly using bolts and make it easily removable. Mount the surge protection devices in horizontal rows on each panel and solder to the feed through terminals of 14 position terminal blocks with #8 screws mounted on the other side. Wire the terminals to the rear of a standard input file using spade lugs for input file protection.

Provide permanent labels that indicate the slot and the pins connected to each terminal that may be viewed from the rear cabinet door. Label and orient terminals so that each pair of inputs is next to each other. Ensure the top row of terminals is connected to the upper slots and the bottom row of terminals is connected to the bottom slots. Indicate on the labeling the slot number (1-14) and the terminal pins of the input slots (either D & E for upper or J & K for lower). Terminate all grounds from the surge protection on a 15 position copper equipment ground bus attached to the rear swing down panel. Ensure that a Number 4 AWG green wire connects the surge protection panel assembly ground bus to the main cabinet equipment ground. Provide a standard input file and surge protection panel assembly that fits outside and behind the input file. Ensure the fold down panel allows for easy removal of the input file without removing the surge protection panel assembly or its parts.

Provide a minimum 14 x 16 inch pull out, hinged top shelf located immediately below fiber optic interconnect center (when applicable). Ensure the shelf is designed to fully expose the table surface outside the controller at a height approximately even with the bottom of the controller. Ensure the shelf has a storage bin interior which is a minimum of 1 inch deep and approximately the same dimensions as the shelf. Provide an access to the storage area by lifting the hinged top of the shelf. Fabricate the shelf and slide from aluminum or stainless steel and ensure the assembly can support the 2070 controller plus 15 pounds of additional weight. Ensure shelf has a locking mechanism to secure it in the fully extended position and does not inhibit the removal of the 2070 controller or removal of cards inside the controller when fully extended. Provide a locking mechanism that is

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easily released when the shelf is to be returned to its non-use position directly under the controller.

D.4. Emergency Generator Provisions

At locations shown in the Plans, preserve the existing emergency generator functionality by providing all necessary equipment including lockable power inlet box and manual transfer switch. Comply with all requirements shown in the Detail drawings in the Plans for emergency generator provisions.

D.5. Model 2010 Enhanced Conflict Monitor

Furnish Model 2010 Enhanced Conflict Monitors with 16 channels. In addition to CALTRANS requirements, ensure the conflict monitor monitors for the absence of a valid voltage level on at least one channel output of each load switch. Ensure that the absence of the programming card will cause the conflict monitor to trigger, and remain in the triggered state until reset. Ensure conflict monitor will recognize configuration changes (i.e. open diode, switch setting) and produce a fault condition.

Provide a conflict monitor that recognizes the faults specified by CALTRANS and the following additional per channel faults that apply for monitor inputs to each channel:

- consider a Red input greater than 70 Vrms as an “on” condition;
- consider a Red input less than 50 Vrms as an “off” condition (no valid signal);
- consider a Red input between 50 Vrms and 70 Vrms to be undefined by these specifications;
- consider a Yellow or Green input greater than 25 Vrms as an “on” condition;
- consider a Green or Yellow input less than 15 Vrms as an “off” condition; and
- consider a Green or Yellow input between 15 Vrms and 25 Vrms to be undefined by these specifications.

Ensure monitor will trigger upon detection of a fault and will remain in the triggered (failure detected) state until unit is reset at the front panel or through the remote reset input for the following failures:

1. **Red Monitoring or Absence of Any Indication (Red Failure):** A condition in which no “on” voltage signal is detected on any of the green, yellow, or red inputs to a given monitor channel. If a signal is not detected on at least one input (R, Y, or G) of a conflict monitor channel for a period greater than 1000 ms when used with a 170 controller and 1500 ms when used with a 2070L controller, ensure monitor will trigger and put the intersection into flash. If the absence of any indication condition lasts less than 750 ms

when used with a 170 controller and 1200 ms when used with a 2070L controller, ensure conflict monitor will not trigger. Have red monitoring occur when the P20 Connector is installed and both the following input conditions are in effect: a) Red Enable input to monitor is active (Red Enable voltages are “on” at greater than 70 Vrms, off at less than 50 Vrms, undefined between 50 and 70 Vrms), and b) neither Special Function 1 nor Special Function 2 inputs are active.

2. **Yellow Indication Sequence Error:** Yellow indication following a green is missing or shorter than 2.7 seconds (with ± 0.1 -second accuracy). If a channel fails to detect an “on” signal at the Yellow input following the detection of an “on” signal at a Green input for that channel, ensure that the monitor triggers and generates a sequence error fault indication.
3. **Dual Indications on the Same Channel:** In this condition, more than one indication (R,Y,G) is detected as “on” at the same time on the same channel. If dual indications are detected for a period greater than 500 ms, ensure that the conflict monitor triggers and displays the proper failure indication (Dual Ind fault). If this condition is detected for less than 250 ms, ensure that the monitor does not trigger.

Enable the monitor function for short/missing yellows and for dual indications on a per channel basis.

Provide Special Function 1 and Special Function 2 that comply with the Los Angeles City DOT *Traffic Signal Specification DOT 170 ATSAC Universal and Related Equipment #54-053-02* to eliminate red failure monitoring while allowing other additional enhanced fault monitoring functions to continue.

Ensure that the removal of the P-20 ribbon cable will cause the monitor to recognize a latching fault condition and place the cabinet into flashing operation.

Ensure that when the Conflict Monitor is triggered due to a fault, it provides an LED indication identifying the type of failure detected by the monitor except for the P20 ribbon cable removal fault. Ensure that the monitor indicates which channels were active during a conflict condition and which channels experienced a failure for all other per channel fault conditions detected, and that these indications and the status of each channel are retained until the Conflict Monitor is reset.

Ensure that the conflict monitor will store at least nine of the most recent malfunctions detected by the monitor in EEPROM memory. For each malfunction, record at a minimum the time, date, type of malfunction, relevant field signal indications, and specific channels involved with the

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malfunction.

In addition to the connectors required by the CALTRANS Specifications, provide the conflict monitor with a connector mounted on the front of the monitor (3M-3428-5302 with two polarizing keys or equal) which mates with a 20 pin ribbon cable connector that conducts the signals from the P20 connector on the cabinet assembly. Provide a P20 connector and terminal assembly that complies with the Los Angeles City DOT "Traffic Signal Specification DOT 170 ATSAC Universal and Related Equipment #54-053-02". Provide connector pins on the monitor with the following functions:

Pin #	Function	Pin #	Function
1	Channel 15 Red	11	Channel 9 Red
2	Channel 16 Red	12	Channel 8 Red
3	Channel 14 Red	13	Channel 7 Red
4	Chassis Ground	14	Channel 6 Red
5	Channel 13 Red	15	Channel 5 Red
6	Special Function 2	16	Channel 4 Red
7	Channel 12 Red	17	Channel 3 Red
8	Special Function 1	18	Channel 2 Red
9	Channel 10 Red	19	Channel 1 Red
10	Channel 11 Red	20	Red Enable

Provide monitor with Ethernet 10/100 Mbps, RJ-45 port for data communication for access to the device by a local notebook computer and remotely via a workstation or notebook computer device connected to the signal system local area network. Integrate unit with Ethernet switch in cabinet. Furnish conflict monitor monitoring software provided by conflict monitor manufacturer. Install on workstations and notebook computers where the signal system software client software is installed.

D.6. Type 170 Detector Sensor Units

Furnish detector sensor units that comply with Chapter 5, "General Requirements for Detector Sensor Units," of the CALTRANS Specifications, and the requirements for Model 222 and Model

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224 loop detector sensor units.

D.7. Cabinet Finish

Cabinet finish shall be an anodized silver aluminum finish, except at the following locations in the historic downtown area where a painted finish is required:

07-0636: Tate @ Market	07-0637: Mendenhall @ Market
07-2029: McIver @ Market	GBO-033: Mendenhall @ Spring Garden
GBO-052: Church @ Bessemer	GBO-059: Fisher @ Elm
GBO-062: Greene @ Fisher	GBO-091: Yanceyville @ Summitt
GBO-255: Bessemer @ Cridland	GBO-257: Elm @ Bessemer
GBO-117: Carr @ Tate	GBO-305: Sunset Circle @Elm

Painted finished shall be applied prior to delivery and conform to the following specifications:

- All steel components (including nuts, bolts, screws, etc.) shall have a shop painted finish coat.
- The color shall be dark green semi-gloss, as used on the existing cabinet at GBO-117 (Carr @ Tate), and as approved by the Engineer.
- The finish coating shall be a six stage chemical treatment for an electrostatically applied fusion bonded polyester epoxy coating. The polyester protective coating shall be one coat, minimum 4 mils thick, heat curable, thermosetting powdered coating.

E. Terminal Splice Box

Furnish terminal splice boxes to splice and extend signal conductors, loop lead-in cables, and existing twisted pair interconnect cables where present. Provide terminal splice boxes as described below. Furnish binder type terminal strips. Separate binder strips shall be furnished for signal wiring and loop lead-in.

No measurement will be made of additional signal conductors, loop lead-ins, and twisted pair cables, as the splicing of all existing signal conductors, loop lead-ins, and twisted pair cables in the splice box, extending them through new risers and conduits, and connecting them to the new controller cabinet shall be considered incidental to furnishing and installing terminal splice boxes. Additional signal conductors, loop lead-in, and twisted pair cable shall be of the same size and type of the existing wires and cables. Provide permanent labels prior to construction on all incoming and

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outgoing conductors using a naming convention such as Phase One Green, Phase Two Yellow, Loops 2A, etc.

Furnish terminal splice box that is fabricated of steel or aluminum and satisfies the requirements of environmentally sealed NEMA Type 4X enclosures.

Bond terminal splice box to equipment ground in cabinet using a 14 AWG stranded THHN. Do not put loop grounds and other grounds with neutral conductors.

Furnish terminal splice boxes with a minimum size of 12 inches wide by 20 inches high by 8 inches deep. Each terminal splice box shall have a terminal block having at least twenty (20) terminals with each terminal having two (2) terminal screws. The terminal screws shall be nickel-plated brass screws and have a minimum outside diameter of 4.3 mm. A removable sorting bar shall be provided between the screws of each terminal. The terminal block shall be of electrical grade thermoplastic or thermosetting plastic and shall have the terminals recessed between molded barriers. The terminal block shall be mounted on the back wall of the terminal splice box in such a manner that no mounting screws, nuts, etc. protrude through the box. The terminal block shall be centered on the back wall in line with the long dimension of the box. Install additional terminal blocks as necessary.

The terminal splice box shall have the following holes in the bottom. The box shall be furnished with weatherproof caps for all holes

- One (1) hole suitable for a 2 inch conduit, at the rear and centered.
- Two (2) holes which will accommodate 2 inch rigid metal conduits, one on either side of the hole described above. Each of these holes shall be provided with suitable cable entrance fittings which will both clamp the entering cables in place and protect their insulation from damage. These holes and their fittings shall be located so that the conduit hole between them can be fitted with a conduit hub without difficulty.

Furnish terminal splice box with brackets suitable for attaching the box to wood poles banded attachments and screws and other attachment hardware as approved by the Engineer. The brackets shall facilitate a firm attachment to the pole. The design of the brackets shall be such that the conduit hubs and cable fittings shall not make mounting of the box difficult. At locations where the terminal splice box is to be attached externally to a metal strain pole, use banding method approved by the Engineer.

The terminal splice box shall have a hinged cover which shall open to the side.

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F. Emergency Vehicle Preemption

Furnish emergency vehicle preemption systems that are Opticom 700 Series models, or approved equivalent, that is fully interoperable with the existing preemption systems used by the City and any equipment installed under this project.

G. Equipment Cabinet

Furnish dual door, model 333 base mounted equipment cabinets for hub equipment. The Cabinet housing shall be a Type 3 Housing as called for in the CALTRANS TEES (2002). The cabinets shall be fabricated to provide an environmentally controlled, electrical transient resistant environment for the operation of the 10 Gig-E Layer 3 Hub Switch. The cabinet shall not be furnished with cabinet input files, output files, terminal panels, a police panel, nor a standard Caltrans power distribution assembly (PDA). Furnish Cabinet with the following features:

- Provide cabinet with two (2) rack mount Kooltronic air conditioning units; each rated at a minimum 3000 BTU. Provide air cooling units with temperature and humidity measurement devices. Integrate temperature and humidity measurement devices with Ethernet contact closure module (SIXNET model ET-8D12-8A12 or approved equal).
- Provide cabinet that maintains temperature humidity in accord with the operating requirements of the 10 Gig-E Layer 3 switch.
- Provide cabinet with APC 120V/208V UPS and power conditioning unit with minimum 6 220V receptacles and minimum 6 120V reseptacles. Insure power receptacles are compatible with all equipment plugs utilizing receptacles
- Provide sealed. Airtight cabinet housing with door vents designed to serve as air intake and exhaust for the air conditioning unit. Do not provide cabinet with ceiling exhaust fan and vent.
- Provide cabinet with insulating material on doors, inner wall and ceilings
- Provide cabinet power distribution unit with 120VAC/ 220 VAC power distribution panel with remote cut-off capability. Provide cabinet with 220 V, 20 Amp, and 120 V, 15 amp power receptacle. Furnish power distribution assembly with 30 AMP circuit breaker and 15 AMP circuit breaker. Insure panel meets all NEC and NEBS standards.
- Provide cabinet with SIXNET model ET-8D12-8A12 Ethernet contact closure module.
- Modify electrical service at external service point on pole or pedestal to provide branched 120V, 220 V service to cabinet. This work shall be incidental to the Equipment cabinet

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and shall not be paid for separately.

- Install EIA 19” racks to permit minimum 6 inches of space on each side of the 10 Gig-E Layer 3 switch for unit air flow.

Furnish shop drawings for cabinet to engineer for approval.

23.3. CONSTRUCTION METHODS**A. General**

At locations shown in the Signal Plans, some existing single-ring cabinets are being replaced with new dual-ring cabinets. Provide additional signal cable as shown on the Signal Plans.

Remove existing controllers and cabinets where required. Prior to any work being performed on an existing cabinet, place permanent labels on all conductors using a naming convention such as Phase One Green, Phase Two Yellow, Loops 2A, etc. Remove the maintenance diary from the cabinet and place it in the new cabinet or present it to the Engineer. Take existing equipment out of service only at the time directed.

Locate new cabinets so as not to obstruct sight distance of vehicles turning on red.

Install controllers, cabinets, detector sensor units, and hardware that provide the required phasing, color sequence, flash sequence, interconnection, railroad clearance and preemption, and emergency vehicle clearance and preemption. At locations with preemption (emergency vehicle, railroad, or transit vehicle), submit a completed Preemption Test Procedure Checklist for approval by the Engineer. The latest checklist can be found at:

<http://www.ncdot.org/doh/preconstruct/traffic/ITSS/ws/preemption.pdf>

Stencil signal inventory number on cabinet side facing roadway. Use 3 inch black characters.

Provide an external electrical service disconnect at all new and existing cabinet locations unless otherwise shown on the plans. When field conditions require deviation from the plans, notify the Engineer.

Do not program controllers for late night flashing operation at railroad preemption installations. For all other installations, do not program the controller for late night flashing operation unless otherwise directed. Ensure all signal heads for same approach flash concurrently during flashing operation.

Provide serial number and cabinet model number for each new controller and controller cabinet

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installed.

Install pole mounted cabinets so height to cabinet middle is 4 feet.

Activate controllers with proposed phasing and timing.

At locations with existing school flasher outputs, integrate school flasher outputs with new controller and cabinet to preserve all existing functionality.

Ensure that maximum resistance between the grounding electrode and all points in the grounding system does not exceed 5 ohms.

In addition to the requirements of the NEC, test grounding electrode resistance at the connection point to the electrical service ground bus for a maximum of 20 ohms. Furnish and install additional ground rods to the grounding electrode system as necessary to meet test requirements. Submit copy of test results to the Engineer and place copy of test results in cabinet.

B. Terminal Splice Box

At locations shown in the Plans, furnish and install a terminal splice box. Splice and extend signal conductors, loop lead-ins, and twisted pair cables from the splice box to the cabinet. Furnish and install binder type terminal strips.

C. Emergency Vehicle Preemption

Comply with the emergency vehicle preemption requirements detailed in **Section 1** of these Specifications. Coordinate emergency vehicle preemption work with the proper operating authority. Contact the proper operating authority and schedule installation of all equipment. Reuse existing hardware, harnesses, and wires if feasible to interface with new signal controller and cabinet.

At the following locations, furnish and install new emergency vehicle preemption equipment, as the existing equipment is not compatible with the new cabinets and controllers

07-0209: High Point @ Merritt

07-0295: Church @ Cornwallis

07-0450: High Point @ Holden

07-0538: Battleground @ Pisgah Church

07-0560: Bennett @ Lee

07-0568: Florida @ Randleman

07-0578: Church @ Cone

07-0596: High Point @ Meadowview

07-0597: Wendover @ Westover Ter.

07-0609: Battleground @ Cone

07-0610: Battleground @ Cornwallis

07-0612: Battleground @ Pembroke

07-0613: Hill @ Wendover

07-0621: Groometown @ High Point

07-0623: High Point @ Vanstory

07-0649: Benbow @ Lee

07-0679: Sixteenth @ Summit

07-0720: Battleground @ Westridge

07-0846: Battleground @ Lawndale

07-0917: Clifton @ Wendover

07-0986: English @ Market

07-1171: Farmington @ High Point

07-1469: High Point @ Veasley

GBO-051: Battleground @ Bessemer

GBO-093: Aycock @ Walker

GBO-095: Aycock/Lovett @ Florida

GBO-161: Aycock/Westover @ Benjamin

GBO-170: Elm @ Northwood

GBO-203: Friendly @ Holden

GBO-205: Cornwallis @ Lawndale

GBO-239: Coliseum @ Florida

GBO-256: Bessemer @ English

GBO-335: Fernwood @ Lawndale

07-0624: Florida @ High Point

07-0657: Aycock @ Lee

07-0715: English @ Wendover

07-0826: Church @ Wendover

07-0890: Market @ Swing

07-0962: Chimney Rock @ Market

07-1073: Friendway @ Market

07-1239: Church @ Golden Gate

GBO-048: Battleground @ Benjamin

GBO-052: Bessemer @ Church

GBO-094: Aycock @ Spring Garden

GBO-102: Green Valley @ Westover

GBO-164: Elm-Eugene @ Meadowview

GBO-197: Friendly @ Green Valley

GBO-204: Friendly @ Westridge

GBO-209: Cone @ Yanceyville

GBO-253: Bessemer @ Lindsay

GBO-257: Bessemer @ Elm

At the following locations, reuse existing vehicle preemption equipment.

07-0189: Norwalk @ Wendover

07-0205: Battleground @ Martinsville

07-0362: I-40 WB Ramp @ Wendover

07-0569: I-40 EB On-Ramp @ Wendover

07-0588: Elm-Eugene @ I-40 WB Ramp

07-0194: Cone @ Summit

07-0285: Elm-Eugene @ I-40 EB Ramp

07-0563: High Point @ Pincroft

07-0579: Lindsay @ Wendover

07-0598: Edwardia @ Wendover

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07-0625: High Point @ Patterson	07-0646: Florida @ Freeman Mill
07-0702: Battleground @ New Garden	07-0703: New Garden @ Friendly
07-0725: College/Guilford College @ Market	07-0831: Chapman/Coliseum @ Lee
07-0851: Alamance Church/Patton @ MLK	07-0867: Dolley Madison @ Market
07-1035: Stanley @ Wendover	07-1036: Landmark Center @ Wendover
07-1269: Church @ Northwood	07-1324: Big Tree @ Wendover
07-1505: Coliseum @ Freeman Mill	07-1518: Bridford @ Wendover
07-1870: Tri-City @ Wendover	07-1944: Battleground @ Markland
GBO-017: Holden @ Vandalia	GBO-025: Lawndale @ Pisgah Church
GBO-136: Eugene @ Smith	GBO-156: Elm-Eugene @ J.J. Drive
GBO-158: Creek Ridge/Industrial @ Elm-Eugene	GBO-167: Elm-Eugene @ Florida
GBO-202: Friendly @ Hobbs	GBO-260: Bennett @ Gorrell

At the following locations with existing push-button preemption, furnish and install new DC isolators or other equipment necessary to preserve the existing functionality.

07-0209: High Point @ Merritt	07-0714: Gatewood @ Wendover
07-0865: Meadowood @ Wendover	07-0865: Meadowood @ Wendover
07-1018: Ballinger/New Garden @ Fleming	07-1302: High Point @ Romaine
GBO-162: Elm-Eugene @ Patton	GBO-194: Davie @ Washington

D. Railroad Preemption

Comply with the railroad preemption requirements detailed in **Section 1** of these Specifications. Furnish and install new preemption and blankout panel (Control Technologies part number 2299-101 or approved equivalent), hardware, harnesses, and wires as required to interface with new signal controller and cabinet. Inspect new railroad preemption in accord with the Standard Specifications and these Project Special Provisions. The Contractor shall perform all work necessary to ensure all railroad preemption functionality remains after installation of the new controller and cabinet.

E. School Flashers

At locations where existing signal controllers are operating school flasher signals, preserve the

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functionality with the new cabinet and controller. Furnish and install hardware and as required to interface operate the school flasher from the new cabinet/controller as approved by the Engineer. Program controller to provide flashing output according to a time of day, day of week, day of year schedule resident in the controller and modifiable via the central software. The following locations have existing signal controllers that operate school flashers.

Creekridge @ Four Seasons	Bessemer @ Yanceyville
Bessemer @ Huffine Mill	McConnell @ Willow
Westover @ Wendover	Bryan/Friendly Acres @ Westridge
Church @ Golden Gate	Lee @ Willow
Bessemer @ Huffine Mill	Benjamin @ Holden
Lake Brandt @ Lawndale	Westover @ Wendover
College @ Guida	Bessemer @ Franklin
English @ McConnell	Immanuel @ Merritt
Cornwallis @ Lawndale	Florida @ Hardie
Hobbs @ New Garden	Air Harbor @ Lake Brandt
Benjamin @ Campus	Lee @ Willow
Elam @ Market	Summit @ Textile
Cone @ Marston	Muir's Chapel @ Tower
Florida @ Hardie	Chapman @ Market
Alma Pinix @ Cone	Aycock @ Florida
Cone @ Summit	Groometown @ High Point
Holden @ Vanstory	Cornwallis @ Elm
Friendly @ Holden	Bennett @ Washington
Market @ Spring	Randleman @ Terrell

Install bollards as shown in the Details to protect equipment cabinet from knock down by vehicles.

23.4. MEASUREMENT AND PAYMENT

Equipment cabinet (____) will be measured and paid as the actual number of each type of equipment cabinet furnished, installed, and accepted. 90% of the payment will be made upon acceptance of the unit; 10% of the payment will be made following final acceptance of the integrated system (including completion of the 120 day observation period). All labor and materials to form a complete Equipment Cabinet including where called for provision of branch circuit, 120V/220V electrical service, traffic protection bollards, and Ethernet cabinet monitoring systems shall be considered incidental and not paid for separately.

Controllers with cabinets (____) will be measured and paid as the actual number of each type of controllers with cabinets furnished, installed, and accepted. 90% of the payment will be made upon acceptance of the unit; 10% of the payment will be made following final acceptance of the integrated system (including completion of the 120 day observation period).

Detector cards will be measured and paid as the actual number furnished, installed, and accepted.

No measurement or payment will be made of conflict monitors, grounding systems, AC/DC isolators, modems, preemption systems, school flasher integration and new hardware required to integrate school flasher, painting of cabinets, and generator connections, as these will be considered incidental to furnishing and installing controllers with cabinets.

No measurement or payment will be made of auxiliary output files, when needed, as these will be considered incidental to furnishing and installing controllers with cabinets. The Contractor shall anticipate that approximately 10% of the base-mounted cabinets to be installed under this project will require auxiliary output files.

Terminal splice box will be measured and paid as the actual number furnished, installed, and accepted.

No measurement or payment will be made of new riser assemblies and conduit needed to complete terminal splice boxes.

No measurement or payment will be made for developing cabinet prototypes, as that will be considered incidental to the installation of new cabinets.

Payment will be made under:

Equipment Cabinet (333 Base Mount)	Each
Controller with Cabinet (2070L, 332 Base Mount)	Each

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Controller with Cabinet (2070L, 336S Pole or Base Mount)	Each
Detector Card (Type 2070L).....	Each
Terminal Splice Box	Each

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24. ELECTRICAL SERVICE**24.1. DESCRIPTION**

Install new electrical service where required by the plans. Coordinate all work involving electrical service with the appropriate electrical utility company.

24.2. MATERIAL**A. General**

Material, equipment, and hardware furnished under this section must be pre-approved on the Department's QPL by the date of equipment installation.

Construct electrical service installations in accordance with the Standard Specifications. For locations shown on the Plans requiring new electrical service, provide a service that includes a new external service disconnect (breaker box) and a meter base. Run service cable(s) separately in 1" rigid metallic conduit (RMC). Do not allow the service conductors to share conduits with any other conductors or communications.

Provide an external electrical service disconnect at all new and existing cabinet locations shown on the plans. Provide a service disconnect with a single pole 50 ampere circuit breaker with a minimum of 10,000 RMS symmetrical amperes short circuit rating in a lockable NEMA 3R enclosure. Provide a ground bus and neutral bus with a minimum of four terminals with a minimum wire capacity of number 14 through number 4.

For pole mounted cabinets, mount the service on an existing pole as indicated in the Plans, and extend the service cables into the cabinet through a new 1" RMC.

Coordinate with utility company to ascertain the practicality of installing electrical service at each location before performing any work.

B. External Electrical Service Disconnect

Furnish external electrical service disconnects with a single pole 50 ampere circuit breaker with a minimum of 10,000 RMS symmetrical amperes short circuit current rating in a lockable NEMA 3R enclosure. Ensure service disconnects are UL listed and marked as being suitable for use as service equipment. Fabricate enclosure from galvanized steel and electrostatically apply dry powder paint finish, light gray in color, to yield a minimum thickness of 2.4 mils (60 µm). Provide ground bus and neutral bus with a minimum of four terminals with a minimum wire capacity range of number 14 through number 4.

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Furnish a NEMA Type 3R outdoor enclosure, 100 Ampere rated meter base for overhead electrical service or 200 Ampere rated meter base for underground electrical service. Furnish a 4 terminal, 600 volt, single phase, 3 wire meter base that complies with the following:

- Line, Load, and Neutral Terminals accept #8 to 2/0 AWG Copper/Aluminum wire
- Ringless Type without bypass
- Made of galvanized steel
- Meet the UL-414 standard
- Overhead and underground service entrance

Provide meter bases in which the ampere rating of the meter sockets are based on the meter sockets being wired with a minimum of 167 degrees F insulated wire. Ensure that the meter bases have an electrostatically applied dry powder paint finish, light gray in color, with a minimum thickness of 2.4 mils (60 μ m), unless otherwise called for in the Plans, Project Special Provisions, or as directed by the Engineer.

Furnish 1-inch watertight hub for threaded rigid conduit with meter base.

If meter base and electrical service disconnect are supplied in the same enclosure, ensure assembly is UL listed and marked as being suitable for use as service equipment.

24.3. CONSTRUCTION METHODS**A. Electrical Service**

At locations where new electrical service is to be installed on wood or metal poles, furnish and install electrical service as required by the Plans. After installation of the meter base, the utility company will transfer the existing meter or install a new meter if required and make any necessary connections to the power lines. Ground the new electrical service in accordance with Division 17 of the Standard Specifications and Standard Drawings.

Provide Engineer with a copy of all permits and final inspections if required.

B. Modify Existing Electrical Service

At locations shown in the Plans, modify electrical service to provide complete electrical service with external service disconnect that complies with the Standard Specifications and Drawings. After all required modifications are complete, each cabinet shall have its own power meter and electrical disconnect that are located on a pedestal or pole and not attached to the signal cabinet. Ensure that

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all connections between the power source, meter, disconnect, and signal cabinet are complete and grounded in accordance with these Project Special Provisions, the Standard Specifications, and the Plans.

C. External Electrical Service Disconnect

Furnish and install new external service disconnect (breaker box) of the type shown in the plans. Route the electrical service through the meter base and service disconnect to the controller cabinet to form a complete electrical service assembly as shown in the plans. Ensure that the existing grounding system for the existing service with the new service disconnect complies with the grounding requirements of these provisions and Division 17 of the Standard Specifications and Standard Drawings.

24.4. MEASUREMENT AND PAYMENT

Actual number of new electrical services furnished, installed and tested. Riser assemblies (1-inch), meter bases, service disconnects, underground and exposed conduit runs to the cabinet, acquisition of service fees, electrical service conductors, ground rod, ground wire and any remaining hardware and conduit to connect the electrical service to the cabinet are considered incidental to installing a new electrical service.

Actual number of modified electrical services, including service disconnects, furnished, installed, and integrated into an existing service to form a complete electrical service. Any electrical service conductors, remaining hardware and conduit to connect the electrical service to the cabinet are considered incidental to the service disconnects. No separate payment will be made for extending or replacing electrical service cable and conduits.

Payment will be made under:

New Electrical Service.....	Each
Modify Existing Electrical Service.....	Each

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25. SPREAD SPECTRUM WIRELESS RADIO**25.1. DESCRIPTION**

Furnish and install a spread spectrum wireless Ethernet radio system with all necessary hardware and signage in accordance with the plans and these Special Provisions to provide a data link between field devices (i.e. Traffic Signal Controllers). Provide a wireless Ethernet radio system with a bi-directional, full duplex communications channel between two “line-of-sight” antennas using license free, spread spectrum technology operating in the 902-928 MHz frequency band. Comply with the provisions of Section 1700 of the Standard Specifications.

Type A radio systems are defined as a single wireless signal transmitting to a single receiver along the fiber optic cable routing (1:1).

Type B radio systems are defined as two wireless signals transmitting to a single receiver (2:1).

Type C radio systems are defined as three wireless signals transmitting to a single receiver (3:1).

Type D radio systems are defined as four wireless signals transmitting to a single receiver (4:1).

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.

25.2. MATERIALS**A. 900MHz Wireless Ethernet Radio Systems**

Furnish license free 902 – 928 MHz radio modems with antennas, coaxial cable, mounting hardware, and configuration software. Design radio modems 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

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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 at up to 1.1 Mbps
- 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

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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 devices (i.e. controller) does not require any field device modifications with regards to hardware or software.

Furnish an ENCOM Model # COMMPAK IP Spread Spectrum Wireless Radio or an approved equivalent.

B. 900MHz Wireless Ethernet Repeater Standalone Radio System**B.1. General**

Furnish an operational 900MHz wireless repeater radio system installed in a NEMA Type 3R enclosure for pole mounting. As a minimum, ensure the 900MHz 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.

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 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.

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

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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 μ 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

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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.

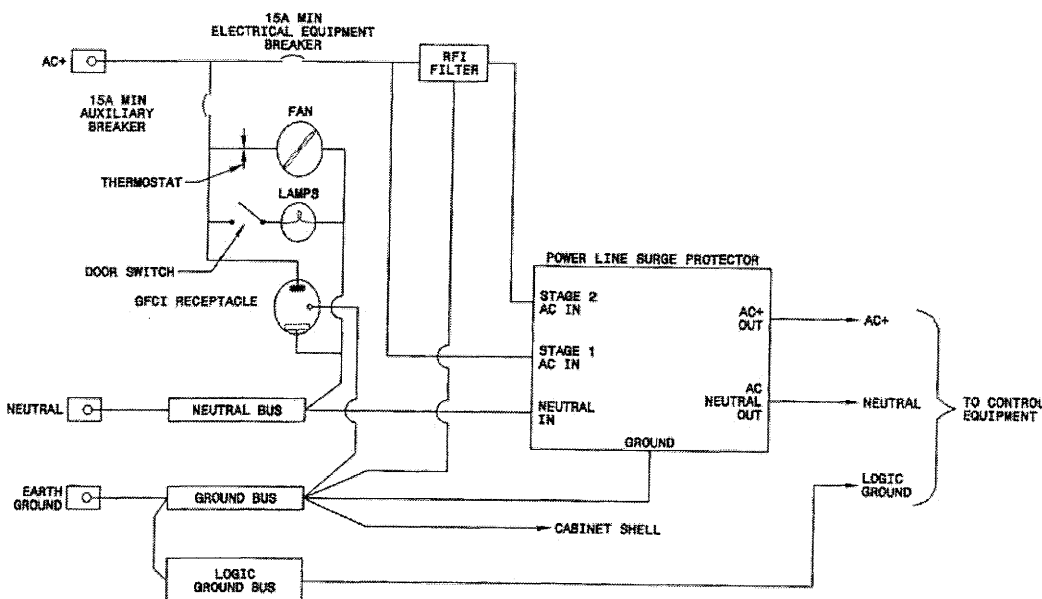
Furnish a fluorescent fixture with lamps mounted above the shelf to light the equipment area.

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:



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C. Software

Furnish units with a Microsoft Windows™ Based software program that uses a GUI (Graphical User Interface) to provide “remote programming, radio configuration, remote maintenance, diagnostics and spectrum analyzer” features. For compatibility with the ENCOM wireless radio or an approved equivalent wireless radio, provide ENCOM ControlPAK software or an approved equivalent software that is designed to function with the approved wireless radio. 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 controller, including 2070 controllers. Ensure the supplied software contains pre-written drivers for industry standard radar and video detection packages.

D. Directional Antenna (Yagi)

Furnish a directional antenna that will allow the system to function as designed. Furnish Cushcraft Model # PC906N (8.5 dB Gain) or Cushcraft Model # PC9013N (13 dB Gain) antenna or an approved equivalent antenna that meets the following minimum specifications:

Cushcraft Model # PC906N (8.5 dB Gain)

Frequency Range	896 – 940MHz
Nominal Gain	8.5 dB
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 ohms
Length	24”
Rated Wind Velocity	125 mph
Rated Wind Velocity (with 0.5 inch radial ice)	100 mph
Projected Wind Surface Area (flat plane equivalent)	0.26 ftsq.

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Number Elements	6
Allows for Vertical or Horizontal polarization	
Minimum separation distance from persons installing and using an active device	9" (230 mm)
Minimum separation distance from other RF sources including radios and antennas	6.5' (2 m)
Welded construction	

Cushcraft Model # PC9013N (13 dB Gain)

Frequency Range	902 – 928 MHz
Nominal Gain	13 dB
Front to Back Ratio	20 dB
Horizontal Beamwidth (at half power points)	40 degree
Vertical Beamwidth (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 ohms
Length	53" (1346 mm)
Rated Wind Velocity	125 mph
Rated Wind Velocity (with 0.5 inch radial ice)	100 mph
Projected Wind Surface Area (flat plane equivalent)	0.46 ftsq.
Number Elements	13
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 to secure the antenna to the metal pole or wood pole, as

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recommended by the manufacturer of the antenna and as approved by the Engineer.

E. Omni Directional Antenna

Furnish an omni directional antenna that will allow the system to function as designed. Furnish 3dB Antenex Model # FG9023 or 6 dB Antenex Model # FG9026 antenna or approved equivalent antennas that meet the following minimum specifications:

Frequency Range	902 – 928 MHz
Nominal Gain	Typical gains of 3 or 6 dB (dependent upon gain needed for application)
Termination	Standard N-Type Female Connector
Impedance	50 ohms
VSWR	1.5:1
Vertical Beam Width	3 dB – 33 degrees; 6 dB – 17 degrees
Lightening Protection	DC Ground
Power Rating, UHF Frequency	100 Watts
Length	3 dB – 25”; 6 dB – 65”
Rated Wind Velocity	125 mph
Solid, single piece construction	
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’
Mount in a vertical direction and limit to vertically polarized RF systems	

Furnish mounting hardware to secure the antenna to the metal pole or wood pole, as recommended by the manufacturer of the antenna and as approved by the Engineer.

F. Coaxial Cable

Furnish a Times Microwave Systems™ LMR 400 Cable or ANDREW CNT-400 Cinta™ Braided Cable, or equivalent antenna coaxial cable to provide a link between the antenna and the lightning arrestor that meets the following minimum specifications:

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Attenuation (dB per 100 feet) @ 900MHz	3.9 dB
Power Rating @ 900MHz	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

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 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: $0.1 \times \sqrt{Fghz}$
- VSWR: 1.25:1 (max) up to 3GHz

Provide instructions on properly installing the connector.

H. Coaxial Cable Shield Grounding and Weatherproofing Kits:

Furnish a Coaxial Cable Shield Grounding Kit containing components that will adequately bond

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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 inches wide by 20 inches long (approximately)
- Instructions on properly installing the weatherproofing system

I. 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 lightning arrestor or an approved equivalent that meets the following minimum specifications:

- Surge: 20kA, 800MHz to 2.0 GHz $\leq 1.1 : 1$ VSWR
18kA, 800MHz to 2.3 GHz $\leq 1.1 : 1$ VSWR
700MHz to 2.7 GHz $\leq 1.2 : 1$ VSWR
- Insertion Loss: ≤ 0.1 dB over frequency range
- Max Power: 500 w @ 920MHz (750 W @ 122° F)
- RF Power: 300 Watts
- Let Through Voltage: $\leq \pm 3$ Volts for 3kA @ 8/20 μ s Waveform
- Throughput energy: ≤ 0.5 μ J for 3 kA @ 8/20 μ s Waveform
- Temperature: -40 to 185° F Storage/Operating 122° F
- Vibration: 1G at 5 Hz up to 100 Hz
- Unit Impedance: 50 Ω
- VSWR: 1.1:1

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- 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

J. Disconnect Switch

Furnish a double pole, single throw snap switch in a weatherproof outlet box with cover. Outlet box and cover shall be capable of supporting a lockout tag device. Outlet box and cover shall be suitable for use in wet locations. Outlet box have one (1) ½-inch hole in back of box. Furnish mounting hardware, sealing gaskets and lockout tag.

K. Warning Signs(s) and Decal(s)

Furnish 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 to the pole using 'Band-It' brackets or a method approved by the engineer.

25.3. CONSTRUCTION METHOD**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. 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 an antenna splitter cable 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 National Electrical Safety Code) 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 make 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 that 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.

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 install a double pole, snap switch to remove power from the spread spectrum wireless 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 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.

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

D. Warning Sign(s) and Decal(s)

Secure 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.

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.

25.4. WARRANTY

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

25.5. MEASUREMENT AND PAYMENT

Actual number of 900MHz wireless radio systems of each type and antenna(s) furnished, installed and accepted. This item includes the appropriate antenna, coaxial cable, splitter cable, coaxial cable shield grounding system with weatherproofing, lightning arrestor, labeling and any integration between the wireless radio system and a fiber optic network if necessary.

All power supplies, power cords, adapters, antenna mounting hardware, connectors, serial cables, signs, decals, disconnect switches, installation materials and configuration software necessary to complete this work, including the radio path Site Survey test and warranties, will be incidental. Final payment will be made when work is accepted by the Engineer. Riser assemblies will be paid for separately.

Actual number of 900MHz wireless repeater standalone radio systems furnished, installed and accepted. This item includes the cabinet, antenna(s) and mounting hardware, coaxial cable, splitter cable, coaxial cable shield grounding system with weatherproofing, lightning arrestor, signs, decals, disconnect switches, installation materials, configuration software, the radio path Site Survey test and warranties. Final payment will be made when work is accepted by the Engineer. Riser assemblies will be paid for separately.

Payment will be made under:

900MHz Wireless Radio System, Type A.....	Each
900MHz Wireless Radio System, Type B.....	Each
900MHz Wireless Radio System, Type C.....	Each
900MHz Wireless Radio System, Type D.....	Each
900MHz Wireless Repeater Standalone Radio System.....	Each

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26. WI-FI NETWORK EQUIPMENT**26.1. DESCRIPTION**

Furnish and install Wi-Fi mesh network access points unit for expanding the coverage area of the City's MIS network.

All work shall be performed by a Cisco-certified wireless network technician.

26.2. MATERIALS

For compatibility with existing equipment, furnish Cisco Aironet 1522 ,Outdoor Mesh Access Points.

Furnish dual-radio Wi-Fi access points that are suitable for outdoor installations and conform to the following minimum wireless standards, data rates, frequency bands, and operating channels.

- IEEE 802.11a: 54, 48, 36, 24, 18, 12, 9, and 6 Mbps with Orthogonal Frequency Division Multiplexing (OFDM), 5.725-5.850 GHz with 5 channels, 4.940-4.990 GHz with 2 channels
- IEEE 802.11b: 11, 5.5, 2, and 1 Mbps with Direct Sequence Spread Spectrum (DSSS), 2.412-2.462 GHz with 11 channels
- IEEE 802.11g: 54, 48, 36, 24, 18, 12, 9, and 6 Mbps with OFDM, 2.412-2.462 GHz with 11 channels

Furnish Wi-Fi access points with wireless access and mesh security features.

- X.509 digital certificates
- MAC address authentication
- Hardware-assisted AES encryption
- IEEE 802.11i
- IEEE 802.1X authentication, including EAP-SIM, EAP-PEAP, EAP-TLS, EAP-TTLS, Cisco LEAP
- Hardware-assisted AES, WPA, TKIP-MIC encryption
- VPN pass-through
- IP Security (IPsec), Layer 2 Tunneling Protocol (L2TP)
- MAC address filtering

Furnish Wi-Fi access points that conform to NEMA 4X environmental ratings.

Provide power to access points using DC power in accord with unit requirements. Provide step down transformer and appropriate gauge cable to power unit at the amperage and voltage called for

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by the unit manufacturer.

26.3. CONSTRUCTION METHODS

Install and integrate Wi-Fi access points according to manufacturer’s requirements and recommendation. Installation and configuration must be performed by a Cisco-certified technician.

26.4. MEASUREMENT AND PAYMENT

Wi-Fi Access Point will be measured and paid as the actual number of units furnished, installed, and accepted.

Wi-Fi Access Point Power Cable will be measured and paid for as linear feet of Wi-Fi Power cable furnished, installed, integrated with WI-FI access points and power distribution assemblies, and accepted. No measurement will be made for terminating and testing of cable, cable labels, and grounding and surge suppression as these will be considered incidental to the installation of the Wi-Fi Access Point Power Cable.

No measurement or payment will be made of mounting equipment, power transformers, antennas, use of a Cisco Certified Technician, and grounding equipment, as this will be considered incidental to furnishing and installing the units.

Payment will be made under:

Wi-Fi Access Point	Each
Wi-Fi Access Point Power Cable.....	Feet

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27. CCTV FIELD EQUIPMENT**27.1. DESCRIPTION**

Furnish and install new CCTV cameras, cabinets, poles, field video encoder (CODEC) units and camera control equipment at locations shown in the Plans.

Integrate existing CCTV cameras with new CODEC units and new communications network.

27.2. MATERIALS**A. General**

Furnish and install, at the locations shown on the Plans, new CCTV camera assemblies. CCTV camera assembly includes camera, lens, housing, pan and tilt unit, pole mounting adapter, camera controller receiver/driver, and camera cabling.

Furnish Pelco Spectra III/Spectra IV high performance dome equipment or approved equivalent.

B. Camera and Lens**B.1. Cameras**

Furnish new charged coupled device (CCD) color cameras. The cameras shall provide automatic gain control (AGC) for clear images in varying light levels. The cameras shall meet the following minimum requirements:

- Video signal format: NTSC composite color video output, 1 volt peak to peak
- Automatic Gain Control (AGC): 0-20 dB, peak-average adjustable
- Automatic focus: Automatic with manual override
- White balance: Automatic through the lens and manual adjustable from remote controller.
- Electronic-Shutter: dip-switch selectable electronic shutter with speed range from 1/60 of a second (off) to 1/30,000 of a second
- Overexposure protection: The camera shall have built-in circuitry or a protection device to prevent any damage to the camera when pointed at strong light sources, including the sun
- Sensitivity: 1.5 lux at 90% scene reflectance
- Signal to noise ratio: Greater than 48-dB

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- Video output Connection: 1-volt peak to peak, 75 ohms terminated, BNC connector
- Power: 24 VAC or less

B.2. Zoom Lens

Furnish each camera with a motorized zoom lens with automatic iris control with manual override and neutral density spot filter. Furnish lenses that meet the following optical specifications:

- Focal length: 0.16" – 3.45", 22X optical zoom, 8X electronic zoom
- Preset positioning: 64 Presets

The lens shall be capable of both automatic and remote manual control iris and focus override operation. The lens shall be equipped for remote control of zoom and focus, including automatic movement to any of the preset zoom and focus positions. Mechanical or electrical means shall be provided to protect the motors from overrunning in extreme positions. The operating voltages of the lens shall be compatible with the outputs of the camera control.

C. Camera Housing

Furnish new dome style enclosure for the CCTV assemblies. Equip each housing with mounting assembly for attachment to the CCTV camera pole. The enclosures shall be equipped with a sunshield and be fabricated from corrosion resistant aluminum and finished in a neutral color of weather resistant enamel. The enclosure shall meet or exceed NEMA 4X ratings. The viewing area of the enclosure shall be tempered glass.

D. Pan and Tilt Unit

Each new dome style assembly shall be equipped with a pan and tilt unit. The pan and tilt unit shall be rated for outdoor operation, provide dynamic braking for instantaneous stopping, prevent drift, and have minimum backlash. The pan and tilt units shall meet or exceed the following specifications:

- Pan: continuous 360 Degrees
- Tilt: up/down 180 degrees minimum
- Input voltage: 24 VAC 50/60 Hz
- Motors: Two phase induction type, continuous duty, instantaneous reversing
- Preset Positioning: 64 PTZ presets per camera

E. Control Receiver/Driver

Each new camera unit shall contain control receiver/driver that are integral to the CCTV dome

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assembly. The control receiver/driver shall receive serial asynchronous data initiated from a camera control unit, decode the command data, perform error checking, and drive the pan/tilt unit, camera controls, and motorized lens. As a minimum, the control receiver/drivers shall provide the following functions:

- Zoom in/out
- Automatic focus with manual override
- Tilt up/down
- Automatic iris with manual override
- Pan right/left
- Minimum 64 preset positions for pan, tilt, and zoom

In addition, each control receiver/driver shall accept status information from pan/tilt unit and motorized lens for preset positioning of those components. The control receiver/driver shall relay pan, tilt, zoom, and focus positions from the field to remote camera control units. The control receiver/driver shall accept “goto” preset commands from the camera control unit, decode the command data, perform error checking, and drive the pan/tilt and motorized zoom lens to the correct preset position. The preset commands from the camera control unit will consist of unique values for the desired pan, tilt, zoom, and focus positions.

F. CCTV Test Panel

Equip each cabinet (Equipment or Traffic Signal Controller) where new CCTV unified cabling terminates with CCTV unit test panel with a null modem adaptor. The test panel shall have a BNC port and a serial port. The BNC port shall allow for a test monitor to be plugged into the panel and NTSC video from the CCTV unit to be viewed from a monitor with a standard coaxial video cable. The serial port shall be equipped with a null modem adapter such that a notebook computer with CCTV unit vendor provided CCTV control software or a CCTV vendor provided joystick may be plugged into it and all CCTV control functionality available in the unit may be performed in the same fashion as if the user were located at the CCTV video head end at the TOC.

G. CCTV Unified Cable

- Furnish cable for connection to CCTV unit that contains CCTV serial wires and cables, CCTV coaxial video cable, and CCTV power wire and cable in a signal cable jacket that is rated for outdoor use. Furnish cable that is rated to meet outdoor temperature, water

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blocking, ultraviolet and insulation characteristics of Belden CM FT1 family of Cables, part number 5339W5. Furnish cable that prevents cross-talk and RFI/EFI between conductors. Furnish cable that uses standard connections on both ends that are compatible with the equipment to which it will be connected. Furnish coaxial cable that meets or exceeds Belden part number 5339W5 (RG-6 type, AWG 18). Furnish serial connections and power connections of the conductor size that operate with voltage drop and signal loss characteristics required for the equipment being connected.

H. CCTV Camera Attachment to Pole

At locations shown in the Plans where new CCTV cameras are to be installed on new CCTV poles, design, fabricate, and furnish an attachment assembly for the CCTV camera unit. Use stainless steel banding approved by the Engineer for attachment.

Furnish CCTV attachment to pole via the stainless steel banding that allows for the removal and replacement of the CCTV enclosure as well as providing a weatherproof, weather tight, seal that does not allow moisture to enter the enclosure.

Furnish CCTV Camera Attachment Assembly that is able to withstand a wind load of 80 miles per hour (mph) with a 30 percent gust factor and can support a minimum camera unit dead load of 45 pounds.

I. Surge Suppression

All equipment at the top of the pole shall be protected by grounded metal oxide varistors connecting each power conductor to ground.

Coaxial cable from each camera shall be protected by a surge protector equal to Vicon V15LP, at each end of the cable.

J. Field Video CODEC Unit

Furnish a field-hardened video encoder designed for unheated/uncooled "outdoor" applications such as roadside control cabinets. The video encoder shall be installed in pole mounted equipment cabinet or traffic signal controller cabinets and shall allow for the encoding and transmission of analog NTSC video signals from existing City of Greensboro CCTV cameras as identified on the Plans as well as new CCTV units that will be provided under this Project.

Furnish a shelf-mountable, field-hardened video encoder to convert analog NTSC video signals into two digital video streams that can be transported over Ethernet. The video encoder shall allow for the simultaneous encoding and transmission of the two digital video streams - one in MPEG-2 or MPEG-4 format (high-resolution) and one in MPEG-4 format (low-resolution). High resolution

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streams shall allow video bit rates from 1 to 4 Mbps and the low resolution stream shall allow video bit rates from 64 kbps to 2 Mbps. The Contractor shall initially configure these formats for 2 Mbps and 384kbps, respectively. The video encoder shall also transmit pan-tilt-zoom control data from all CCTV control points to the CCTV camera via a serial connection to the CCTV camera resident on the CODEC.

The video encoder shall support the following digital transport standards at a minimum: RTP/IP, UDP/IP, TCP/IP, and unicast/multicast IP. The Contractor shall initially use UDP/IP for video transport and TCP/IP for camera control transport unless otherwise approved by the Engineer.

The video shall support resolutions of CIF (352 (H) x 240 (V)), 1/2 D1 (352 (H) x 480 (V)), and D1 (720 (H) x 480 (V)) at a minimum. The video encoder units shall provide a display showing diagnostic data such as data rate, quality level, frame rate, and video status on the front panel. All supporting user interface software shall be provided with each encoder unit.

The video encoder shall be equipped with at least one NTSC video input, two RS-232/422 serial ports and one 10/100BaseTX Ethernet port. The 10/100BaseTX port shall support half-duplex or full-duplex and provide auto negotiation, and shall be initially configured for full-duplex.

The video encoder shall be remotely manageable using standard network applications such as telnet, SNMP monitors, and/or web interface administration. The video encoder shall be equipped with LED or other approved indicators for the following functions:

Power

Link

Activity

Speed (10/100 Mbps) Cameras

J.1. Electrical Requirements

The video encoder shall operate from 115 VAC (+/-10%) power at 60 Hz. The Contractor shall furnish any external step down transformers, power converters, and/or regulation equipment needed to operate the video encoder.

J.2. Physical and Environmental Requirements

The video encoder enclosure shall be constructed of high-strength galvanized steel. For Contractor-supplied cameras, the video encoder shall be installed in equipment cabinets or traffic signal controller cabinets and secured to the cabinet in a manner that is approved by the Engineer.

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The video encoder enclosure, including adapters/connectors, shall fit neatly within the confines of the equipment cabinet or traffic signal controller cabinet. All necessary mounting hardware shall be provided by the Contractor.

The video encoder shall meet or exceed NEMA TS-2 requirements for shock, temperature, humidity, and vibration. The video encoder shall operate at ambient temperatures from -40° to 185° F (-40° to 85° C) and ambient relative humidity from 0% to 90% (non-condensing). No cooling airflow shall be required.

J.3. Communication Interface Requirements

The video encoder shall comply with the 10/100BaseTX standard and have at least one standard RJ-45 interface. The 10/100BaseTX port shall operate as half-duplex or full-duplex and provide auto negotiation.

The video encoder shall have at least one video input that supports composite NTSC format compatible with the CCTV video interface cables. Interconnection with the NTSC video input shall be made with a surge protector that provides an external electrical ground bonding capability and does not require an electrical receptacle. The CCTV coaxial surge protector shall provide a clamping voltage no greater than 30 volts.

The video encoder shall have at least two serial ports – one for pan-tilt-zoom camera control and the other for local maintenance or data transport. The two serial ports shall support RS-232 and RS-422 data transmission and shall be transparent to the central system using TCP/IP network access methods. Interconnection with camera control receivers with or without adapters or converters (i.e. RS-422/232 for compatibility with CCTVs) shall provide opto-isolated surge suppression. The optical isolation shall provide an isolation of no greater than 2000 VAC for data signals and ground.

J.4. Cables and Connectors

The Contractor shall furnish and install all cables and connectors necessary for video encoder installation. This shall include at a minimum CAT 5E cables with RJ-45 connectors to connect the Video Encoder to the Field Ethernet Switch in the equipment cabinet or traffic controller cabinet and standard serial data cables to connect the Video Encoder to the CCTV camera for pan-tilt-zoom functions and local configuration administration.

K. Pole Mounted CCTV Equipment Cabinet

Furnish pole mounted 336 stretch cabinet as initially described in **Section 23** of these Project Special Provisions. Furnish and install only those accessories related to PDA and grounding system.

L. Cabinet Prototype

The Contractor shall develop a cabinet prototype to show how all hardware and associated cabling called for in these project special provisions will be installed and configured in the field. The cabinet prototype shall be approved by the Engineer prior to any cabinet installations begin.

Do not furnish any other cabinet accessories listed in **Section 23**.

27.3. CONSTRUCTION METHODS**A. General**

Install CCTV assemblies at locations as shown in the Plans and in the diagrams on the following pages.

Mount CCTV camera units at 40 feet above ground level on new poles. At existing poles, mount CCTV unit at highest location in the pole communications space meeting NESC requirements.

Mount CCTV camera on side of pole nearest intended field of view and avoid occluding the view with the pole. Use banding or other method approved by the Engineer to fasten CCTV camera to pole.

Electrically bond each camera and pan/tilt/zoom mechanism and its housing to the CCTV camera attachment assembly using a number 6 AWG braided copper conductor.

B. Electrical and Mechanical Requirements

Ground all equipment as called for in the Standard Specifications, these Project Special Provisions, and the Plans.

Install surge protectors on all ungrounded conductors entering the CCTV enclosure. House the protectors in a small, ventilated weatherproof cabinet attached near the CCTV attachment point in a manner approved by the Engineer. The air terminal ground wire shall not pass through this cabinet.

Install coaxial cable as required to interconnect video encoders with the CCTV units. Insure that all connections are tight and fully secure.

C. Pole Mounted CCTV Equipment Cabinet

Use banding or other method approved by the Engineer to fasten CCTV cabinet to pole.

Install all conduit, condulets, and attachments to equipment cabinets in a manner that preserves the minimum bending radius of the fiber optic cable and creates water proof connections and seals.

At each new CCTV cabinet where fiber optic cable is routed, coil a minimum of 20 feet of fiber optic cable in the cabinet as shown in the Plans.

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D. Field Video CODEC Unit

At locations where the field Video CODEC unit is called for installation into new pole mounted equipment cabinet or traffic signal controller cabinets, integrate field CODEC with Ethernet switch, CCTV assembly, CCTV test panel, power distribution assembly, and surge protection. Ground and provide electrical transient protection to the CODEC in accord with these Project Special Provisions and the CODEC manufactures requirements. Prior to delivery of the Video Encoder, the Contractor shall provide a factory acceptance certificate demonstrating that the Video Encoder has been successfully bench tested by the manufacturer or an independently-certified test lab.

27.4. MEASUREMENT AND PAYMENT

CCTV Assembly will be measured and paid for as the actual number of assemblies furnished, installed, integrated, and accepted. No separate measurement will be made for cabling (with the exception of unified cables as discussed below), connectors, CCTV camera attachment assemblies, conduit, condulets, grounding equipment, CCTV camera enclosures, surge protectors, or any other equipment or labor required to install the CCTV assembly. The assembly includes the CCTV Camera unit, housing, pan and tilt unit, controller/receiver unit, CCTV Test Panel, and all associated cabling, configuration, integration and labor to furnish and install the assembly. CCTV poles for mounting of CCTV assemblies shall be paid for under the Wood Pole item (**Section 6**) and Metal Pole item (**Section 7**).

Pole Mounted CCTV Equipment Cabinet will be measured and paid for as the actual number of pole mounted CCTV cabinets furnished, installed, integrated, and accepted. No measurement will be made of all required system interconnection, surge protection, and grounding systems as this will be considered incidental to furnishing and installing CCTV cabinet. No measurement or payment will be made for developing cabinet prototypes, as that will be considered incidental to the installation of new cabinets.

CCTV Unified Cable will be measured and paid for as the actual linear feet of unified coaxial cable furnish, installed, integrated, and accepted.

Field Video CODEC will be measured and paid for as the actual number of units, furnished, installed, integrated, and accepted. All cabling, integration, and configuration required to install the field video CODEC unit shall be incidental and not be paid for separately.

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Payment will be made under:

CCTV Assembly	Each
Pole Mounted CCTV Equipment Cabinet	Each
CCTV Unified Cable	Linear Feet
Field Video Codec Unit	Each

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28. SYSTEM SOFTWARE

28.1. DESCRIPTION

Furnish, install, and fully integrate local controller software on the new and existing signal controllers. Furnish local software that is fully operable with the central software using Ethernet/IP-based communication protocols

Furnish, install, and fully integrate new central signal system software on new and existing computer hardware to form the Greensboro signal system with the head-end and main operations at the TOC to be housed at the Melvin Municipal Office Building located at 300 West Washington Street.

. Furnish, install, and fully integrate system support software on new and existing computer hardware as called for.

Under this project, signal system central software will be installed on server computers furnished via the City of Greensboro as described in **Section 29** of these Project Special Provisions. Signal System client software will be installed on laptop computers and workstation computers furnished via the City of Greensboro as described in **Section 29** of these Project Special Provisions and on existing workstation computers and laptop computers within the City of Greensboro and at NCDOT Division and Central Offices.

The table below indicates the location and type of computer (newly furnished via the City of Greensboro or existing) where the signal system central software is required to be installed.

Location	New Workstation Computer Furnished via City of Greensboro	Existing Workstation Computer	New Laptop Computer Furnished via City of Greensboro	Existing Laptop Computer
Greensboro Traffic Operations Center Computer Room	1			
Greensboro Traffic Operations Center	2			4

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Location	New Workstation Computer Furnished via City of Greensboro	Existing Workstation Computer	New Laptop Computer Furnished via City of Greensboro	Existing Laptop Computer
Greensboro Traffic Operations Center Office	2			
Justice Drug Complex	1			
City of Greensboro Signal Shop	2		4	10
City of Greensboro Offices		7		
NCDOT Division 7 Offices		1		
NCDOT Traffic Engineering Branch Office in Garner, NC		1		

28.2. SELECTION OF SYSTEM SOFTWARE

The Department and City of Greensboro have researched, visited, and bench tested the available distributed processing signal system and local controller software packages. The following (in alphabetical order by vendor) specific central/local software packages have been pre-qualified for use on this project:

Naztec – ATMS.NOW and Apogee

Siemens – ACTRA and SEPAC

TransCore – TransSuite and ASC/2070

The distributed processing signal system software and local controller software to be furnished, installed, and integrated by the Contractor shall be one of these three packages and meet the

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functional requirements listed below. The Contractor may not “mix and match” the local and central software offering listed above. The most recent software release available at the date of letting shall be the version implemented. No other software packages may be proposed for use by the Contractor.

A representative from the software provider (both central software and local software) must be onsite during the installation and integration of the Central Software, and integration of the system communications network with the central hardware and the burn-in of local controller hardware. A representative of the software provider(s) must be present during the subsystem and component testing of those components related to the central and local hardware and software. A representative of the software provider(s) must be present during the system acceptance test. A representative of the software provider(s) must be available to perform site visits, assist with trouble shooting, and to maintain and debug software and address communications network/hardware issues in person, throughout the life of the project and through final acceptance.

28.3. FUNCTIONAL REQUIREMENTS

The following defines a series of functional requirements which the system must support. As part of the system test development called for in these Project Special Provisions, the Contractor shall be responsible for insuring all software functionality and all software functional requirements are tested and verified. The Contractor shall be responsible for furnishing all equipment that may be necessary to demonstrate conformance with these requirements. When available, equipment furnished and installed as a part of this Contract may be used.

The proposed system shall be highly reliable and low-maintenance (R 100).

- (FR 101) The central and local software shall utilize the standard NCDOT cabinet/controller architecture, including model 170 cabinets and NCDOT 2070 controllers, and fully comply with the controller functions defined in the NEMA Standards Publication for TS-2 Traffic Controller Assemblies.
- (FR 102) The central software and server hardware shall be integrated with an uninterruptible power supply (UPS) that detects power outages and allows for the orderly shutdown of the system, or transfer to backup power. The system shall be brought back online automatically when primary power is restored.
- (FR 103) The central software shall provide for redundancy functions so that field units and central databases are compared on a regular basis and upon modification to ensure data integrity.
- (FR 104) The central software shall provide for redundancy functions so that duplicate

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servers are backed up.

- (FR 105) The central software shall support a multi-level security system that controls access to the system. The user's capabilities shall range from view only to total system control depending on the privileges granted from the password assigned to an individual or agency.
- (FR 106) The central software shall support paging with system codes or text messaging for alarm levels selected by the user. The paging functionality shall facilitate the rollover to additional staff if the first staff member paged does not respond in a user-defined timeout period.
- (FR 107) The central software shall monitor and return status information on all local detectors, system detectors, controllers (flash, free, coordination, etc.), and communication status. The central software shall notify operators by message or alarm in the event of equipment malfunction.

The proposed system shall be easy to interface with commercial off-the-shelf operating systems and productivity software (R 200).

- (FR 201) The central software shall have a user-friendly, Microsoft Windows™-based graphical user interface with standard Windows drag and drop menus, and "cut and paste" data exchange between the system software and other Windows applications.
- (FR 202) The central software shall have a GIS-based system map in a coordinate system utilized by the City. The map shall allow the user to zoom in to reveal additional system, sub-system, corridor, and intersection data at user established graphical zoom levels.
- (FR 203) The central software shall have a database that is compatible with standard formats, such as SQL and XML formats.
- (FR 204) The central software shall support inputs from external sources, such as GPS antennas, for time management and synchronization functions.
- (FR 205) The central software shall allow for the direct import/export of controller and system data in UTDF format.
- (FR 206) The central software shall support import capabilities to allow for the direct import of signal timing data generated by signal timing models (such as Synchro and TS/PP-Draft) directly into online signal timing sheets for upload into controller

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databases.

- (FR 207) The central software shall support the download of controller timing parameter databases into a format that allows for their direct export into signal timing modeling software, such as Synchro and TS/PP-Draft.
- (FR 208) The central software shall allow intersection schematics in Windows Enhanced Metafile format.

The proposed system shall be scaleable to meet the City's current and future needs (R 300).

- (FR 301) The central software shall support at least 750 traffic signals.

The proposed system shall have local controllers and cabinets capable of supporting and the traffic control functionality described following (R 400).

- (FR 401) The local controller software shall support a minimum of twelve vehicle phases and a minimum of twelve pedestrian phases. This shall include functions for lead, lag, exclusive, and sequential phases.
- (FR 402) The local controller software shall support a minimum of four pedestrian overlaps and a minimum of eight vehicle overlaps.
- (FR 403) The local controller software shall support a minimum of 32 vehicle detectors with functionality that can recognize single-lane detector data, system detector data, and can calculate vehicle occupancy, volume, and speed. The local controller software shall support a minimum of twelve pedestrian detectors.
- (FR 404) The local controller software shall support a minimum of ten vehicle pre-emption inputs with at least three different priority levels.
- (FR 405) The local controller software shall support inputs from GPS units for time-based coordination for intersections that may not have interconnect installed under this project.
- (FR 406) The local controller software shall support IEEE 802.3 10BASE-T Ethernet/IP direct connections and serial data connections.
- (FR 407) The local controller software shall support signal indications such as four-section/flashing arrow protective/permissive left turn heads.
- (FR 408) The local controller software shall support the integration of advance beacon control and other flashing output.

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- (FR 409) The local controller software shall include time-based coordination (TBC) capability for back-up system control that is internal to each local controller.
- (FR 410) The local controller software shall support the use of a data key for storage of controller database.
- (FR 411) The central software and local controller software shall account for revised Daylight Savings hours.
- (FR 412) The local controller software shall have user programmable dates for Daylight Savings time.
- (FR 413) The local controller software shall support special function output.
- (FR 414) The local controller software shall have the ability to map inputs and outputs in software (functionality available in NEMA TS-2 Type 1 and 170 cabinet/controller architectures) and support internal logic control functions.
- (FR 415) The local controller shall write intersection configuration information to permanent flash memory for retrieval through keypad entry by field technicians.

The proposed system shall have a central software system able to support existing and additional functionality (R 500).

- (FR 501) The central software shall support the modification and regrouping of intersections into different subgroups for timing control boundaries, reporting, and system actions (such as group flash) by time of day, scheduler initiation, or user intervention through the graphical interface.
- (FR 502) The central software shall support a minimum of 200 system-initiated or schedule-initiated events that are routine (hourly, daily, weekly, monthly, or annually) or one time.
- (FR 503) The central software shall support traffic responsive operation and provide a smooth (greater than a 2 cycle) transition from one timing plan to another.
- (FR 504) The central software shall support simultaneous control of multiple control zones with each having different control modes and timing plans (cycle length, offset, and split). Coordination shall be possible between adjacent control zones or subsystems.
- (FR 505) The central software shall support flash/free control operation.

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- (FR 506) The central software shall be able to start up and shut down computer control with minimum disruption to traffic flow.
- (FR 507) The central software shall support the upload and download of intersection control parameters and controller features.
- (FR 508) The central software database shall be structured so that system monitoring data, such as speed and volumes from system detector stations, may be accessed and archived in a manner useful for real time publication to World Wide Web advanced traveler information system Web sites.
- (FR 511) The central software and local controller software shall support NTCIP communications protocols or have an identifiable path to implement NTCIP protocols in the system as a future upgrade.

The proposed system shall be able to support advanced communication topologies as well as multiple different topologies (R 800).

- (FR 801) The central software shall support IP/Ethernet communications between the central application servers and field devices, including signal controllers and CCTV cameras.
- (FR 802) The central software shall support telephone line communications between the central applications servers and field devices with both broadband (T-1) and narrowband (dial-up) communications.
- (FR 803) The central software shall support wireless radio communications at the ends of the communications cable routing.
- (FR 804) The central software shall support access via the City of Greensboro Citrix Remote computing platform.
- (FR 805) The central software shall support access via City of Greensboro Virtual Private Networking (VPN) network connections.

28.4. MATERIALS**A. General****A.1. System Software Simultaneous Requirements**

The system software shall be compatible with the Ethernet network and remote access

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communications environment being furnished under this project. The system software shall allow for a minimum of twenty-four (24) simultaneous LAN users. These users may be directly connected to the LAN or connected via a secure, encrypted, virtual private network connection (VPN) connection. In addition, the system software shall support up to 8 users connected via the City of Greensboro's Citrix™, remote access connection(s) and/or via dial-up connection. Depending on security level an operator may have up to full access for system control, database entry/examination, malfunction diagnosis, system operation evaluation, and measures of effectiveness analysis. Access by a particular user to a particular command shall be allowed or disallowed based upon that user's assigned security level.

The project communications network is further discussed in **Section 30** of these Project Special Provisions.

A.2. Software License

Provide a perpetual, irrevocable software license to the Department and the City of Greensboro that gives them the right to copy and use the distributed processing signal system software furnished with this project at any facility within the City of Greensboro signal system limits or at any other offices in the State of North Carolina that the City and State, or their authorized agent, may establish for the purpose of traffic signal monitoring and control in the Greensboro signal system jurisdictional area.

Furnish software modifications necessary for system operation as per this Project Special Provision to the agency at no additional cost during the warranty period.

For any software functionality that is specifically developed for this project, the software developer shall provide hardcopy and digital copies of the un-compiled source code of the software. This source code must be fully documented and commented, so that an experienced programmer/developer (3 plus years) in the language(s) that the software is written may interpret, modify, and debug the code. The required software compilers shall be specifically and clearly identified and include the operator system platform, the version number, release number and date, and brand.

For copy written COTS software, a copy of the source code (both hardcopy and un-compiled digital commented as described in the preceding paragraph) shall be held in an escrow account by an independent agent agreed to prior to final acceptance of the system by the Department. The version of the source code in the escrow account shall be updated as modifications, fixes, enhancements, and improvements are made to the software and implemented on the software products used by the Department. In the event the provider of COTS software product(s) defaults, discontinues support of

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the software product(s) furnished under this project, goes out of business, or otherwise is unavailable to support the software product(s), the software source code contained in the escrow account shall immediately become the property of the Department.

Provide any third party software licenses to the Department and the City of Greensboro for software that may be used. Example: report-configuring, diagnostic, or monitoring software.

A.3. Operating System

The operating system for all software provided under this project shall be Microsoft Windows Server 2003 and Microsoft Windows Server 2003 Client or Microsoft Windows XP compatible with the Microsoft Windows Server 2003 software. The release used shall be the latest revision available as recommended by the supplier of the system software.

The network operating system (NOS) shall be Microsoft Windows Server 2003 or approved equal and must be compatible with the traffic signal system software.

The NOS and software operating system shall be compatible and work seamlessly with the traffic signal system software.

B. Other Software**B.1. Signal Timing Software**

Furnish Synchro Plus SimTraffic, version 6 (or latest version that is compatible with the computer operating system provided on the computer workstations and laptop computers integrated under this project) as offered by Trafficware Corporation. Furnish a minimum of 10 seats of the software to be installed on workstations and laptop computers as designated by the Engineer.

Furnish TS/PP-Draft, version 6.0 (or latest version that is compatible with the computer operating system provided on the computer workstations integrated under this project) as offered by any authorized distributor. Furnish a minimum of 10 seats of the software to be installed on workstations and laptop computers as designated by the Engineer.

Furnish two (2) Garmin eTrex Legend GPS Receivers, or approved equivalent, with Cigarette Lighter Adapters (#010-10203-00) for each receiver. The GPS receivers shall be considered necessary accessories and incidental to furnishing the TS/PP-Draft software.

Furnish all signal timing software that is installed on all workstation and notebook computers. Include a complete user's manual and original installation disks or CD-ROMs for each software package. Provide full technical and maintenance support for all software.

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B.2. Productivity Software

Furnish copies of the latest release of the Microsoft Office™ Suite, Professional Edition, including Excel, Access, Word, and PowerPoint and install on all computers integrated under this project. If a computer to be integrated under this project already has the called for software, consult Engineer and obtain permission prior to installing new version of the software on to the workstation to be integrated under this project. A license shall be provided for each workstation and laptop computer furnished with the project. Furnish and install a copy of the latest release of Microsoft Office Suite, Professional Edition, on each workstation and laptop computer furnished.

B.3. Utility Software

Furnish utility software for uploading and downloading entire signal controller databases locally at the signal cabinet. Furnish software that is compatible with local controller software and signal system central software. Furnish software with printing functionality. Furnish utility software that can import and export controller databases from the central software and that will automatically flag differences in controller databases stored on the laptop computer(s) with the utility software, the central software database resident on the central software server computers, and the local controller. Install up to 10 seats of the utility software on laptop computers integrated under this project as designated by the Engineer.

28.5. INTEGRATION AND TESTING**A. General**

Install and fully integrate distributed processing signal system software on Distributed Processing Signal System server called for in **Section 29** of these Project Special Provisions. Install and fully integrate distributed processing signal system software on each workstation and laptop computer in the City of Greensboro signal system.

Install and fully integrate distributed processing signal system software on Distributed Processing Signal System Communications server called for in **Section 29** of these Project Special Provisions as required.

Install all software furnished for the system in accordance with the procedures recommended by the software supplier.

Install a copy of the distributed processing traffic signal system software and all communications software necessary to achieve dial-up, remote operations on the laptop computers.

Register all software products furnished with this project with the software supplier. The City of Greensboro Department of Transportation and NCDOT Division 7 shall be identified as the

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registered owner of all software.

A.1. Operating System

Install and integrate the operating system and all necessary utilities.

B. Distributed Processing Signal System Software

Install and integrate the distributed processing traffic control applications software and all other software with the communications system and local controllers to provide a traffic signal system that provides the functionality required by these Project Special Provisions. A Windows Server 2003 based installation program shall be provided for installing the software on the file server. Provide a separate Windows XP based installation program for installing the client software on workstations.

Load all parameters necessary to implement coordinated signal operations. The Engineer will furnish the timing parameters in standard traffic engineering format (cycle, split, and offset) prior to the initiation of the 120-day observation period. Make any modifications to the cycle, split, and offset information furnished by the Engineer that are necessary to implement the timing plans into the system database. The test period may not begin until the timing parameters have been loaded. The Engineer may, at his/her option, observe the loading of the timing plans.

As directed by the Engineer, make modifications to the coordinated signal timing parameters (cycle, split and offset) prior to system acceptance to improve system coordination and efficiency. The Engineer will furnish the parameters to be modified by the Contractor. Make these modifications at no additional cost. No timing plan changes will be required after the successful completion of the system operational test (as approved by the Engineer).

Prepare comprehensive, detailed graphic displays for the system display, for all control section displays, and for all intersection displays. Submit samples to the Engineer for approval, including three extent levels of system-wide, control zone, and intersection.

Add all system detectors to the graphic display and assign appropriately for operations.

Submit specific landmarks and features to be displayed in the section and intersection displays to the Engineer for approval. Develop each screen upon approval of the areas to be displayed by each screen and make revisions as required from review.

Provide training to City and Department personnel relative to the creation and editing of the sub-area and intersection displays as required in these Project Special Provisions.

C. Other Software

Install the signal timing software, productivity software, and utility software on all workstations

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and laptop computers integrated under this project.

D. Testing**D.1. General**

Provide the following tests and demonstration of the system software:

- System Operational Test (as called for in **Section 35**)
- 120-Day Observation Period (as called for in **Section 1** and **Section 35**)

28.6. MEASUREMENT AND PAYMENT

Local Controller Software will be measured and paid for on a lump sum basis. This shall include the furnishing, installation, testing, and all materials, equipment, controller hardware, firmware, and operating system modifications. labor, tools, storage, shipping, and incidentals necessary to install the software on each new controller provided under this project and existing controllers where the software will be installed. Partial payment for this item will be made on a prorated basis as local controllers are installed, tested, and accepted. The software shall be provided on up to 500 locations throughout the life of the project including test cabinets, and software for use in test controllers at NCDOT offices and test facilities not located in Greensboro.

Signal System Software will be measured and paid for on lump sum basis. This shall include the furnishing, installation, testing, and all materials, equipment, labor, tools, storage, shipping, and incidentals necessary to install the software, complete system integration, and provide a complete operational system. Partial payment for this item will be made as follows: 25% of the lump sum price upon delivery; 25% of the lump sum price upon completion of Zone A deployment with the DSL Ethernet CDB intersections operating under the central system software furnished under this project, the central software being installed, integrated, and operational without fault on the systems servers, and a client version of the central software being installed, integrated, and operational without fault on the TOC Computer Room Workstation; 25% of the lump sum price upon integration of the client software at the workstations at the TOC, the Justice Drug Complex, and the City of Greensboro Signal Shop, laptop computers designated by the Engineer, and via the City of Greensboro's Citrix™ based remote access solution; and 25% of the lump sum price upon successful completion of the Observation Period. No payment will be made for providing software licenses as required in these Project Special Provisions. No payment will be made for 3rd software required to complete the Signal System Software solution such as database software and report generation software as this will be considered incidental to the Signal System Software.

System Support Software will be measured and paid for on a lump sum basis. This shall include

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the signal timing and productivity software, local controller utility software . This shall include the furnishing, installation, and all materials, equipment, labor, tools, storage, shipping, and incidentals necessary to install and configure the software and provide a complete operating system. Payment for this item will be made as follows: 100% of the lump sum price upon delivery, installation and testing of the software into the appropriate hardware. GPS receivers for the TS/PP-Draft software will not be paid for separately but will be considered incidental. No payment will be made for providing software license and source code as required in these Project Special Provisions.

All other software and hardware otherwise required to accomplish the functionality required by the Project Special Provisions will not be paid for separately but will be considered incidental. No payment will be made for providing software license as required in these Project Special Provisions.

Payment will be made under:

Local Controller Software.....	Lump Sum
Signal System Software	Lump Sum
System Support Software.....	Lump Sum

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29. COMPUTER HARDWARE AND PERIPHERALS**29.1. DESCRIPTION**

Install and integrate new server computers, printers, new workstation computers, existing workstation computers, new laptop computers, and existing laptop computers in the TOC, the City of Greensboro Signal Shop, the Justice Drug Complex, and the NCDOT PTRTMC with all software and hardware to provide fully operational computing platforms and systems to accomplish the operational requirements of the computerized signal system as called for in the Plans and these Project Special Provisions. As noted in the Plans and these Project Special Provisions, computer hardware will be specified by the Contractor and acquired by the City of Greensboro MIS Department via their lease program.

Furnish, install, and integrate KVM switches, plotter, UHF modulator, and GPS antenna, called for in the Plans and these Project Special Provisions.

Prior to installing and configuring the computer hardware at each facility, develop a computer hardware architecture and system design document that shows the entire layout of the computer hardware systems and their interconnection. The function, description, and proposed model number of each computer hardware component will be shown in the document. The report will describe the computer hardware layout in text and using graphics. Submit to Engineer for review and approval.

For server computers, workstation computers, and laptop computers, the City of Greensboro MIS Department will lease this equipment via their lease program and provide it to the Engineer to provide to the Contractor to install and integrate. For these items, the Contractor shall follow the following process to define item requirements, and acquire the equipment:

- Determine the operational requirements of each hardware component to be leased by the City as needed to meet the functional requirements of the software or function the hardware is to be used for.
- Draft a detail requirements listing for each computer hardware component that will be leased, include catalog cut-sheets from sample devices. Submit a separate requirements listing for each item that is to be leased.
- Submit detail requirements listing to the City of Greensboro MIS Department, via the Engineer, a minimum of 90 calendar days prior to requiring component.
- The Engineer will provide a cut sheet and detailed specification of the item provided by the City's lease vendor based on the detailed requirements for the item submitted by the

Contractor within 30 days of the submittal of the detailed requirements listing.

- The Contractor will acknowledge in writing to the Engineer that the proposed item meets the need of its intended function and direct the Engineer to direct the City to lease the item. If the Contractor takes exception to the item to be provided by the City's lease vendor, exceptions must be noted in writing with the specific requirements not met by the item within 15 calendar days of receiving the detailed requirement. The City will address the exception with their lease vendor and/or the Contractor and resolve the exception.
- Once final requirements are agreed to, the Engineer will direct the City MIS Department to lease the equipment and deliver the equipment to the Contractor's facility

The Contractor will be subject to all terms of the MIS Department's lease agreement. The City of Greensboro will be responsible for the payment of leased equipment.

The Contractor shall be responsible for the purchase of all software and operating systems not furnished with the leased equipment required for system applications to be deployed under this project.

29.2. MATERIALS

A. General

Request hardware and furnish hardware that operates at 115 VAC \pm 10 percent at 60 Hz. Request hardware and furnish hardware that operates in a +40 to +122 degree Fahrenheit environment at 20 to 80 percent relative humidity.

All workstation computers, laptop computers, and server computers (including those serving as video monitor processor units) shall be from the same manufacturer. Requirements for server computers and workstation computer that use proprietary power supplies will not be accepted.

B. Applications Servers

B.1. General

Application servers required for a typical traffic signal system and central video system operating in a client/server, local area network with remote access has been shown in the Block Diagrams in the Plans. The Contractor may elect to use a different server configuration and allocate the servers for different purposes as long as the system functionality is preserved and no more servers than those shown in the Plans are required to complete the solution unless approved by the Engineer.

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Servers shall support the Windows™ Server 2003 operating environment.

Servers will be installed in EIA 19 inch Equipment racks and must not exceed 3 rack units.

Servers shall come equipped with 10/100/1000 MB network interface cards.

Servers shall come with minimum 1 terabyte of hardware storage.

Servers shall be based on Intel Quad Core Xeon Processor, Intel Dual Core Itanium Processor, or equivalent technology.

The following server functionality is required under this project.

B.2. Distributed Processing Signal System Server

A server shall be requested to host the Distributed Signal System Application Software call for in **Section 28** of these Project Special.

B.3. Distributed Processing Signal System Communications Server

A server shall be requested to manage the real-time communications of the Distributed Signal System Software with the Ethernet communications network. This server shall be equipped with all hardware and software required for the Distributed System Software to meet all of the data communications requirements discussed in, **Section 28** of these Project Special Provisions including once-per-second polling of all traffic signal controllers. This server shall also house the Network Performance Monitoring and Management Software called for in **Section 30** of these Project Special Provisions

B.4. CCTV Video Server

A server shall be requested to host the Central CCTV application software and the modified Regional Protronix Video Pro Enterprise (VPE) software called for in **Section 31** of the Project Special Provisions.

B.5. Remote Access Server

A server shall be requested to host remote access software and allow up to eight simultaneous users to access all services on the LAN via dial-up modem, ISDN connection, fractional or full T-1 connection, DSL connection, Cable modem connection, or full bandwidth Ethernet connection. Furnish minimum six client licenses of remote access software compatible with laptop computers to be installed under this project. Request server with communications ports and modems as required to provide remote access connections as required in the plans and these Project Special Provisions.

B.6. Domain Controller Server

A server shall be requested to serve as a Domain Controller Server to manage security and user authentication in the Windows™ Server environment. that is equipped with all hardware and software required for the Distributed System Software.

B.7. System Back-Up and Storage

A server shall be requested to serve as a system back server. This server shall be configured to replace any of the applications servers in a cold back-up fashion.

Also, request a tape backup system that utilizes LTO-4 tape technology that is capable of archived back-up of the entire server farm. Request tape back-up system that mount in the 19” equipment racks furnished under this project.

Furnish software to allow for manual and automatic back-up at user-defined times and intervals. The back-up software shall allow the user to define the parameters of the back-up, including directories, drive partitions, and file dates. The software shall have a graphical user interface to allow the user to view each back-up tape in a logical directory/subdirectory view. The software shall also maintain a database of all back-up tapes and issue each back-up tape a unique, user-defined title. Contractor shall furnish a minimum of 3 years worth of back-up media under this project.

Include with the LTO drive appropriate software The software shall permit the back-up of all computers on the City of Greensboro Signal System LAN.

C. Workstation Computers**C.1. General**

Request eight (8), dual monitor, workstation computers for installation and integration in the TOC, the TOC computer room, the City of Greensboro Signal Shop, and the Justice Drug Complex.

Request workstation computers that are in a tower form factor and come equipped with dual, 19” LCD flat panel monitors

Request workstation computers that operate in a Windows XP™ environment and that are compatible with the network operating system

Request workstation computers with memory, storage, and video card to allow the simultaneous operation of the client video software, the client signal distributed signal system software, network management software, system support software.

Request workstations with 10/100/1000 MB network interface card.

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Request workstations with 1394 “Firewire” port, minimum 4 USB ports, serial, and parallel ports.

Request workstations with television tuners to support cable television input.

D. Laptop Computers

Request Laptop computers that operate in a Windows XP™ environment and that are compatible with the network operating system.

Request laptop computers with memory, storage, and video card to allow the simultaneous operation of the client video software, the client signal distributed signal system software, network management software, system support software.

Request laptop computers with 10/100/1000 MB network interface card.

Request laptop computers with internal 802.11a/b/g/n WI-FI cards.

Request laptop computer with docking stations.

E. Video Monitor Processor Units**E.1. General**

Video monitor processor units shall be server class computers that serve to software decode MPEG 4 and if furnished, MPEG 2 digital video for display on the 50” LCD monitors and the video projection unit.

Request nine (9) rack mount server computers to serve as video monitor processor units in the TOC.

Request two (2) rack mount server computers to serve as video monitor processor units in the Justice Drug Complex..

Request two (2) tower server computers to serve as video monitor processor units at the City of Greensboro Signal Shop.

Request video monitor processor units that software decode up to 16 MPEG 2 or 16 MPEG 4 digital video streams at 25 frames per second, D1 resolution as described in **Section 27.2.J**.

Request video monitor process units with 10/100/1000 MB network interface card.

F. Printer

Request color laser printers with the following features:

- Utilizes the PCL 6 printer language featuring commands for fully integrated HP-GL/2 vector graphics and advanced imagery/special effects printing with a minimum of 80 internal, scaleable fonts.
- Utilizes the latest version of Windows print typefaces.
- Provides a minimum of 16 MB of RAM.
- Provides modular input/output (I/O) and Ethernet 10/100/1000 Base-T network communications protocols.
- Comes equipped with an Ethernet 10/100/1000 Base-T network interface card and an RS-232 serial (9-pin) interface, bi-directional IEEE 1284 ECP-compliant parallel interface, and one (1) open EIO expansion slot.
- Prints a minimum 17 pages per minute (ppm) for both color and black and white prints.
- Provides 1,100 sheet capacity and 3 input trays supporting 8.5 x 11 inch, 8.5 x 14 inch, and 11 x 17 inch media.

G. Surge Suppression Strips

When required, furnish surge suppression power strips with an illuminating on/off switch, isolating filter banks, a minimum of six 120 VAC, 60 HZ outlets, and a minimum of 808 Joules.

H. Keyboard Video Mouse Switch

Furnish Keyboard-Video-Mouse (KVM) switch that allows a single keyboard, mouse, and RGB monitor to access and switch between multiple application servers in the rack cabinets. Furnish KVM switch unit that has the following features:

- Rack mountable with a maximum height of 1.75 inches
- Installs into the 19" rack cabinet furnished under this project and is a retractable, drawer style, mouse and keyboard with a fold-down/flip up monitor
- Control of a minimum of 8 servers using a single unit
- Multiple switching methods including front panel, keyboard, or on-screen display
- Compatible with servers furnished under this project
- Compatible with keyboard, monitor, and pointing device supplied with rack cabinets under this project

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Furnish all necessary cabling to integrate KVM switch.

I. IP Keyboard Video Mouse Switch

Furnish digital IP KVM switch with minimum 16 RJ-45 ports for connection of up to 16 server or central computers to the unit using the KVM/CAT-5E cable. Furnish unit that allows direct access to a local keyboard, mouse, and monitor, via direct connection of each device (keyboard, mouse, and monitor) into keyboard, monitor, and mouse ports on the KVM digital, IP switch. The purpose of these ports is to allow an analog connection to the unit for local devices (keyboard, monitor, and mouse) to be switched between sever computers connected to the unit.

Furnish KVM digital IP switch that allows the display and control of connected sever and CPU units via host computer units connected to the KVM digital IP switch via a 10 mbps or greater local area network connection. The KVM digital IP switch will be IP addressable and have resident software that manages all remote PC access to the switch and its connected central computer and servers as well as authenticates and verifies remote users.

RGB monitor display and keyboard and mouse controls signals will be transmitted to the remote computers via the LAN. The KVM switch will be connected to the LAN via a 100 BASE-T, RJ 45 Ethernet port. Monitor signals, keyboard signals, and mouse signals will be transmitted to the remote computers via TCP/IP protocol over the LAN. Each remote PC that has access to server and central computer units via the KVM digital IP via the LAN shall be capable of viewing and controlling any of the connected central and server computers by means of an MS Windows compatible client graphical user interface. The client GUI, when activated through standard Windows activation (e.g. double click of its icon from the mouse, launching from the "Start" menu, etc.) will enter a login screen requiring the remote user to enter a username and password. Upon authentication of the user by the KVM digital IP switch, a window displaying the central computer and server devices connected to the KVM digital IP switch will appear and the remote user will be able to select the server or central computer they wish to access.

The KVM IP switch shall also have a have a serial port that is accessed through a PC with terminal emulation software (e.g. Windows HyperTerminal) that permits user configuration of the KVM IP unit and access to its firmware. The serial port shall also be used for the flash update of unit firmware.

All software utilized in the KVM IP switch system shall be transparent to all servers and central computers connected to the KVM IP Switch. No software shall be required to be installed on any

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server or computer to facilitate operation of the KVM IP switch.

Furnish KVM digital IP switch with the following characteristics:

- Sever inputs 16
- KVM/CAT-5 inputs ports (RJ-45) 1
- LAN connections (100 BASE-T, RJ-45) 1 each
- Local keyboard, mouse, and video connections 1
- Local RS-232 serial ports for terminal access 1
- Operating temperature and humidity range 14 Degrees F to 131 Degrees F
0%-95%, non-condensing
- Size Less than 3.5 (2RU) tall
- Power 120 VAC
- Network Standards Ethernet, IEEE 802.3, 802.3U
- Local Port Video Resolution 1600 x 1280
- Digital Port Resolution 1280 x 1024
- Operating System compatibility Windows 2003, Windows 2000 or
other approved equal

J. Plotter

Furnish, install, and integrate large-format, color plotter that uses ink-jet technology. Furnish plotter that produces high-quality drawings for engineering applications on paper, vellum, translucent media, and polyester film. The plotter shall accommodate the loading of sheet media in standard and odd sizes from A4/A through A0/E, including architectural sizes. Load rolls shall be accommodated in both 22" and 34" widths, one at a time. The plotter shall automatically cut and stack a minimum of twenty (20) standard 22" x 34" drawings without user intervention.

Furnish plotter that provides for draft and final plotting at normal quality at 140 sqft/min. Maximum plotting time (excluding file transmission and ink-drying times) shall not exceed two (2) minutes in normal mode for a standard 22" x 34" drawing.

Furnish plotter that provides for final plotting high or enhanced quality at 70 sqft/min.

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Maximum plotting time (excluding file transmission and ink-drying times) shall not exceed two (2) minutes in normal mode for a 22" x 34" color drawing.

The plotter shall plot at 1200 x 600 dpi for black ink and at 600 x 600 dpi for color.

The plotter shall be supplied with a minimum of 64MB RAM expandable to 128MB RAM.

The plotter shall have a front panel that provides for menu selection of all available options and processes.

The plotter shall accommodate modular input/output (I/O) and 10/100 Base T network communications protocols. Each plotter shall be equipped with a 100 Base-T network interface card (NIC), as described in the Local Area Network Section of the Technical Specifications and all software and hardware required for interface with the LAN shall be provided. Each plotter shall be furnished with all cables necessary for connection to a multiple outlet power strip. Power and data cables shall have the minimum length of 10 feet.

K. UHF Modulator

Furnish UHF modulator to output CCTV video on antenna (UHF) or cable (CATV) systems. The UHF modulator shall have the following minimum characteristics:

- One (1) video input with BNC connector
- Output digitally tuned channels (UHF 14-69, CATV 70-94 & 100-125)

L. GPS Antenna

Furnish global positioning system (GPS) antenna for precise timing and synchronization applications. Furnish GPS antenna with the following minimum features:

- GPS receiver and antenna in a single environmentally sealed enclosure
- Generates a pulse-per-second (PPS) output synchronized to UTC within 50 nanoseconds (one sigma), outputting a time tag for each pulse
- RS-422/485 communications

Furnish the following accessories with the GPS antenna. These items are considered incidental to furnishing, installing, and integrating the GPS antenna.

- Mounting pole with standard 1"-14 straight thread
- RS-422 Interface cable of sufficient length (but not greater than 400 feet) to route from GPS antenna to server, including all required connectors and adapters

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- RS-422 to RS-232 converter, including all cables to connect with server
- Windows-based software program for monitoring GPS operations and communications
- DC Power supply

Furnish GPS antenna that is Trimble Acutime 2000 model or approved equivalent.

29.3. CONSTRUCTION METHODS**A. General**

Install and integrate the central hardware required to support the software functions called for in **Section 28** of these Project Special Provisions.

Install and integrate the hardware at the TOC as shown in the block diagram in the Plans.

B. Surge Suppression Strips

Furnish and install surge suppression power strips for all computer hardware and peripherals, video subsystem, local area network, and central communications equipment not connected to a UPS.

C. Applications Servers**C.1. Distributed Processing Signal Server**

Install and integrate the distributed processing signal system server into equipment rack cabinet at TOC Computer Room as shown in the Plans. Integrate with LAN switch, KVM switch, and UPS. Fully configure server to operate distributed system processing software. Integrate with GPS Antenna.

C.2. Signal System Communications Server

Install signal system communications server into equipment rack at TOC Computer Room as shown in the Plans. Integrate with LAN switch, KVM switch, and UPS. Fully configure server to facilitate signal system communications and to manage and monitor the system Local Area Network.

C.3. CCTV Video Server

Install video server into equipment rack at TOC as shown in the Plans. Integrate with LAN switch, KVM switch, and UPS.

C.4. Remote Access Server

Install remote access server into LAN equipment rack cabinet at the TOC. Integrate with LAN switch, KVM switch, UPS, and the existing City of Greensboro firewall. Coordinate with Engineer to determine available firewall ports.

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Install and configure software with usernames, passwords, and Remote Access Windows desktop that allows client user gaining access to the LAN via the server, has complete access to all software applications on the LAN, available to a local user. Configure new notebook computers and up to two additional dial-up remote users as designated by the Engineer for remote dial-in access. Install all third party software and drivers required to create fully functional remote access server. Install all client software on new notebook computers and dial up remote workstations (as designated by the Engineer) required for operation of all software services available on the LAN.

Integrate Remote Access Server with City of Greensboro Citrix™ remote access solution.

D. Keyboard Video Mouse Switch

Install and integrate KVM switch into LAN equipment rack cabinets at the TOC Computer room, the TOC, the GDOT Signal Shop, and the PTRTMC. Integrate with application servers. Install one per new rack in each new rack cabinet furnished under this project.,

E. IP Keyboard Video Mouse Switch

Install and integrate IP KVM switch into LAN equipment rack cabinet at the TOC. Integrate with application servers, LAN switch, and microcomputer workstations on the LAN.

F. Computer Workstations

Install and integrate two (2) dual monitor workstation computers in operator work centers at the TOC as shown in the Plans. Integrate with LAN switch. Fully configure workstation computers with all client software to operate all client applications called for under this project including the distributed processing signal system and video system.

Install and integrate two (2) dual monitor workstation computers in the TOC offices as shown in the Plans. Integrate with LAN switch. Fully configure workstation computers with all client software to operate all client applications called for under this project including the distributed processing signal system and video system.

Install and integrate one (1) dual monitor workstation computers in the TOC Computer Room as shown in the Plans. Integrate with LAN switch. Fully configure workstation computer with all client software to operate all client applications called for under this project including the distributed processing signal system and video system.

Install and integrate two (2) dual monitor workstation computers in City of Greensboro Signal Shop in offices designated by the Engineer. Integrate with LAN switch. Fully configure workstation computers with all client software to operate all client applications called for under this project including the distributed processing signal system and video system.

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Install and integrate one (1) dual monitor workstation computers in the Justice Drug Complex in the as directed by the Engineer as shown in the Plans. Integrate with LAN switch. Fully configure workstation computer with all client software to operate all client applications called for under this project including the distributed processing signal system and video system.

Install and integrate nine (9) video monitor processor units in the TOC. Integrate with LAN switch, LCD monitors, and video projection units as called for in the Plans. Fully configure with software to perform software decoding of digital video streams as called for under this project.

Install and integrate two (2) video monitor processor units in the City of Greensboro Signal Shop. Integrate with LAN switch and LCD monitors. Fully configure with software to perform software decoding of digital video streams as called for under this project.

Integrate up to seven (7) existing City of Greensboro workstation computers with the local area network installed under this project using existing City of Greensboro network connections.

Integrate up to ten (10) existing City of Greensboro laptop computers with the local area network installed under this project using existing City of Greensboro network connections or new wireless and Ethernet connections

Integrate existing DMS server at Justice Drug Complex with local area network installed under this project.

Integrate existing Video Server at the PTRTMC with the local area network installed under this project.

G. Laptop Computers

Install and integrate four (4) laptop computers Integrate with LAN switch. Fully configure laptop computers with all client software to operate all client applications called for under this project including the distributed processing signal system and video system. Deliver laptop to the TOC prior to the start of the scheduled training. Fully configure laptop computers with all client software to operate all signal system and subsystems, including distributed processing signal system and the CCTV subsystem. Configure laptop computers with client version of local intersection software to enable direct connection of laptop computer to the local distributed processing intersections for upload, download, monitoring, and manipulation of local intersection controller databases. Fully configure laptop computers such that when plugged into a network outlet on the City of Greensboro Signal System LAN, the user is able to login to the system as though he/she were logging in from any other workstation on the LAN.

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H. Printer

Install and integrate one (1) printer in the TOC. Integrate with the LAN.

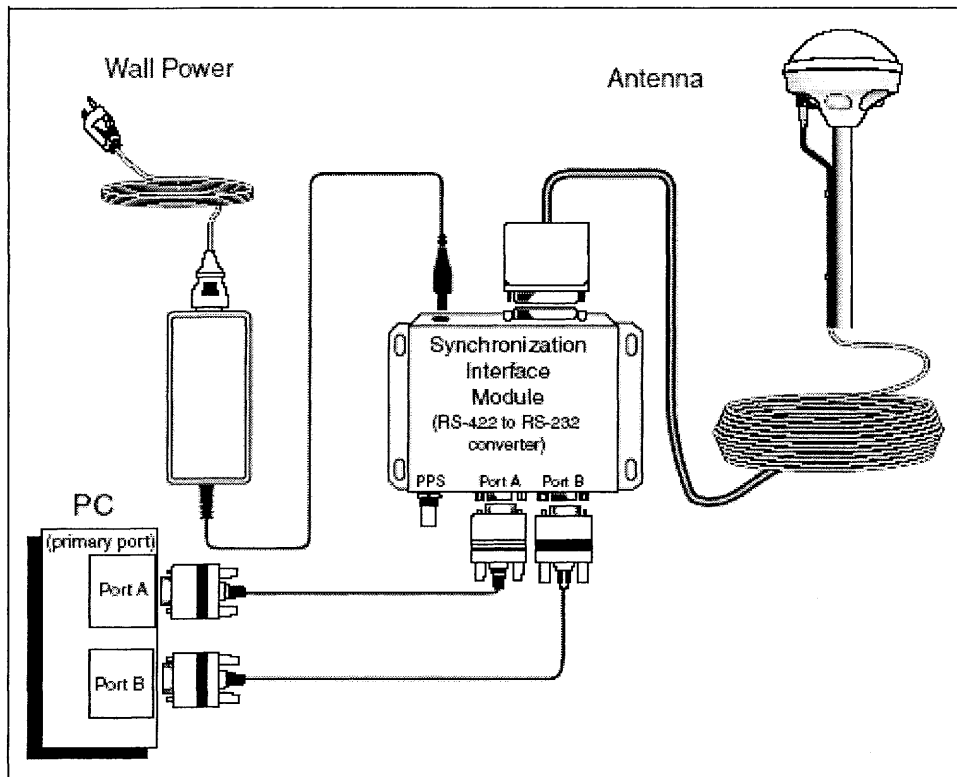
I. Plotter

Install and integrate one (1) plotter in the TOC. Integrate with the LAN.

J. GPS Antenna

Install GPS antenna on the Municipal Building as approved by the Engineer. Mount antenna using method approved by the Engineer such that the antenna has an unobstructed view of the sky and is not within close proximity to other transmitting antennas such as radars, satellite communication equipment, and cellular communication equipment. Ensure that antenna is properly grounded in accordance with the Standard Specifications and the manufacturer's recommendations to insure all electronic components downstream of the antenna, including the synchronization interface module and the signal system computer hardware, are isolated from electrical transients and surges. Route interface cable from antenna to signal system server in the TOC Computer Room using methods approved by the Engineer.

Integrate GPS antenna with server such that the software can perform clock synchronization tasks. The following diagram details all of the required connections.



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K. UHF Modulator

Install and integrate UHF modulator with new video CODEC unit and existing character generator to provide for touring output of video streams to City of Greensboro Community Access Television Station (Channel 13) as shown in the Plans.

L. Computer Hardware Integration

Fully integrate computer hardware equipment to form complete and operational systems as called for in these Project Special Provisions and shown on the block diagram in the plans. Install and configure all central computer hardware at the TOC to accomplish the functionality called for in these Project Special Provisions and hardware functionality required to support the computer software to be installed on to the computing hardware called for under this project. Integrate with LAN equipment and field equipment.

29.4. MEASUREMENT AND PAYMENT

KVM Switch will be measured and paid for the actual number of KVM switches furnished, installed, integrated, and accepted.

IP KVM Switch will be measured and paid for the actual number of KVM switches furnished, installed, integrated, and accepted.

Plotter will be measured and paid for the actual number of plotters furnished, installed, integrated, and accepted.

UHF Modulator will be measured and paid for the actual number of UHF modulators furnished, installed, integrated, and accepted.

GPS Antenna will be measured and paid for the actual number of GPS antennas furnished, installed, integrated, and accepted. All required installation accessories, including but not limited to cables, converters, mounting equipment, power supply, and software, shall be considered incidental and will not be paid for separately. All labor and materials to route the antenna cable to the Distributed Signal System Server shall be considered incidental and not paid for separately.

Computer Hardware Integration will be measured and paid for on a lump sum basis. Partial payment for this item will be made as follows: 10% of the lump sum price upon completion of the Hardware Integration Architecture, 40% of the lump sum price upon delivery, installation, and integration of the computer hardware at the TOC, and 50% of the lump sum price upon successful completion of the Observation Period.

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This shall include the installation, testing, and all materials, equipment, labor, tools, storage, shipping, and incidentals necessary to install and make fully operational the computer hardware equipment at locations called for in the Plans and in these Project Special Provisions.

All cabling, sockets, port adapters, or other accessories required to configure, integrate, and interconnect computer equipment shall be considered incidental and shall not be paid for separately. This shall include provision of the surge suppression power strips and uninterrupted power supplies.

The quantity of computer hardware integration will be paid for at the contract unit price lump sum for "Computer Hardware Integration."

Testing will not be paid for separately but will be considered incidental to equipment installation.

Payment will be made under:

KVM Switch	Each
IP KVM Switch.....	Each
Plotter	Each
UHF Modulator.....	Each
GPS Antenna.....	Each
Computer Hardware Integration	Lump Sum

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30. LOCAL AREA NETWORK**30.1. DESCRIPTION****A. Overview**

A fault-tolerant, mesh Ethernet network will be furnished under this project. This network will consist of 10, 10 Gigabit Ethernet (10 Gig-E) layer 3 Switches also referred to as Hubs in the Plans and these Project Special Provisions. Each Hub is connected to at least two other Hubs for path diversity for the 10 Gigabit “backbone.” This network will service both the signal system enterprise and the sites in the City of Greensboro managed by the City of Greensboro MIS Department. These “edge” devices will consist of managed, layer 2 Ethernet switches. The layer 2 edge switches are “daisy chained” together in groups utilizing a pair of optical fibers with each end of the daisy chain terminating at a HUB. There are 25 groups of edge switches servicing traffic signal controllers, CCTV camera CODECs, DMS units, and Cisco Aironet 1522 Wi-Fi Mesh units. There are 6 groups of Layer 2 managed switch edge devices arranged in a daisy chain fashion interconnecting City of Greensboro Facilities whose telecommunications are managed by the City of Greensboro MIS Department. Lastly, there is a group of edge devices in the CBD consisting of layer 2 managed switches utilizing twisted pair cable and DSL technology.

Under this Project, the City of Greensboro MIS department will be furnishing the 10 Gig-E Layer 3 Hub Switches that will comprise the network core, and the 10/100/1000 layer 2 switches called for in the TOC, and the Melvin Municipal Building basement. The 10 Gig-E switches shall be Cisco Model 6503E with model 720 supervisor engines.

The Contractor will, furnish, install, and integrate field Ethernet Switches and DSL Ethernet switches in field cabinets, at the Justice Drug Complex, and the TOC Computer room as called for in the Plans.

The Contractor shall integrate the existing switch and router at the PTRTMC to create segmented link for LAN connection between the PTRTMC LAN and the City of Greensboro Traffic Signal System LAN.

The Contractor shall configure, install, and integrate the 10 Gig-E Hub switches and integrate them with the field Ethernet and DSL Ethernet switches to form the field to central communications network.

The Contractor shall configure, install, and integrate the 10/100/1000 switch at the TOC and the wireless access point at the City of Greensboro Signal Shop furnished by the City MIS Department

with the Server Computers, Workstation Computers, and Video Monitor Processor Units as called for in **Section 29** and shown on the Plans

B. Field Topology

The 10 Gig-E Layer 3 Hub switches are located throughout the City. Sheet 2AZ in the Plans, shows how the 10 Gig-E Layer 3 Hub Switches are interconnected. The table below shows the alphabetic labels assigned to them and their physical location.

LABEL	LOCATION
HUB A	NCDOT PIEDMONT TRIAD REGIONAL TMC
HUB B	FIRESTATION #9 (MIS 539)
HUB C	FIRESTATION #12 (MIS 527)
HUB D	BENJAMIN AT GREEN VALLEY (@ INTERSECTION GBO-166)
HUB E	SANFORD SMITH BUILDING (MIS 563)
HUB F	MELVIN MUNICIPAL OFFICE BUILDING
HUB G	CITY SIGNAL SHOP
HUB H	JUSTICE BUILDING COMPLEX
HUB I	ELM-EUGENE AT I-85 NB RAMP (@ INTERSECTION 07-1970)
HUB J	STANLEY AT HILLTOP (@ INTERSECTION 07-1512)

The traffic signal controller and ITS field devices being deployed under this project communicate over Layer 2 managed Ethernet switches resident in signal controller and equipment cabinet. As stated, the switches are connected in a “daisy chain” fashion via a pair of optical fibers. There are 2 groups connected in this manner. A naming convention has been established utilizing two alphabetic characters indicating the pair of Hubs the group terminates to followed by the group number.

The table below presents the Traffic Signal Controller and ITS Device groups for those devices connected over the optical fiber network.

SIGNAL CONTROLLER, ITS ETHERNET, WI-FI HOTSPOT GROUPS	
GROUP LABEL	GROUP LABEL
BJ01	HI14
BJ02	JH15
BC03	AD16
BC04	AD17
CE05	AD18
CE06	BD19
CE07	AD20
EG08	CD21

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SIGNAL CONTROLLER, ITS ETHERNET, WI-FI HOTSPOT GROUPS	
GROUP LABEL	GROUP LABEL
EG09	AH22
EG10	HI24
EG11	AD25
GI12	GI26
JI13	

In addition, there is a group of Signal Controllers that are connected utilizing existing twisted pair copper cable (with limited optical fibers at ends) in the Central Business District. These are part of Group FF23. These switches utilize seven existing 4-wire (2 pair) channels in the existing twisted pair cable and are arranged in a drop and repeat fashion. There are seven head-end DSL Ethernet Switches in the TOC computer room (one for each channel) that are to be connected to the 10 Gig-E Hub Switch.

For MIS facilities, a similar topology is used. For the MIS facilities, the interconnection of the edge locations to the 10 Gig-E backbone and to one another shall be performed by others. The MIS Facility groupings are shown in the table below.

	ID	Facility Name	Location	Group
ADMIS (5 Facilities)	530	Fire Station 16	1000 Meadwood St	ADMIS
	533	Fire Station 19	6900 Downwind Rd	ADMIS
	534	Fire Station 20	8404 W. market St	ADMIS
	606	Swing Road Station	300 Swing Rd	ADMIS
	1416	Transfer Station	6310 Burnt Poplar Rd	ADMIS
BDMIS (9 Facilities)	513	Benjamin Library	1530 Benjamin Pkwy	BDMIS
	532	Fire Station 18	5903 Ballinger Rd	BDMIS
	536	Fire Station 5	1401 Westover Ter	BDMIS
	539	Fire Station 9 (HUB B)	4302 W. Friendly Ave	BDMIS
	565	Tannenbaum	2200 New Garden Road	BDMIS
	603	Kathleen Clay Edwards Family branch library	1420 Price Park Rd	BDMIS
	904	Burmill Park	5834 Bur-Mil Club Road	BDMIS
	569	Historical Museum	130 Summit Ave	EGMIS
	571	Central Library	219 N Church st	EGMIS
1415	Fire Station 21	2870 Horsepen Creek Rd	BDMIS	
CE1MIS (8 Facilities)	527	Fire Station 12 (HUB C)	1805 Pisgah Church Rd	CE1MIS
	528	Fire Station 14	3622 Summit Ave	CE1MIS
	531	Fire Station 6	4504 Lake Brandt Rd	CE1MIS
	555	N Buffalo Treatment	2199 White St	CE1MIS
	573	Bryan Park Enrichment Ctr	6275 Bryan park Rd	CE1MIS
	578	Lake Townsend Treatment Plant	6332 Townsend Road	CE1MIS

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	ID	Facility Name	Location	Group
	612	Fire Station 2	5109 N Church St	CE1MIS
	901	SportsPlex	2400 16th Street	CE1MIS
CE2MIS (8 Facilities)	519	Cone Building	1101 4th St	CE2MIS
	524	Fire Station 1	1514 N Church St	CE2MIS
	537	Fire Station 7	1064 Gatewood Ave	CE2MIS
	546	Landfill offices	2503 White St	CE2MIS
	552	Mcgirt-Horton Library	2509 Phillips St	CE2MIS
	563	Sanford Smith (HUB E)	514 Yanceyville St	CE2MIS
	589	TZ Osborne Wastewater Treatment	2350 Huffine Mill Rd	CE2MIS
	590	Curb Market	501 Yanceyville Rd	CE2MIS
EGMIS (8 Facilities)	535	Fire Station 4	401 Gorrell St	EGMIS
	557	P&R Maintenance	316 E. Florida St	EGMIS
	566	Vance Chanvis Library	900 S bembow Rd	EGMIS
	593	J Edward Kitchen Operations Center	2602 S Elm-Eugene ST	EGMIS
	902	Fire 56	820 Franklin Blvd	EGMIS
HJMIS (7 Facilities)	518	Coliseum	1921 W Lee St	HJMIS
	525	Fire Station 10	4208 High Point Rd	HJMIS
	529	Fire Station 15	1400 W. Vandalia Rd	HJMIS
	538	Fire Station 8	2201 Coliseum Blvd	HJMIS
	542	Glenwood Library	1901 W. Florida St	HJMIS
	607	Hemphill Branch Library	2301 W Vandalia Rd	HJMIS
	903	Trotter Rec/Hester	3906 Betula Street	HJMIS

C. Virtual Local Area Networks (VLANS)

For the layer 2 Field Ethernet Switches and DSL Switches installed in the field, VLANs shall be developed to group devices by type. Common ports shall be used for the edge devices for common devices. Up to two ports shall be reserved for future device classes. One port shall be reserved for network connection by a laptop computer at the equipment cabinet.

D. Requirements Definition Document

Prior to commencing work, the Contractor shall develop a Requirements Definition Document (RDD) that will form the basis for the overall network architecture and design. It is expected that the Contractor will work closely with the MIS Department to define, the network. The document will contain:

- Complete description of the proposed implementation of the access, distribution and core layers for the Signal System network as described in the Plans and These Project Special Provisions
- Development of an IP Design Scheme with ranges assigned to each node to be integrated by the Contractor;
- Proposed IP subnet definition and addressing including any and all masks;
- Proposed IP multicast configuration including multicast routing (i.e., PIM sparse or dense) and Rondeveau Point (RP) designation as necessary;

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- Proposed Recommendations for failover and redundancy including network device power, supervisor cards, and network ports;
- Proposed configuration and guidelines for Layer 3 routing (OSPF, EIGRP, RIP, etc.);
- Proposed configuration and guidelines for Virtual LAN assignments including management VLANs, device VLANs and routing VLANs; and
- Proposed configuration and guidelines for specific port assignments on each of the Layer 2 and 3 devices.

The Engineer will provide the Contractor with an IP address range or ranges from which the Contractor will develop the IP address scheme. Once the RDD is completed, it is expected that the Contractor will assist the MIS Department in properly assigning and configuring each network device to the set of guidelines and configuration standards such that each device can be installed and be fully operational.

The RDD shall also include any assumptions on the part of the Contractor that will affect the MIS Departments deployment of their network to service the Facilities that they manage that will not be integrated under this project. The Contractor shall refine the RDD based on input from the MIS Department as well as any modifications to the physical plant or due to system integration efforts. The RDD shall be prepared by a qualified networking professional and will be approved by the Engineer. The Qualified network professional will be present during the installation and testing of the local area network as well as during system testing.

E. Equipment Furnished by City MIS Department

For the network equipment that will be furnished by the City MIS Department, the Contractor will provide information regarding the number of each type of Ethernet port that will be needed for equipment to be furnished by the MIS Department. The table below describes the type of ports that are anticipated to be required on the MIS furnished Ethernet equipment to support the traffic signal system network and 10 Gig-E network bone. Equipment supplied by the City MIS Department shall utilize IEEE 802.3z compliant small form factor pluggable (SFP) modules to provide optical links. Request Cisco approved SFP that are rated for the distances and optical losses incurred on the runs the optics will service. Request optics that operate over the optical fiber utilized under this project. Request optics that fully operate with paired optics on link where Contractor supplied equipment will serve as other end of optical path.

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Equipment Type	Port Purpose	Optical/ Electrical	Information Required
10 Gig-E Hubs in MIS Facility (Hubs B, C, and E)	10 Gig-E Uplink ports to form Hub to Hub Connections	Optical	Number of 10 Gig-E ports that support SFP modules. Type of SFP optics (LX or ZX) rated to service optical loss over run). Additional switch modules to house additional 10 Gig-E ports in addition to the 2 resident on the 6503E, 720 Supervisor Engine (if required).
	Gig-E ports to service GB uplink ports on Field Ethernet Switch Groups	Optical	Number of Gig-E ports that support SFP modules. Type of SFP optics (LX or ZX) rated to service optical loss over run.
10 Gig-E Hubs in PTRTMC, TOC Computer Room, GDOT Signal Shop, and Justice Drug Complex (Hubs A, F, G, and H)	10 Gig-E Uplink ports to form Hub to Hub Connections	Optical	Number of 10 Gig-E ports that support SFP modules. Type of SFP optics (LX or ZX) rated to service optical loss over run). Additional switch modules to house additional 10 Gig-E ports in addition to the 2 resident on the 6503E, 720 Supervisor Engine (if required).
	Gig-E ports to service GB uplink ports on Field Ethernet Switch Groups	Optical	Number of Gig-E ports that support SFP modules. Type of SFP optics (LX or ZX) rated to service optical loss over run.
	10/100/1000 ports to service local equipment	Copper	Number of 10/100/1000 ports required to complete connections to computers, servers, video monitor processor units, local Ethernet switches, CODECs, printers, and other equipment to complete LAN at buildings housing system components called for in the Plans and these Project Special Provisions

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Equipment Type	Port Purpose	Optical/ Electrical	Information Required
10 Gig-E Hubs in Field Equipment Cabinets (Hubs D, I, and J)	10 Gig-E Uplink ports to form Hub to Hub Connections	Optical	Number of 10 Gig-E ports that support SFP modules. Type of SFP optics (LX or ZX) rated to service optical loss over run). Additional switch modules to house additional 10 Gig-E ports in addition to the 2 resident on the 6503E, 720 Supervisor Engine (if required).
	Gig-E ports to service GB uplink ports on Field Ethernet Switch Groups	Optical	Number of Gig-E ports that support SFP modules. Type of SFP optics (LX or ZX) rated to service optical loss over run.
	10/100/1000 ports to service local equipment and cabinet monitoring equipment	Copper	Number of 10/100/1000 ports required to complete connections to traffic signal controllers, CODECs, or WI-FI hotspots whose Ethernet connections may terminate in the 10 Gig-E Hub switch as well as the hub cabinet monitoring system.
Gig-E Switch in Melvin Municipal Building Basement	10/100/1000 ports to service local equipment.	Copper	Number of 10/100/1000 ports required to complete connections to CODEC to service touring CCTV Channel 13 feed and to interconnect with 10 Gig E Switch in TOC Computer Room via existing City LAN cabling as called for in the Plans and these Project Special Provisions
Gig-E Switch in TOC	10/100/1000 ports to service local equipment.	Copper	Number of 10/100/1000 ports required to complete connections to computers, servers, video monitor processor units, local Ethernet switches, CODECs, printers, and other equipment to complete LAN as called for in the Plans and these Project Special Provisions

The table below displays the distances of the routed optical fiber for the HUB to HUB links. The

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distances do not account for splices and interconnect center connection panel connections. The Contractor shall be responsible for computing complete link budgets and determining the appropriate SFP modules to request to service the link.

HUB TO HUB LINK	DISTANCE	
	KM	MILES
A to B	7.0	4.3
A to F	40.8	25.3
A to H	14.7	9.1
A to J	6.9	4.3
J to I	11.3	7.0
I to E	9.9	6.1
H to D	23.7	14.7
H to G	6.4	4.0
G to F	22.8	14.2
B to C	16.4	10.2
C to D	11.7	7.3
C to E	15.7	9.7

The table below displays the distances of the routed optical fiber for the HUB to Group uplink path for the longest end. It does not list all HUB to Group links. The distances do not account for splices and interconnect center connection panel connections. The Contractor shall be responsible for computing complete link budgets for all links and determining the appropriate SFP modules to request to complete service the link.

GROUP TO HUB	DISTANCE	
	KM	MILES
BJ01	9.1	5.7
BJ02	3.3	2.0
BC03	8.9	5.5
BC04	9.5	5.9
CE05	13.5	8.4
CE06	4.8	3.0
CE07	11.6	7.2
EG08	6.6	4.1
EG09	7.3	4.5
EG10	3.3	2.0
EG11	4.8	3.0
GI12	3.5	2.2

J113	4.0	2.5
HI14	6.7	4.2
JH15	3.3	2.0
AD16	11.3	7.0
AD17	5.8	3.6
AD18	10.1	6.3
BD19	18.7	11.6
AD20	11.6	7.2
CD21	4.3	2.7
AH22	9.7	6.0
HI24	10.3	6.4
AD25	8.9	5.5
GI26	30.6	19.0

E.1. MIS Furnished LAN Hardware Request Procedure

The Contractor shall follow the process detailed below to acquire the identify the requirements of the network equipment that will be furnished by the City MIS department:

- Submit detail requirements listing to the City of Greensboro MIS Department, via the Engineer, a minimum of 90 calendar days prior to requiring component.
- The Engineer will provide a cut sheet and detailed specification of the item provided by the City’s lease vendor based on the detailed requirements for the item submitted by the Contractor within 30 days of the submittal of the detailed requirements listing.
- The Contractor will acknowledge in writing to the Engineer that the proposed item meets the need of its intended function and direct the Engineer to direct the City to lease the item. If the Contractor takes exception to the item to be provided by the City’s lease vendor, exceptions must be noted in writing with the specific requirements not met by the item within 15 calendar days of receiving the detailed requirement. The City will address the exception with their lease vendor and/or the Contractor and resolve the exception.
- Once final requirements are agreed to, the Engineer will direct the City MIS Department to lease the equipment and deliver the equipment to the Contractor’s facility

The Contractor will be subject to all terms of the MIS Department’s lease agreement. The City of Greensboro will be responsible for the payment of leased equipment.

The Contractor shall be responsible for the purchase of all firmware and operating systems not furnished with the leased equipment required for system applications to be deployed under this project.

30.2. EXISTING MATERIALS

A. Wi-Fi Mesh Units

For reference, the existing Wi-Fi mesh units will be Cisco Aironet 1500 series devices.

30.3. MATERIALS

A. General

Furnish equipment for the LAN that complies with IEEE standard 802. Furnish Field Ethernet LAN switches and DSL Ethernet Switches manufactured by the same vendor and fully compatible and interoperable with the network monitoring software, the Ethernet equipment to be furnished by the City MIS Department, and the existing router and switch at the PTRTMC.

Furnish Field Ethernet and DSL Ethernet switches fabricated for use in traffic signal controller cabinets that meet or exceed NEMA TS-2 requirements for temperature, shock, humidity, and vibration.

Furnish Field Ethernet and DSL Switches that are din rail mounted and come equipment with hardware to permit mounting in an EIA 19" equipment rack.

Furnish field Ethernet and DSL Ethernet Switches with internal Power Supply. Furnish field Ethernet and DSL Ethernet switches meeting the following power supply requirements:

- 85 to 264 Vac (50/60Hz)/ 88 to 300Vdc.
- Power supply shall have two stage isolation accomplished via two transformers: first steps down from primary AC/DC to 48VDC; the second steps down from 48VDC to 3.3VDC.
- A power cord of not less than 5 feet in length shall be supplied
- The switch shall require no more than 10W of power

Furnish Field Ethernet and DSL Switches that weigh no more than 3 lbs and are no more than 150 cubic inches in volume.

Furnish Field Ethernet and DSL Switches that comply with the following electrical safety requirements: UL60950 or CSA C22.2 No. 60950 (safety requirements for IT equipment) and FCC Part15 Class A for EMI emissions.

B. Field Ethernet Switch

Furnish ruggedized field Ethernet switches with the following minimum characteristics:

- Eight (8) 10BASE-T/100BASE-TX ports:

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- Minimum of two (2) 1000 BaseX Optical uplink ports that utilize SFP plugs.
- Furnish SFP modules rated to service the Field Ethernet to Field Ethernet optical uplinks and Field Ethernet to 10 Gig-E Hub Uplink rated for optical attenuation required to service the link. Use SFP modules that are LX or ZX and are matched and compatible with the SFP module it is mated with. Furnish attenuators if required to service link without saturation receiving optics.
- Furnish SFP modules rated for use with the optical cable furnished under this project.
- Furnish SFP modules with SC connector or other connector approved by the Engineer.
- SFP modules shall be considered incidental to the field Ethernet switch.
- Management console port

Furnish Field Ethernet switches with the following features:

- 10/100BaseTX ports:
 - RJ45 connectors
 - Cable type: Category 5, unshielded twisted pair (CAT 5 UTP)
 - Segment Length: 100m
 - Auto-negotiation support (10/100Mbps)
 - Auto MDIX crossover capability
 - Full Duplex operation (IEEE 802.3x)
 - TVS (transient voltage suppression) between Line +/-, Line +/-ground, and Line - ground to protect the circuitry
- Networking Requirements
 - The switch shall support automatic address learning of up to 8192 MAC addresses. The switch shall support the following advanced layer 2 functions:
 - IEEE 802.1Q VLAN, with support for up to 4096 VLANs
 - IEEE 802.1p priority queuing
 - IEEE 802.1w rapid spanning tree
 - IEEE 802.1s multiple spanning tree
 - IEEE802.1AD link aggregation

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- IEEE 802.3x flow control
 - IGMPv2 with 256 IGMP groups
 - Port Rate Limiting
 - Configuration via test file which can be modified through standard text editor
 - Forwarding/filtering rate shall be 14,880 packets per second (PPS) for 10Mps, 148,800 for 100Mps, 1,488,000 for 1000Mps
 - DHCP Option 82
- Network Management Functionality Requirements
 - SNMPv2, SNMPv3
 - RMON
 - GVRP
 - Port Mirroring
 - 802.1x port security
 - Radius Server
 - TACACS+ Server
 - SSL – Secure Socket Layer
 - SSH – Secure Shell
 - TFTP,
 - Network Time Protocol (NTP),
 - Simple Network Time Protocol (SNTP)
 - Management via web or Telnet

C. DSL Ethernet Switch

Furnish ruggedized field DSL Ethernet switches with the following minimum characteristics:

- Six (6) 10Base-T/100BASE-TX ports, RJ-45 connectors
- One (1) Ethernet over DSL interface (rated at 2.5 mile attenuation budget), RJ-11 connector
- Two (2) 10/100 fiber uplink ports with SC connectors and optics rated at a 16.5 db optical budget.
- Management console port

- Support operation in a drop and repeat, bus configuration.

Furnish DSL Ethernet switches with the following features:

- 10/100BaseTX ports:
 - RJ45 connectors
 - Cable type: Category 5, unshielded twisted pair (CAT 5 UTP)
 - Segment Length: 100m
 - Auto-negotiation support (10/100Mbps)
 - Auto MDIX crossover capability
 - Full Duplex operation (IEEE 802.3x)
 - TVS (transient voltage suppression) between Line +/-, Line +/-ground, and Line - ground to protect the circuitry
- Networking Requirements
 - The switch shall support automatic address learning of up to 8192 MAC addresses. The switch shall support the following advanced layer 2 functions:
 - IEEE 802.1Q VLAN, with support for up to 4096 VLANs
 - IEEE 802.1p priority queuing
 - IEEE 802.1w rapid spanning tree
 - IEEE 802.1s multiple spanning tree
 - IEEE802.1AD link aggregation
 - IEEE 802.3x flow control
 - IGMPv2 with 256 IGMP groups
 - Port Rate Limiting
 - Configuration via test file which can be modified through standard text editor
 - Forwarding/filtering rate shall be 14,880 packets per second (PPS) for 10Mps, 148,800 for 100Mps, 1,488,000 for 1000Mps
 - DHCP Option 82
- Network Management Functionality Requirements
 - SNMPv2, SNMPv3

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- RMON
- GVRP
- Port Mirroring
- 802.1x port security
- Radius Server
- TACACS+ Server
- SSL – Secure Socket Layer
- SSH – Secure Shell
- TFTP,
- Network Time Protocol (NTP),
- Simple Network Time Protocol (SNTP)
- Management via web or Telnet

D. Terminal Server

Furnish terminal servers for communications with DMS units that have the following features:

- A 10 Base-T port for connectivity to the Ethernet LAN Switch.
- A minimum of sixteen (16) EIA-232 serial ports, each of which shall support data rates up to 115.2 kbps.
- Multi-protocol support of LAT, Novell, IPX, Telnet 3270, and TCP/IP
- TCP/IP support of RLOGIN, Dynamic SLIP, PPP, BOOTP, TFTP and SNMP.
- Minimum 2 MB RAM.
- Standard 19” Equipment Rack-mountable.
- Contain all software and drivers required to support access of serial ports from servers and client workstations.

E. Network Performance Management and Remote Monitoring Software

Furnish network performance management and remote monitoring (RMON) software. Furnish the license(s) and additional copies of the software to allow it to be installed on all the laptop computers and workstations designated by the Engineer to a maximum of 30 total seats.

Furnish software capable of monitoring all nodes and utilized ports on the 10 Gig-E base enterprise including nodes managed by the City of Greensboro MIS Department. Furnish software cable of 50% expansion in the number of nodes and ports managed over the number of nodes and

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ports present and utilized at the final acceptance of the project as documented in the RDD.

The software shall use a GUI to configure, manage, and monitor the local network. At a minimum, the software shall provide the following functions and features:

- SNMP based
- Full management of network firewall
- Support SSH
- Utilize a GUI Web/Browser style interface
- Provide a schematic display of the entire network enterprise that may be drilled down to the port level or panned out to and CORE level
- Provide Inventory tracking
- Provide bandwidth monitoring
- Provide SMTP support
- Provide auto alerting
- Monitor QOS
- Support management VOIP
- Support NETFLOW
- Support Wireless network management
- Receive SYSlog messages
- Generate usage/error reports
- Be capable of “pushing” upgrades to network gear via TFTP
- Detect switch failures.
- Detect router failures
- Detect hub failures.
- Detect cable failures.
- Provide network performance information.
- Support the monitoring of cabinet and equipment temperature alarms via use of SNMP traps.

F. Category 5E Cable and Wall Information Outlets

Furnish Category 5E network cable, RS-232, monitor cabling, and all other cabling in the lengths required to interconnect devices as called for in the plans, specifications, and manufacturers requirements. Furnish quality and grade of cable capable of being operable at up to twice the distance installed on this project. Furnish cabling meeting all manufacturers’ requirements and all applicable standards for performance and safety.

Furnish wall information outlets as required, with RG-45, RJ-11, BNC, or other connectors as required to terminate cabling in walls and floors for connection to devices and components.

G. LAN Patch Panel

Furnish LAN Patch Panels in the locations shown in the Plans. Patch panels shall be rack-mounted.

Furnish patch panels that meet or exceed Category 5E transmission requirements of TIA/EIA-568A supporting bandwidths up to 100 MHz. Furnish patch panels that are UL-listed. Furnish patch panels that provide for rear punchdown termination of horizontal cables from the office workspaces, provide at least 48 ports and occupy no more than 2 RUs mounting height EIA standard 19" equipment rack. All ports shall provide 8-position modular jacks for jumper cables and they shall be accessible from the front of the patch panel. Jumper cables shall be neatly arranged using cable management guides or an approved equivalent.

30.4. CONSTRUCTION METHODS

A. General

Contact Engineer prior to entering any building. Coordinate and obtain approval from Engineer regarding allowable working time in buildings. No activity at the PTRTMC facility done under this project shall result in the PTRTMC system operations being unavailable between the hours of 6:00 AM and 6:00 PM on weekdays.

Furnish MAC addresses for all equipment utilized as part of this project. Affix MAC Address label to each device utilized. Furnish IP addresses for all equipment utilized as part of this project. Affix final IP address each device utilized. Use labels that do not smear or fade.

In field equipment cabinets, fully integrate new Ethernet switches with the fiber optic interconnect centers. Integrate all field equipment as call for.

Fully integrate switches, routers, firewall, and external modems, with computer and central system hardware to form a complete local area network that allows users from the City of Greensboro's TOC and NCDOT's PTRTMC as shown on the block diagram in the Plans to access applications on application servers and the CCTV central hardware. Fully integrate network to allow the notebook computer users to be able to connect to the network via the LAN port or Card on the notebook computer using a network cable or via the wireless LAN access point.

Fully integrate LAN to accomplish HUB and local device failover and fault tolerance.

Fully integrate LAN equipment to provide virus protection, user authentication, and security functions to prevent unauthorized users and data from entering the signal system LAN.

B. Ethernet LAN Switches

Install and integrate all Ethernet switches at field and central locations as depicted in the diagrams and tables and called for in these Project Special Provisions. Integrate with new, MIS furnished and existing LAN equipment as called for. Integrate with computer hardware, and field devices as called for.

Integrate Ethernet network to maintain all existing LAN connectivity between the NCDOT PTRTMC and the City of Greensboro as well as all additional connectivity called for under this project.

Provide inline surge protection for all Ethernet connections in field cabinets.

Configure and test all Ethernet equipment prior to installation.

Do not install 10 Gig-E Layer 3 Ethernet Switches in to field equipment cabinets (HUBS D, J, and I) until field equipment cabinet has been tested and verified to maintain proper operating environment and optical fiber connections to form HUB to HUB connections have been completed and HUBS D, J, and I can be connected optically to complete their HUB to HUB connections as called for in the Plans and these Project Special Provisions.

C. Firewall

Configure 10 Gig-E Layer 3 switches to segment and provide firewall from 911 Operator Operating Workstations, the NCDOT PTRTMC LAN with the exception of the regional video sharing access and control, digital video, and other network services at the PTRTMC as requested by the Engineer; the City of Greensboro Enterprise LAN, and the existing City of Greensboro Internet web server used to publish streaming CCTV traffic video to the Internet via the City's website. Configure 10 Gig-E Layer 3 switches to permit the use of VPN/Internet remote access solutions for Laptop computers with client software accessing system servers, for City of Greensboro Workstations utilizing non-LAN connections to access system servers, (e.g. users from a home computer), and users not connected to the LAN but accessing the network via Internet connections (e.g. users in the NCDOT Division 7 offices or the NCDOT Central Traffic Engineering Branch Offices in Raleigh).

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D. Remote Access

Configure 10 Gig-E Layer 3 switches and remote access sever for remote access of Laptop and Workstation computers to access system applications in conjunction with client software of VPN links via secure, encrypted, Internet connections and/or Intranet connections.

Configure 10 Gig-E Layer 3 switches and remote access sever and integrate with existing City of Greensboro Citrix™ remote access solution to facilitate remote access to system applications via a Citrix Metaframe™ session.

E. Category 5E Cable and Wall Information Outlets

Route Category 5E network cabling in raised floors, drop ceilings, existing cable raceways, and locations approved by the Engineer at Firestation #9 (MIS 539)(Hub B), Firestation #12 (MIS 527)(Hub C), Sanford Smith Building (MIS 563)(Hub E), the Melvin Municipal Building, the City of Greensboro Signal Shop, the Justice Drug Complex, and the PTRTMC to interconnect LAN equipment and computer hardware equipment as called for in the Plans and these Project Special Provisions.

F. LAN Patch Panel

Install LAN patch panel(s) into communications rack cabinets at Firestation #9 (MIS 539)(Hub B), Firestation #12 (MIS 527)(Hub C), Sanford Smith Building (MIS 563)(Hub E), the Melvin Municipal Building, the City of Greensboro Signal Shop, the Justice Drug Complex, and the PTRTMC to interconnect LAN equipment and computer hardware equipment as called for in the Plans and these Project Special Provisions.

G. Terminal Server

Install terminal servers at DMS locations in the field equipment cabinet. Configure and integrate existing DMS server at Justice Drug Complex to enable existing DMS software to communicate with the DMS units via the terminal server and Ethernet network with modification in performance or functionality from the current serial connection between the existing DMS server and the existing DMS units.

H. Network Performance Management and Remote Monitoring Software

Install Network Performance Management Software on laptop computer and workstation

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computers as designated by the Engineer.

Populate Network Performance Management databases with data for each node, port, device, and network element.

I. Testing

Test all hardware to be integrated and all cabling installed or re-used in accord with IEEE 802.3 requirements. Test all integrated equipment in conformance with manufacturer requirements and recommendations. Test all LAN links and test failover, fault-tolerance of links. Develop network test plan and submit to Engineer for approval as part of system testing as described in **Section 35** of these Project Special Provisions.

Test all network firewall and remote access configurations developed, deployed, or integrated under this project.

30.5. MEASUREMENT AND PAYMENT

Field Ethernet Switch will be measured and paid for as the actual number of Ethernet switches furnished, installed, and accepted. All SFP modules, optics, cabling, attenuators, configuration, and testing or other labor or materials required to install and integrate the field Ethernet Switch will be considered incidental and not be paid for separately.

DSL Ethernet Switch will be measured and paid for as the actual number of DSL Ethernet switches furnished, installed, and accepted. All optics, cabling, attenuators, configuration, and testing or other labor or materials required to install and integrate the DSL Ethernet Switch will be considered incidental and not be paid for separately.

Terminal Servers will be measured and paid for as the actual number of Terminal Servers furnished, installed, and accepted. All cabling, configuration, modifications to the software on the existing DMS server, modifications to the existing DMS Server hardware, testing or other labor or materials required to install and integrate the Terminal Server will be considered incidental and not be paid for separately.

LAN Integration will be paid for and measured as lump Sum. LAN integration including configuration and integration of all LAN hardware, firmware, and software to complete the LAN architecture. Integration of the existing City of Greensboro firewall and integration of Internet based software applications with Greensboro's existing Internet connection infrastructure shall be incidental and not paid for separately. All cabling, hardware, accessories, labor, and materials not

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provided with City of Greensboro MIS furnished network equipment required to make the unit function as part of this project shall be considered incidental and not paid for separately. Furnishing, installing, and configuring, the LAN Network Performance Management and Remote Monitoring Software shall be included as part of the LAN integration and not paid for separately. Partial payments for this item will be made on the following schedule: 20% upon completion and acceptance of the RDD; 20% upon installation, integration and acceptance of LAN equipment at the TOC, 20% upon installation, integration and acceptance of LAN equipment at HUB locations, 20% upon deployment and acceptance of the Network Performance Management and Monitoring Software, and 20% upon installation, integration and acceptance of the entire project furnishing of and acceptance of network as-built documentation.

Payment for all cabling, jumpers, adapters, sockets, LAN patch panels, and other hardware shall be considered incidental and no separate payment will be made.

Payment will be made under:

Field Ethernet Switch	Each
DSL Ethernet Switch	Each
Terminal Server	Each
LAN Integration.....	Lump Sum

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31. CENTRAL VIDEO SYSTEM**31.1. DESCRIPTION**

Furnish, install, and fully integrate closed-circuit television (CCTV) control software at the TOC and remote locations as shown in the block diagrams.

Furnish, install, and fully integrate Central Video CODECs at the Melvin Municipal Building and the PTRTMC.

Furnish, install, and integrate LCD Monitors and at the TOC, the City of Greensboro Signal Shop, and the Justice Drug Complex.

Furnish and install video wall monitor framing system in the TOC.

Furnish, install, and fully integrate Network Video Recorder in the TOC computer room.

31.2. MATERIALS**A. General**

All central video equipment shall operate at 115 VAC (+/- 10 percent) at 60 Hz (+/- 10 percent). The equipment shall operate in a +32 to +120 degree F environment at 20 to 80 percent relative humidity.

B. Central Video Software

Furnish a network-ready, client-server Central Video software package that operates over the System Network.

Furnish commercial off the shelf (COTS) Central Video Software Package.

Provide licensing to provide up to 50 simultaneous full function client connections

The Central video software shall manage MPEG 4 and MPEG 2 digital video streams output from the video CODEC units provided under this project via the Ethernet communications network.

Furnish CCTV central control software that allows the user to:

- Select CCTV field units
- Control selected CCTV units via software based graphical controls and, for workstations so equipped, a fully functional CCTV control keypad
- Assign field CCTV images and component device output (NVR) to monitors,

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workstations video capture cards, and component device inputs

- Assign workstation monitor images to LCD and projection monitors furnished and installed as part of this project
- Allows television tuner images to be routed to LCD and projection monitors furnished and installed under this project.
- Integrate with NCDOT's regional video sharing and distribution system to allow for:
 - Users on the City of Greensboro video system to view and control CCTV units terminate on the NCDOT analog video matrix switch through the Ethernet network connection between the two centers and the CCTV Control GUI furnished as part of this Software
 - Users on the NCDOT regional video system, including users at the PTRTMC and City of Winston-Salem TOC shall be able to access and control CCTV units that reside on the City of Greensboro Ethernet network via the LAN connection between the PTRTMC and the City of Greensboro. This shall be accomplished through modification of the existing Protronix Video Pro Enterprise (VPE) software to permit the control of City of Greensboro CCTV unit via the VPE GUI and the transmission of CCTV video over the center to center Ethernet connection and the Video decoders called for under this project.

Furnish Central Video Software with the following features:

- Support MPEG 2 and MPEG 4 streams at all transmission rates available via the CODEC units supplied under this project.
- Support digital video resolutions including D1, ½ D1, SIF, QSIF, VGA, QVGA, AND QQVGA STREAMS
- Support TCP, multicast and unicast streams
- Display the streams in real time at 25 frames per second
- Support the viewing of up to 12 simultaneous per monitor or projection unit connected to a Video Monitor Processor unit installed and integrated under this project
- Shall utilize standard, server class computers and not require special or custom hardware for video display to the LCD monitors and projector units furnished under this project

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- Permit the remote configuration of VIDEO codec units supplied under this project
- Manage up to 250 IP streams
- Shall transcode MPEG-4 streams to Windows Media Format for publication to the world-wide-web. Each transcoded stream shall have an IP address for use on the City of Greensboro and NCDOT Traffic Management Websites that display streaming video of City of Greensboro CCTV units
- Support predefined layout of video views on LCD Monitors and projection units in any combination of up to 12 simultaneous streams. Up to 20 different configurations may be set for each video monitor processor.
- Support the viewing of real time, streaming video in an Internet Browser window for any computer in the enterprise with client software.
- Support the creation of JPEG still images from any of the video streams on the enterprise
- The software shall auto discover new encoders and decoders of the brand make and model supplied under this project.
- The software shall allow client users to set preferences for
- The Central video software shall manage MPEG 4 and MPEG 2 digital video streams output from the video CODEC units provided under this project via the Ethernet communications network.
- The central video shall work with the LAN equipment and computer hardware installed and integrated under this project.

All third party database or other COTS software required to provide the functionality called for shall be included as part of the Central Video Software.

B.1. Operator Access Privileges

Provide up to 36 unique operator identification passwords. Operator privileges shall be definable by the system administrator. At a minimum, the following privileges shall be definable (yes/no) for each operator:

- Video switch control

- Pan, tilt, zoom camera control
- Programming control
- NVR control

In addition, the software shall allow these privileges to be assigned by TOD/DOW/DOY.

B.2. Programming Control

Provide user-defined programming of up to 100 timed events. Provide the user with the option to associate an alphanumeric name with each event. Provide 7-day, 24-hour programming ability.

At a minimum, programmed events shall include:

- Assigning CCTV field units and other input devices to any monitor or workstation on the enterprise
- Command pan/tilt unit to a defined pre-set
- Initiate a video tour
- Activate or deactivate the NVR

The software shall allow for up to six (6) events to be initiated per timed event.

The software shall permit the manual override of the scheduled events.

B.3. System Wide Graphical User Interface

The graphical user interface (GUI) shall provide a graphic map of the overall project area with icons representing camera locations. This graphic shall be identical to the map used for the signal system software. Selecting an icon will provide the user with camera control, unless the camera is in use by another user. If the selected camera is in use by another user, a message identifying the current user shall be displayed. In addition, a display showing the camera's current user defined preset position will be shown. The map shall include all existing City of Greensboro CCTV units, all CCTV units installed and integrated under this project, and all NCDOT CCTV units in Guilford County that terminate at the PTRTMC.

B.4. CCTV Control Graphical User Interface

A GUI based system will be used to facilitate CCTV control. The CCTV control GUI shall be available to every computer with a client version of the software. The CCTV control GUI shall control all CCTV units furnished under this project, all existing City of Greensboro CCTV units integrated under this project, and all existing Pelco Spectra 3/Spectra 4 units integrated under this project via the modification to the regional CCTV system. The GUI shall permit the following

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- Variable Speed, pan/tilt positioning of CCTV unit
- Focus: near/far
- Zoom: in/out
- Iris: open/close
- Auto iris override

C. Central Video CODEC**C.1. Functional Requirements**

The Central CODEC unit shall consist of video encoder units and video decoder units that are card slot based installed in rack mount chassis. Card-mounted video encoders shall be used to conserve rack space in the PTRTMC. PTRTMC card-mounted video encoders shall be provided with a card cage that supports at least six encoders for every 3 rack units (3RU)

The video encoder units will meet all of the requirements of the Field Video CODEC in **Section 27** with the exception that it shall be card mounted and installed in a chassis.

The video decoder card shall be mounted and shall support all of the formats of the Field Video CODEC in **Section 27**. The video decoder will take as inputs MPEG-2 and MPEG-4 streams as inputs from the Ethernet network and decode them into base band NTSC video.

The Central CODEC units shall be from the same manufacturer and be the same make and model with the exception of the card mounting and where applicable, the decoding functionality of the Field Video CODEC. The Central Video CODECs encoders and decoders shall be interchangeable in the rack mount chassis.

D. Network Video Recorder (NVR)

Furnish and install network video recording (NVR) software to archive video from CCTV cameras in the field. Furnish NVR software that is compatible with the video management software.

Furnish and install NVR software with the following minimum features:

Furnish network video recorder and all necessary software and hardware to store CCTV video streams for a user-defined length of time. The CCTV cameras to be stored shall be user selectable.

The network video recorder shall support a minimum of 100 cameras at 30 frames per second, 4 common intermediate format (CIF) resolutions, and it shall supply a minimum of 32 simultaneous playback streams and 10 simultaneous queries. The network video recorder shall be expandable to support additional ports for up to 250 cameras and 64 simultaneous playback streams. The network

video recorder shall be capable of continuous, scheduled, alarm/event, and motion recordings. The network video recorder shall have pre- and post-alarm recording available, and shall be fully programmable on a per-channel basis.

The network video recorder shall have expandable storage capacity and it shall maximize storage efficiency that identifies data to be removed when storage time expires. The network video recorder shall offer both unsecured and secured modes, using a proprietary key system in the secured mode to prevent unauthorized devices from communicating with the device.

The network video recorder shall offer plug-and-play configuration and data authentication facilities. The network video recorder shall have outputs viewable on a minimum of 32 individual workstations simultaneously, shall record video, audio, and data streams for every channel, and shall have storage locking. The network video recorder shall have full over-the-network remote control and administration, and it shall have system diagnostics and error logging.

The network video recorder shall provide performance enhancement and fault tolerance by employing RAID 5 disk management across up to 12 hard disk drives, and, in addition, it shall feature a hot drive swap that automatically configures the drives when installed.

The network video recorder shall meet or exceed the following functional specifications while supporting the storage and playback requirements noted in this chapter or as otherwise approved by the Engineer:

- EIA 19 Equipment Rack Mounted
- Processor: Quad Core Pentium Xeon or Itanium Processor
- Internal Memory: 4 GB DDR
- Internal Operating System: Windows™ Server 2003 or approved equal
- System Storage (storage for server processor and application software: 100 GB
- Video Storage (storage for video): 14 days of storage for each video stream from CODECs available on the network at maximum resolution and transmission rate. Storage and system shall be expandable to accommodate ultimate 250 video stream capacity of Central Video Software resolution and transmission rate
- Interface: SATA, hot-swappable
- RAID Level: 5
- Video Resolution: 4CIF: 704 x 480, 2CIF: 704 x 240, CIF: 352 x 240, QCIF: 176 x 120
- Network Interface: Two Gigabit Ethernet RJ-45 ports (1000BaseT)

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- Auxiliary Interface: Three high-speed USB 2.0 ports
- Power Input: 100-240 VAC, 50/60 Hz, autoranging
- Power Supply: Internal, dual-redundant, hot-swappable
- Operating Humidity: 20% to 80% noncondensing
- Dimensions: Maximum 3 RU per component

Provide system software to interface with the network video recorder. The software shall have a graphical user interface with drag-and-drop operations and shortcut menus. The software shall allow users to view live video, record video; and search, playback, and export recorded video. Recorded video shall be searchable by device, time, and date. The software shall provide an administrative interface to configure the network video recorder, set up users with rights and permissions, and creating recording schedules. The software shall have the following minimum characteristics:

- Runs on workstations with Windows XP operating system
- Synchronized playback of 4 camera video streams
- Digital zoom in live or playback video
- Export video and still images in MPEG-4 and JPG formats
- Be capable of video playback using its own player, the Windows Media Play, and the Central Video Software player.

Provide twenty (20) seat licenses for the network video recorder system software.

E. LCD Video Monitors

Furnish new minimum 50" LCD video wall monitor. The video monitors will be used in a 24/7/365 environment.

LCD Video Monitor shall be UL listed, FCC Part 15 compliant, and shall meet FCC Class A or Class B device requirements, and Bellcore GR-1089-CORE electromagnetic compatibility requirements. Equipment shall meet the following specifications, standards, and subparts as applicable.

All video monitor equipment shall have any safety handling related instructions plainly marked on its case.

All switches, indicators, and connectors shall be clearly and permanently marked as to identity and function. Printed circuit boards shall have permanent markings, including a part number and functional name. Each removable module shall, as a minimum, include a permanently attached (e.g.,

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stamped, etched, etc.) part number. Each removable module shall also include a permanently attached serial number. All component identifications shall correctly correspond to schematics, parts lists, and written narratives included in operation/maintenance manuals.

Display monitors shall provide the following features and functions at a minimum:

- 1280 x 768 native pixel resolution
- One (1) Ethernet Port with 10/100 Network interface card
- 16.7 million displayable colors
- Brightness of at least 450 candela per square meter
- Contrast ratio of 600:1 or better
- 15:9 aspect ratio
- One BNC or RCA connector for NTSC composite color video input
- One digital RGB DVI input
- One S-video input
- One Analog RGB computer UXGA video input
- RS-232 DB-9 interface control port
- Audio L/R stereo inputs and outputs
- Infrared remote control
- Switching between video inputs via remote control, on the monitor panel, or via serial port
- Horizontal and Vertical viewing angles of at least 160 degrees
- Swing-out articulating arm wall-mounting brackets

Each LCD video display monitor shall have a nominal operating temperature range of 5°C to +40°C and 20 to 80 percent relative humidity, non-condensing.

Each video display monitor shall weigh no more than 100 pounds without attachments/brackets and no more than 150 pounds with mounting brackets and tilting hardware. Each display cabinet should be no more than 12" deep, 49" wide, and 31" high.

Each LCD video display panel shall operate from 115 V +/- 10%, 60 Hz +/- 5% VAC input power. Power consumption shall be no more than 550W per display panel. Each video display panel

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shall be supplied with all the necessary hardware needed for mounting to wall as directed by the engineer.

F. Video Projection Unit

Furnish Video Projection Unit (VPU) for CCTV video and computer graphics. The projected display, measuring a minimum of 100 inches diagonally and shall be clearly readable in a fully-lighted room from any viewing angle within 30 degrees of an axis perpendicular to the screen. Furnish projector with minimum image resolution of 1280 X 1024 pixels minimum. Furnish unit capable projecting the following input formats and resolutions: NTSC; PAL; SECAM; VGA; S-VGA; XGA; S-XGA; U-XGA

The VPU shall be contained within a compact, chassis-style/high resolution LCD projector. Furnish VPU projector that meets or exceeds the following specifications:

- Variable focus lens with throw distance between 1.5 and 3 times screen width
- 1,500-Hour Lamp (User Replaceable)
- 2200 ANSI Lumens Brightness
- Input video resolutions up to 2000x1280
- One (1) Ethernet Port with 10/100 Network interface card
- RS232 Serial Port for PC/Serial Device Control
- (2) Computer RGB Inputs; (1) NTSC Video Inputs
- On-Screen Menus/Bar Graph Displays
- Built-In Test Pattern Generator (Color Bars, Checkerboard, etc.)
- Digital Image Size, Freeze, and Enlarge Features
- Ten Programmable and Selectable Source Settings
- Hinged Panel For Quick Lamp Replacement
- Custom Color Temperature Adjustment
- ISO 9001 Certification
- FCC Part 15 Class B Compliance For EMI

Furnish VPU unit with wireless remote control with lens and unit control capabilities. Wireless remote shall be able to control the unit from a minimum distance of 25 feet, and shall be able to control the unit from an operator workstation when in its ceiling mounted position.

Furnish unit that has Ethernet LAN connectivity, is IP addressable, and has software that permits

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unit control by users on the LAN. This may be achieved through use of a terminal server.

Furnish unit that is ceiling mountable and contains all hardware and accessories required for ceiling mounting. Ceiling mounting shall be capable of sustaining a minimum dead load of 1.5 times the unit's weight and shall permit the user access to the units control panels, communications ports, input ports, and output ports. Unit shall be able to be removed from and replaced to the ceiling mounting bracket by the user without use of tools.

- Operating temperature Range 32 Degrees F to 95 Degrees F
- Humidity 0%-95%, non-condensing
- Voltage 120 VAC, 60Hz

Furnish all hardware, software, and cabling to form a complete system including RS-232 cabling, Ethernet cabling and software.

G. Video Wall

Furnish video monitor wall framing system to hold eight (8) 50" video monitors of the size and weight called for in these specifications and a 80" diagonal large screen for projection of the video projection unit. Furnish video framing system that is constructed of wood or other approved material and is finished with scratch resistant paint or other approved surface. Furnish system that permits full view of all contained monitor units and full access to all knobs, buttons, and dials on front and sides of monitor units. Furnish system that allows a minimum of 12" between the bottom of the large screen and the floor. Furnish system that allows for the placement and removal of monitor units without use of tools. Furnish system that is free standing and secured to the floor. Furnish system that has slots, grommet holes, and cable raceways, for the discrete placement of cabling such that no cabling is visible from the front or sides of the system. Furnish unit that fits into the TOC operator room. Furnish system that allow for the addition of at least 2 additional units video monitors of the size and weight of those being provided under this project. Prior to construction of the video monitor framing system, develop shop drawings and submit to Engineer for approval prior to commencement of construction of the video monitor wall framing system. .

31.3. CONSTRUCTION METHODS**A. General**

Install and test all central video equipment in accordance with the manufacturer's

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recommendations.

Route all cabling in ceiling, floor, conduit, or cable raceways unless otherwise approved by the Engineer.

B. Central Video CODEC

Install video encoders and video decoders at in the Melvin Municipal Building and the PTRTMC in the quantities and at the locations shown on the plans. Integrate with network LAN switches, UHF modulator, rack cabinets, and existing analog video matrix switches to form as called for in the Plans.

C. Network Video Recorder (NVR)

Install digital video recorder into equipment rack in TOC Computer Room and integrate with LAN to provide digital recording of all video streams from field and central CODEC units.

D. LCD Video Monitor

Install LCD video monitors as shown in the Plans. Insure that monitor is installed securely and in a fashion that allows for their removal for maintenance and access to monitor display controls. Connect, configure, and fully integrate new monitor with the video matrix switch. This includes installation of cabling and connection of monitors to power source. Route cabling in ceiling, floor, and raceways as approved by the Engineer. Integrate with Video Monitor Processor units.

E. Video Projection Unit

Install Video Projection unit on ceiling of TOC Computer Room. Position to allow for clear resolution, 80" diagonal image on the video wall.

31.4. VIDEO SOFTWARE INTEGRATION AND TESTING**A. Integration**

Install and fully integrate Central Video software on CCTV server called for in **Section 29** of these Project Special Provisions as required.

Install and integrate the Central Video software with field hardware. Install Central Video client software on all workstation computers and laptop computers where the client Distributed Signal System Software is called for installation in **Section 28** of these Project Special Provisions.

Install and fully integrate Central Video Software with Video Monitor Processor units.

Modify and fully integrate existing Protronix VPE software to provide existing functionality and additional functionality called for herein for user accessing view and control of City of Greensboro

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CCTV units and for users of the City of Greensboro Video system that accessing view and control of NCDOT and City of Winston-Salem CCTV units.

Develop and submit to Engineer for approval high level central video software design document that describes all major elements and functionality of the Central Video software and describes the modifications to the Protronix VPE software.

B. Testing**B.1. General**

Provide the following tests and demonstration of the system software:

- System Operational Test (as called for in **Section 35**)
- 120-Day Observation Period (as called for in **Section 1** and **Section 35**)

31.5. MEASUREMENT AND PAYMENT

Central Video Software shall be measured and paid for as lump sum. The lump sum unit price includes furnishing, installation, testing, and all materials, equipment, labor, tools, storage, shipping, and incidentals necessary to install the software, complete system integration, and provide a complete operating system. Partial payment for this item will be made as follows: 20% upon approval of the high level Central Video Design Document; 40% upon delivery and installation of the software and 20% of upon successful completion of the Observation Period.

Central Video CODEC will be measured and paid for as the actual number of video CODEC units furnished, installed, integrated, and accepted.

Network Video Recorder will be measured and paid for as the actual number of network video recorders furnished, installed, integrated, and accepted. All software, hardware, labor, and materials to configure, deploy, and integrate the Network Video Recorder shall be considered incidental and not paid for separately.

LCD Video Monitor will be measured as the actual number of LCD video monitors furnished, installed, integrated, and accepted.

Video Projection Unit will be measured as the actual number of Video Project Units furnished, installed, integrated, and accepted.

Video Wall will be measured and paid for as the actual number of video wall video monitor

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framing units furnished, installed, and accepted.

No direct measurement will be made for surge suppression strips. These will be considered incidental to the devices attached to them.

No direct measurement will be made for cabling used to interconnect devices within buildings including coaxial cabling, network cabling, serial cabling, and power cabling. These items will be considered incidental to the devices they are connected.

Configuration and integration of central video components will be considered incidental and shall not be measured separately.

No separate payment shall be paid for installation and integration of network video recorder software or the modification of the Protronix VPE software. This work will be considered incidental and measured separately.

Payment will be made under:

CCTV Central Software.....	Lump Sum
Central Video Codec.....	Each
Network Video Recorder.....	Each
LCD Video Monitor.....	Each
Video Projection Unit.....	Each
Video Wall.....	Each

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32. SUBMITTAL DATA**32.1. DESCRIPTION**

The intent of this Section of the Project Special Provisions is to provide the requirements and process by which submittal data shall be reviewed.

32.2. SUBMITTALS**A. General**

Provide the submittal data which meets the requirements of this Section. All documentation, except as otherwise specifically approved by the Engineer, shall meet the following requirements:

Provide reproducible documents no larger than 22 x 34 inches in size for any documentation which exceeds the size of 11 x 17 inches. No documentation shall be smaller than 8.5 x 11 inches. Reproducible documents shall not be folded or creased.

All documentation shall be considered as an item of work and shall be completed before acceptance of the Project.

B. Project Implementation Schedule

Develop and submit to the Engineer, a Project Implementation Schedule in accordance with Section 108-2 of the Standard Specifications.

The project implementation schedule shall address all major activities, components, and milestones of the project, and shall at a minimum include the following:

- Contractor Submissions
- Equipment Deliveries
- Sample and Materials Testing
- Major Construction Events
- System Installation Milestones
- In-Place Component Testing
- Training
- 120-Day Observation Period
- Final Acceptance

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Demonstrate compliance with the sequence of construction detailed in **Section 1** of these Project Special Provisions and in the Plans.

C. Certification

Provide written certification to the Department that all Contractor-furnished material is in accordance with the contract. When requested by the Department, provide additional certifications from independent testing laboratories and sufficient data to verify item meets applicable Specifications. Ensure additional certification states the testing laboratory is independent of the material manufacturer and neither the laboratory nor the manufacturer has a vested interest in the other.

D. Submittal Data

Identify all proprietary parts in Contractor-furnished material. The Department reserves the right to reject material that uses proprietary components not commercially available through electronic supply houses.

For Contractor-furnished material listed on the QPL, furnish submittals in the format defined by the QPL.

For Contractor-furnished material not on the QPL, furnish three copies of the equipment list including three (3) copies of catalog cuts. Identify proposed material on catalog cuts by a reproducible means (highlighter pen does not transfer to copies). Ensure material lists contain material description, brand name, manufacturer's address and telephone number, stock number, size, identifying trademark or symbol, and other appropriate ratings. Submit for review by the Engineer 40 days prior to installation. Do not fabricate or order material until receipt of the Engineer's approval.

The purpose of the submittal data is to show specifically and in detail how the Contractor intends to satisfy the requirements of these Project Special Provisions and the Plans. If pre-printed literature is used to satisfy some or all of these requirements, cross off and initial statements on the literature which conflict with these Project Special Provisions or Plans. Attach appropriate statements clearly indicating each requirement given in these Project Special Provisions and provide a comparison on how the submittal meets or exceeds the requirements. Clearly label each item of submittal data with the bid item number or other description of the item(s) to which it applies.

Each formal submittal shall contain sufficient information and details to permit the Engineer to fully evaluate the situation. Submittals which are, in the judgment of the Engineer, insufficient to permit proper evaluation will be rejected. Do not deviate from formal submittals marked

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“Approved” or “Approved as Noted” without the written consent of the Engineer.

Because of the nature of this work, detailed submittal data is required prior to approval of most of the items in order to avoid non-conformance that does not become apparent until it is too late to correct without serious consequences. In addition, because certain groups of items as set forth below are closely interrelated, it is required that the submittals on the items in each group always be made as a group with complete information being resubmitted each time, if more than one submittal is necessary. Plan the submittal data effort accordingly.

In order to expedite the submittal data process and equipment review, address all of the requirements of these Project Special Provisions and the Plans in the submittal data, leaving nothing to assumption and clearly addressing the functional and technical interrelationships among the various items. Except for cabinets, detailed wiring diagrams are not required as part of the submittal data nor will they be reviewed unless specifically required by these Project Special Provisions or by the Engineer’s request.

Submittal data for the items in each of the following groups shall be submitted as an integrated unit:

- Group A – Central System and Local Controller Software
- Group B – Cabinet and Controller Equipment
- Group C – Fiber Optic Network Cable, Twisted Pair Cable, Wireless Radio, and Equipment
- Group D – Ethernet Communications and LAN Equipment
- Group E – Computer Hardware and Peripherals
- Group F – CCTV Camera Assemblies and Wi-Fi Mesh Units
- Group G – Central Video System
- Group H – System Support Equipment and Test Equipment

The items in each of these groups will also be reviewed and approved as an integrated unit. Submittals for items not included in the above groups may be made independently.

The submittal data for all groups shall list the Project Special Provision section and sub-section requirements for each hardware item being considered for use on this project. It shall also show the corresponding data from the hardware item being submitted and how the submittal meets or exceeds the requirements. Attach appropriate documents or statements indicating how the submittal will

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fulfill the Project Special Provisions. This shall be all-inclusive for each pay item. Hardware submittals that do not address all the requirements in the Project Special Provisions will be rejected for insufficient information.

Cabinet prototypes shall be considered submittals.

Plan for any given package of submittal data to be in the hands of the Engineer for forty (40) calendar days. Following review of the submittal data, the Engineer will return to the Contractor one (1) copy or an agreed upon number of the submittal marked "Approved", "Approved as Noted" or "Rejected". The Engineer will also mark each item which must be resubmitted. Proceed with any items marked "Approved". Also proceed with items marked "Approved as Noted" if resubmission is not required. Do not proceed with any items, which are marked "Rejected", or with items for which resubmission is required but shall proceed immediately to correct said items and resubmit them for review. No time extensions shall be granted as a result of the need to resubmit various items for review. Review by the Engineer of various items shall not relieve the Contractor of his obligation to furnish and install the work in accordance with these Project Special Provisions and the Plans.

Develop a submittal data transmittal form and submit the same to the Engineer for approval as to format. Assign a submittal number to each submittal package, which shall be transmitted under the cover of the approved form. The numbering system shall be logical and ascending. Specifically list on the transmittal sheet each item or element included. (An element is one part of several parts of information related to the same line or pay item.) When drawings are submitted, each shall be listed separately. Completely fill out all portions of the transmittal sheet except those reserved for use by the Engineer. The transmittal sheet will be used by the Engineer to indicate the action taken on the submittal package and a copy of the transmittal sheet showing these actions will be returned to the Contractor. Only clearly related items shall be transmitted under the same transmittal sheet.

32.3. MEASUREMENT AND PAYMENT

Submittals shall be incidental to the contract price for each item requiring submittal data.

No separate payment shall be made for submittals.

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33. DOCUMENTATION**33.1. DESCRIPTION**

This section specifies the documentation to be provided by the Contractor.

33.2. DOCUMENTATION

Provide as-built documentation. All documentation, except as otherwise specifically approved by the Engineer, shall meet the following requirements:

- Provide any documentation that exceeds the size of 11x17 inch paper in a reproducible format 22x34 inches in size.
- No documentation shall be smaller than 8.5x11 inches.
- Reproduces shall not be folded or creased.

Provide documentation, at a minimum, for the following.

A. Plan of Record Documentation

Prepare as-built drawings that depict any change of components, measurement or layout of the Plans. All construction changes, with the final location and depth of conduits, wiring external to the cabinet, locations of splice closures, system detector locations, and SMFO cable terminations, etc., shall be shown in detail in reproducible format. These as-built drawings of construction changes shall be submitted as soon as that change is complete. Each change shall be noted and dated. Failure to revise as-built documentation to reflect current work may result withholding of payments until the as-built documentation is brought current. The submitted as-built may be field-checked by the Engineer at his discretion. If the as-built documentation is found to have an unacceptable number of inaccuracies, the Engineer may withhold payment until the as-built plans are corrected. The Plans shall include all field installations including the SMFO cable network installed.

One (1) reproducible drawing of the Plans and one electronic copy of the plans will be provided to the Contractor for his use. Provide any other base maps that may be necessary to comply with this requirement.

Any changes made to the original plans shall be made by modifying the original electronic files such that all changes are marked with callout boxes.

Within ten (10) days after the observation period begins, furnish one reproducible copy of the draft as-built plans in hard copy format for review. Provide draft hard copy as-builts on 22x34 inch

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bond plan sheets.

Correct any comment to the draft as-built plans upon review by the Engineer prior to the acceptance of the project. Submit final as-built plans in electronic and hard copy format. Provide electronic plans in MicroStation (latest release in use by the Department) format on CD . Submit hard copy as-builts on 22x34 inch plan sheets.

The Engineer will provide electronic copies of MicroStation design files for the original plans (including splice details) for the Contractor's use in preparing as-built drawings. Any other base maps that may be necessary for the Contractor to prepare the as-built drawings in accordance with this special provision will be the Contractor's responsibility. Use CADD conventions that are consistent with those used on the original plans. Designate any changes to drawings in a method approved by the Engineer. Correct any errors to the as-built plans upon review by the Engineer prior to the acceptance of the project. Submit final as-built plans in electronic and hard copy format. Provide electronic plans in MicroStation (latest release in use by the Department) and AutoCAD formats on compact disc (CD).

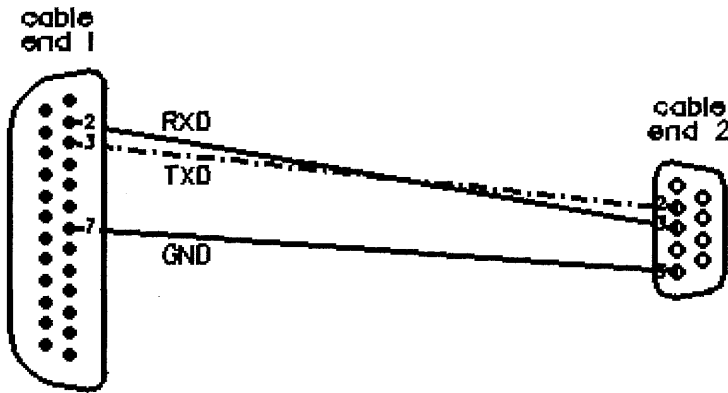
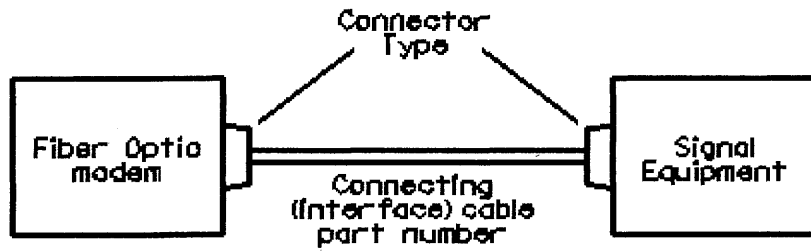
B. Wiring Diagrams

Provide detailed wiring diagrams that include interconnection (wired and wireless) of equipment with pinout configurations, pin functions, and cable part numbers. This includes configurations at each controller or equipment cabinet and at central locations. Provide two copies of system connection diagrams showing system interconnection cables and associated terminations. Use naming convention approved by the Engineer and conforming to Belcore standards.

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Example:



connector 1 pin number			connector 2 pin number
2	—————	RXD	3
3	—————	TXD	2
7	—————	GND	5

Provide one electronic copy of the wiring diagrams in MicroStation and AutoCAD formats.

C. Splice Diagram

Prepare as-built splice diagrams that depict the communications cable plant as constructed. The splice diagram shall depict the splices made at each splice enclosure by identifying fiber spliced and buffer tube. The splice diagram shall be in a format similar to those provided with the project plans. All expressed fibers, spare fibers, used fibers and capped fibers shall be identified.

Original splice diagrams will be provided in electronic format in a MicroStation format. Designate any changes to these diagrams by using a method as approved by the Engineer. Furnish as-built splice diagrams in Microstation and AutoCAD formats on a CD and in hard copy format.

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D. Manuals and Equipment Documentation**D.1. Cabinets, Controllers and Test Equipment**

Furnish documentation in accordance with the Standard Specifications with the following additions:

- Operating instructions and maintenance manuals shall be bound, and consist of minimum 8.5x11 inch with 11x17 inch minimum schematics. Operating instructions and maintenance manuals shall be provided for each type of traffic signal equipment, including controllers, controller software, traffic signal monitors, and detector cards. Twenty five (25) sets of such manuals and instructions and one (1) set of electronic PDF files on CD shall be provided to the City.
- Except for the test cabinet, two sets of operating instructions and two sets of maintenance manuals shall be furnished for each item of test equipment specified in these Project Special Provisions.
- The controller cabinet and CCTV cabinet wiring diagrams shall be provided on 22x34 inch plan sheets. These shall include final as built field hook-ups, system and local detectors, fiber optic communications interface connections, preemption wiring, surge protection, and all auxiliary relays. These final diagrams shall reflect any changes made to the original diagrams. Hand marked changes shall be allowed. Two (2) copies of the cabinet wiring diagrams shall be provided for each controller and CCTV assembly provided. One copy shall be submitted to the Engineer and the other shall be placed in the cabinet for future reference.

Five (5) copies of draft documentation shall be submitted to the Engineer for written approval no later than the delivery of the corresponding equipment. Upon written approval by the Engineer, submit final documentation for field hardware prior to the end of the 120-day observation period.

In addition to the documentation specified above, provide and install in a weatherproof holder that is mounted within each cabinet, prints of schematic diagrams applicable to the equipment contained in the cabinet.

D.2. CCTV Field Equipment

Furnish one (1) copy of manuals for each camera site detailing: the operation of; the maintenance and troubleshooting procedures for; and parts lists for each piece of equipment furnished. This shall include, but not be limited to:

- CCTV cameras

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- Pan-tilt units
- Camera housings
- Camera control receiver
- CODEC units

D.3. Central Video Software

Furnish two (2) copies of manuals for Central Video software installed under this system detailing the configuration, the operation, maintenance, and troubleshooting procedures for controlling the new and existing CCTV cameras that are part of the system. Furnish documentation that describes the configuration, operation, maintenance, and troubleshooting procedures for existing video subsystems modified under this project including:

- Regional video sharing subsystem
- Justice Drug Complex 911 Operator Video Access
- City of Greensboro Channel 13 link
- City of Greensboro Website Streaming Video Links

D.4. Distributed Signal System Software

Provide and submit to the Engineer for written approval, full and complete documentation for all of the Distributed Signal System Software that has been furnished and installed as part of this project.

New flow charts and descriptive graphics shall be prepared and furnished as necessary, indicating connection to and relationship to existing program modification, additions and changes to the base software and their programs or routines.

Prepare and supply complete and fully debugged listings of all source coding provided with and used in the development of this system. Three (3) copies of the source code shall be provided on CD-ROM.

Supply three (3) copies of the distributed processing traffic signal system software documentation (and three (3) copies of the CCTV software, if a stand alone package is furnished) to the Engineer forty days (40) before the initial applications software test. From the date of computer delivery until acceptance of the project, update the Engineer's software documentation within two (2) weeks of performing any software changes. If the software documentation does not reflect the current software operation, the Engineer may stop all work on the project until the software

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documentation is updated. Maintain one (1) debugged and current backup version of the software on disk on-site at all times, once the computer has been delivered. Failure to maintain this documentation shall be grounds for the Engineer to halt the project until it is provided.

Supply four (4) additional current traffic control applications software documentation manuals, four (4) copies of distributed signal system software on CD-ROM, and two (2) copies of program listings to the Engineer prior to acceptance of the project. Also demonstrate to the Engineer that the backup version of the program on disk is debugged and current. Provide this backup version to the Engineer after acceptance of the project.

D.5. Traffic Control System User's Manual

Submit four (4) copies of the System User's Manual for review and approval by the Engineer 40 days prior to the initial applications software test.

These manuals shall consist of two (2) volumes:

- Procedures for equipment setup, program loading, operating procedures, operational options, program monitoring, recovery procedures, and error message definition and corrections.
- Procedures for preparing, updating, and troubleshooting the database and pattern histories.

The operation of the TOC LAN, file servers, microcomputer workstation, printers, and plotter shall be described in detail with respect to display of program information and parameters, changing of input parameters, and operation of special keys and other equipment.

Sample output formats shall be provided. They shall be reproductions of laser printer, plotter, and workstation display outputs. The computer information required to provide such a display shall be illustrated with the appropriate output format.

A complete list of error messages associated with the software operation shall be provided for both the system operation and the database and pattern history. Each error message that could appear during system operation shall be defined as to the actual meaning, cause, and corrective action to be taken. This information shall be in addition to the basic troubleshooting and malfunction information that shall be provided.

This System User's Manual shall be continually updated on a monthly basis to reflect the current applications software. Failure to perform this task shall allow the Engineer to halt work on the project until this task is corrected and demonstrated to the satisfaction of the Engineer.

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Submit to the Engineer five (5) final copies of the System User's Manuals immediately prior to the acceptance of the project. These manuals shall be updated to reflect the current system operation and the Engineer's comments. The Engineer shall approve in writing these manuals before final acceptance of the project.

D.6. Traffic Management System Communications Network**33.3. MEASUREMENT AND PAYMENT**

All documentation shall be considered incidental to the construction of the system and shall be completed before acceptance of the Project.

Preparation of as-built drawings shall be considered incidental to the bid items and no separate payment shall be made.

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34. SYSTEM SUPPORT AND TEST EQUIPMENT**34.1. DESCRIPTION**

Furnish fiber-optic system support equipment and signal system support equipment with all necessary hardware in accordance with the Plans and these Project Special Provisions.

All system support equipment shall be furnished and accepted prior to completion of the observation period.

34.2. MATERIALS**A. General**

Furnish equipment with test probes/leads, batteries (for battery operated units), line cords (for AC operated units), and carrying cases. Provide operating instructions and maintenance manuals with each item.

Prior to starting any system testing or training, furnish all fiber-optic system and signal system support equipment.

B. Signal System Support Equipment

Furnish new, unused signal system support equipment to the Engineer in the quantities shown below:

- Twenty (20) 2070L signal controllers as specified in **Section 23**
- Four (4) base-mounted 336 cabinets as specified in **Section 23**
- Four (4) pole-mounted 332 cabinets as specified in **Section 23**
- Five (5) DC isolator cards as specified in **Section 23**
- Five (5) AC isolator cards as specified in **Section 23**
- Eighty (80) detector cards as specified in **Section 23**
- Twenty (20) conflict monitors as specified in **Section 23**
- Ten (10) field Ethernet switches as specified in **Section 30**
- Two (2) DSL Ethernet switches as specified in **Section 30**
- Two (2) Wi-Fi access points as specified in **Section 26**

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B.1. Controller Tester**B.1.1. General Features**

Provide bench type aluminum housing. Input panel and output panel shall be mounted at an angle to provide ease of viewing. Ensure that the tester incorporates handle(s) and a place to store the C1 and C11 harness' for ease in transport. Suit case style housing is not acceptable.

Provide tester with a power switch and pilot lamp.

Provide terminations for each C1S and C11S connector pin, in the tester, so each function will be available for troubleshooting and/or testing.

Provide an internal DC power supply to operate output LED indicators, so that no power is drawn from the controller under test.

Provide means for testing controller AC power interruption, adjustable from .1 seconds to 2.5 seconds (minimum). Ensure power receptacle for controller is fuse protected.

Provide the following test points for external measurement:

- Neutral – Connected to power line neutral.
- Logic Ground – Connected to controller logic ground.
- Power Interrupt – Connected to the power interrupt circuit (12 VDC circuit).

Ensure test points are five-way binding post type.

Provide neatly screened labeling for all inputs and outputs. Stickers, overlays or “taped-on” labels are not acceptable. Ensure labeling corresponds to local controller software as given in this specification.

Provide rubber “feet” to minimize slippage on bench top.

B.1.2. Output Display

Provide a LED for each controller output. Ensure that each of the 8 vehicle phases, pedestrian phase, and four overlap LED indicators are of appropriate color, and are identified with the appropriate C1 pin number.

Provide LEDs that are the bright, wide angle viewing type. Ensure the color of the LED can be distinguished without power applied to the output display (diffused type).

Provide a display that is phase oriented with LEDs arranged in vertical rows. Phase function shall be indicated (1, 2, 3, etc.). Each overlap shall be indicated (A, B, C, D). Other C1 outputs

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should be placed in an area separate from the intersection display and overlap display. C11 outputs shall be in an area separate from all other outputs.

Ensure each LED output indicator is identified with the appropriate C1 pin number. Ensure that the functions of the outputs are labeled per the local controller software. No other vendor specific functionality shall be present on the display panel:

B.1.3. Input Panel

Provide “on-off-momentary” toggle action switches for all inputs. Ensure switches lock into position when the user pushes the switch “up”, and is momentary when the user pushes the switch “down”.

Ensure each switch is labeled as per the functions of the local controller software. Ensure the switch is also identified with the appropriate C1 pin number. No other vendor specific functionality shall be present on the input panel.

B.2. Signal Monitor Tester with Notebook Computer

Furnish a stand-alone portable signal monitor test unit with notebook computer intended for use on work-bench. The Tester shall use/control an Intel-based notebook computer for input/output. The Tester shall test Signal Monitor displays, timing and voltage functions, and input/output combinations of either true or false conflicts. Any software provided with the tester shall be modular, menu driven, and offer a “help” screen. A video “setup/usage” training tape shall be provided with each unit. All input/outputs shall be in plain English. It shall be possible to generate a hardcopy printout, or to store the results to a disk file. A “No Faults Detected” indication shall be displayed as appropriate.

B.3. Test Cabinet/Controller

Furnish and install two (2) test cabinet/controllers at the Signal Shop. The test cabinet shall include a 2070L controller in a Type 336 cabinet and a 2070L controller in a Type 332 cabinet.

Furnish and install one (1) test cabinet/controller at the TOC. The test cabinet shall include a 2070L controller in Type 332 cabinet.

The test cabinets shall include plexiglass doors and be placed on coasters. The test cabinets shall include a full complement of detector amplifiers, switch packs, a signal monitor, and field Ethernet Switch. The test cabinets shall also contain two (2) AC Isolators, two (2) DC Isolators and a Rail Road preempt test panel. Rail Road preempt test panel should be of the same type provide for Rail Road crossing locations in the field. The test cabinets and panel shall be fully labeled.

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B.3.1. Construction

The test cabinet shall have a heavy-duty aluminum dolly base with heavy duty casters. The base shall accommodate a fully equipped base-mounted cabinet/controller. A pole or pedestal shall be attached to the base to support a display panel, which shall be located beside the cabinet convenient for use by maintenance personnel. The panel shall have all indicators and switches on the front, and shall have a suitable aluminum enclosure. The panel shall be fully labeled.

B.3.1.1 Indicators

The panel shall contain indicators to display the outputs of all the cabinet's traffic signal load switches. Red, yellow, and green indicators shall be used to display the outputs of the traffic signal load switches. In addition, indicators shall be provided for four (4) pedestrian displays and four (4) special functions. The indicators shall use incandescent bulbs or LED's that are user replaceable.

B.3.1.2 Controls

The panel shall be equipped with controls which are connected to simulate all of the inputs, for test purposes, to the controller which are not already accommodated by switches in the controller cabinet.

B.3.1.3 Harnesses

The panel shall be connected to the controller cabinet by means of harnesses. The harnesses shall be concealed in the pedestal or pipe supporting the panel and shall enter the cabinet from the bottom.

B.3.2. Connection to System

The test controllers will be connected to the system on dedicated communication channels. Furnish and install a jumper cable sixteen (16) feet (minimum). This jumper cable shall be used to connect the test cabinet's fiber optic Ethernet switch to the communication system. (The connection point will be the fiber termination panel at the TOC).

B.4. CCTV Test Cabinet

Furnish and install one (1) CCTV test cabinet at the Signal Shop.

The test cabinet shall include a Type 336 cabinet as installed at field locations under this project. The test cabinets shall include plexiglass doors and be placed on coasters. The test cabinets shall include a CCTV test panel, video codec unit, field Ethernet switch, and all cabling necessary to integrate all cabinet equipment. The test cabinets and panel shall be fully labeled.

Integrate the test cabinet with the CCTV assembly furnished as system support equipment in this

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section.

B.4.1. Construction

The test cabinet shall have a heavy-duty aluminum dolly base with heavy duty casters. The base shall accommodate a fully equipped base-mounted cabinet. A pole or pedestal shall be attached to the base to support a CCTV camera, which shall be located beside the cabinet convenient for use by maintenance personnel.

B.4.2. Connection to System

The test controllers will be connected to the system on dedicated communication channels. Furnish and install a jumper cable sixteen (16) feet (minimum). This jumper cable shall be used to connect the test cabinet's Ethernet switch to the communication system.

C. Fiber Optic System Support Equipment

Furnish new, unused fiber optic system support equipment to the Engineer in the quantities shown below:

- Three percent (3%) of each fiber count of fiber optic cable installed as specified in **Section 13** and furnished on reels
- Ten (10) control cabinet fiber optic interconnect centers as specified in **Section 14**
- Ten (10) aerial splice enclosures as specified in **Section 14**
- Fifty (50) mechanical ST-type splice connectors as specified in **Section 14**
- Two hundred (200) ST-type jumpers of 3 foot length as specified in **Section 14**
- Two Hundred (200) factory connectorized (ST-type) pigtails of ten foot length as specified in **Section 14**
- Fifty (50) mechanical SC-type splice connectors as specified in **Section 14**
- Two hundred (200) SC-type jumpers of 3 foot length as specified in **Section 14**
- Two hundred (200) factory connectorized (SC-type) pigtails of ten foot length as specified in **Section 14**
- Ten (10) units of heat shrink tubing for risers as specified in **Section 9**
- Ten (10) heat shrink retrofit kits as specified in **Section 9**

C.1. Fiber-optic Restoration Kit

Furnish a fully functional fiber-optic restoration kit consisting of the following items (minimum):

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- Plier-type strippers
- Non-niks fiber stripper tool with procedures
- Buffer tube stripper tool with procedures
- Fiber-optic Cleaver (average cut less than 0.5 degrees from perpendicular) Diamond Blade
- Screw driver set
- 48 Alcohol wipes
- Tape, 3/4-inch, electrician
- Kim wipes
- Metal ruler
- Tweezers
- Crimping pliers
- CamSplice assembly manual
- CamSplice assembly fixture
- 12, Non-adhesive, mechanical, CamSplice, splices
- 2 Mechanical Splice Trays, 12 CamSplices Capacity, Compatible with the Interconnect Centers being installed in the Traffic Signal Controller Cabinets
- Scissors
- Hard-sided, padded, storage case

C.2. Fiber-optic Power Meter

Furnish fiber-optic power meters for measuring absolute power and link losses, as well as monitoring power levels and testing threshold levels. Provide the following features:

Spectral range	750 nm to 1700 nm
Calibrated wavelengths	850, 1310, and 1550 nm
Accuracy	± 3 percent (± 0.1 dB at -20 dBm at 70 degrees F) at calibrated wavelengths
Readout resolution	4 digits, 0.01 dBm
Display	Backlit LCD

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Fiber-optic connector	ST type
Power-up stabilization	Less than five seconds at ambient temperature
Tone threshold settings	User selectable from 1 to 35 dB, plus OFF
Analog output port	Voltage: 0 to + 1 V FSD of linear power range Output impedance: 5 kilohms, nominal
Temperature	Operating: 32 to 122 degrees F Storage: 0 to 150 degrees F
Relative humidity	5 to 95 percent, non-condensing
Battery power	Alkaline: 28 hours NiCad: 8 hours (recharger and NiCad batteries provided)
Carrying case	

C.3. Optical Light Generator

Furnish optical light generators for measuring absolute power and link losses, as well as monitoring power levels and testing threshold levels. Provide the following features:

Calibrated wavelengths	1310 nm, and 1550 nm
Accuracy	3 percent at 70 degrees F at calibrated wavelengths
Fiber-optic connector	ST type
Power-up stabilization	Less than five seconds at ambient temperature
Temperature	Operating: 32 to 122 degrees F Storage: -10 to 150 degrees F
Relative humidity	5 to 95 percent, non-condensing
Battery power	Alkaline: 28 hours NiCad: 8 hours (recharger and NiCad batteries provided)
Carrying case	

D. OTDR

Furnish handheld OTDR device for testing, troubleshooting, and certifying fiber optic cables. Provide the following features:

Wavelengths	1310 nm +/- 25nm, and 1550 nm +/- 30nm
Pulse Width	5ns, 20 ns, 40ns, 100ns, 300ns, 1us, 3us, 10us

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- Color Full Color
- Picture Elements 480 (H) x 234 (V)
- Dot Pitch 0.171 (W) x 0.264 (H)
- Back Light Built In
- Controls Color, brightness, on/off, tint, red & blue drive
- Supply voltage 12 VDC, 500 mA
- Connectors Switchable video – BNC; Power – DC jack
- Operating Temperature 32 degrees F to 104 degrees F
- Dimensions (maximum) 5.5 inches (W) x 3.6 inches (H) x 1.8 inches (D)
- Weight (maximum) 1 lb

Include 12 feet of power and video cables with the monitor and case. Furnish monitor with all equipment necessary to operate from 120 VAC power source.

F. Wireless Radio System Support Equipment

Furnish two (2) spread spectrum wireless radio modem units, Type A, as specified in **Section 25**.

34.3. MEASUREMENT AND PAYMENT

Item in this section will be measure and paid for as follows:

Actual number of 2070L controllers furnished and accepted.

Actual number of 336 cabinets furnished and accepted.

Actual number of 332 cabinets furnished and accepted.

Actual number of DC isolator cards furnished and accepted.

Actual number of AC Isolator cards furnished and accepted.

Actual number of detector cards furnished and accepted.

Actual number of conflict monitors furnished and accepted.

Actual number of field Ethernet switches furnished and accepted.

Actual number of DSL Ethernet switches furnished and accepted.

Actual number of Wi-Fi access points furnished and accepted.

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Actual number of controller tester units furnished and accepted.

Actual number of signal monitor tester units furnished and accepted. Notebook computer shall be considered incidental to the signal monitor tester and will not be paid for separately.

Actual number of test 332 cabinet and controller units furnished and accepted.

Actual number of test 336 cabinet and controller units furnished and accepted.

Actual number of CCTV test cabinets furnished and accepted.

Linear feet of fiber optic drop cable furnished and accepted.

Linear feet of fiber optic communications cable furnished and accepted.

Linear feet of fiber optic plenum rated communications cable furnished and accepted.

Actual number of fiber optic interconnect centers furnished and accepted.

Actual number of splice enclosures furnished and accepted.

Actual number of ST splice connectors furnished and accepted.

Actual number of ST jumpers furnished and accepted.

Actual number of ST pigtails furnished and accepted.

Actual number of SC splice connectors furnished and accepted.

Actual number of SC jumpers furnished and accepted.

Actual number of SC pigtails furnished and accepted.

Actual number of heat shrink tubing for risers furnished and accepted.

Actual number of heat shrink tubing retrofit kits furnished and accepted.

Actual number of fiber optic restoration kits furnished and accepted.

Actual number of fiber optic power meters furnished and accepted.

Actual number of optical light generators furnished and accepted.

Actual number of OTDR units furnished and accepted.

Actual number of CCTV assemblies furnished and accepted.

Linear feet of CCTV camera unified cable furnished and accepted.

Linear feet of outdoor rated Ethernet cable furnished and accepted.

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Actual number of CCTV test monitors furnished and accepted.

Actual number of video codec units furnished and accepted.

Actual number of spread spectrum wireless radio systems furnished and accepted.

Payment will be made under:

.Furnish 2070L Controller	Each
.Furnish 336 Cabinet.....	Each
.Furnish 332 Cabinet.....	Each
.Furnish DC Isolator Card.....	Each
.Furnish AC Isolator Card.....	Each
.Furnish Detector Card	Each
.Furnish Conflict Monitor	Each
.Furnish Field Ethernet Switch	Each
.Furnish DSL Ethernet Switch	Each
.Furnish Wi-Fi Access Point.....	Each
.Furnish Controller Tester	Each
.Furnish Signal Monitor Tester	Each
.Furnish Test 332 Cabinet/Controller	Each
.Furnish Test 336 Cabinet/Controller	Each
.Furnish CCTV Test Cabinet	Each
.Furnish Drop Cable (6-Fiber)	Linear Foot
.Furnish Drop Cable (12-Fiber)	Linear Foot
.Furnish Communications Cable (12-Fiber)	Linear Foot
.Furnish Communications Cable (24-Fiber)	Linear Foot
.Furnish Communications Cable (36-Fiber)	Linear Foot
.Furnish Communications Cable (48-Fiber)	Linear Foot
.Furnish Communications Cable (72-Fiber)	Linear Foot

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·Furnish Plenum Rated Communications Cable (24-Fiber).....	Linear Foot
·Furnish Plenum Rated Communications Cable (96-Fiber).....	Linear Foot
·Furnish Plenum Rated Communications Cable (144-Fiber).....	Linear Foot
·Furnish Fiber Optic Interconnect Center	Each
·Furnish Splice Enclosure	Each
·Furnish ST Splice Connector	Each
·Furnish ST Jumpers	Each
·Furnish ST Pigtails.....	Each
·Furnish SC Splice Connector.....	Each
·Furnish SC Jumpers	Each
·Furnish SC Pigtails	Each
·Furnish Heat Shrink Tubing.....	Each
·Furnish Heat Shrink Tubing Retrofit Kit.....	Each
·Furnish Fiber Optic Restoration Kit	Each
·Furnish Fiber Optic Power Meter	Each
·Furnish Optical Light Generator	Each
·Furnish OTDR	Each
·Furnish CCTV Assembly	Each
·Furnish Unified Cable.....	Linear Foot
·Furnish Ethernet Cable (Outdoor Rated).....	Linear Foot
·Furnish CCTV Test Monitor	Each
·Furnish Video Codec Unit	Each
·Furnish Wireless Radio System, Type A.....	Each

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35. TESTING & ACCEPTANCE**35.1. DESCRIPTION**

Test all equipment and cable furnished and installed under this Contract. Conduct this testing in the presence of the Engineer. **The Department reserves the right to perform any inspections deemed necessary to assure that the equipment conforms to the requirements specified herein.**

Perform factory and field testing (both pre- and post-installation) on the local controllers, cabinets, and related hardware.

Cable provided under this contract shall have been pre-tested in accordance with the EIA/TIA Fiber Optic test procedures and as required by Bellcore GR-20-CORE. Supply proof of successful testing, including documentation of test results.

35.2. EQUIPMENT TESTS**A. Factory Tests**

Test a representative, random sample of the equipment furnished to prove compliance with the environmental and electrical requirements of the Project Special Provisions.

Select at least one (1) of each or five (5) percent of the total field units supplied, whichever is greater, for testing. Field units are defined as follows:

- CCTV Camera Assembly

Properly operate test field units for two (2) hours after having been stabilized at the minimum specified temperature, humidity, and voltage. After these tests, operate test units in a proper manner for two (2) hours at the specified normal input voltage after the temperature has been stabilized at 68 degrees F.

The Engineer may accept certified test reports from previously conducted tests of the same models and series as the ones being supplied if the procedure was satisfactory and the documented results indicate compliance with the environmental and voltage specifications.

B. Workshop

The Engineer shall witness all tests.

Provide an enclosed workshop with a test board for testing new controllers and cabinets before installation. Locate the workshop within the City of Greensboro. Ensure that the workshop provides protection from weather and sufficient space to house two test observers, test material, and

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controllers and cabinets being tested.

Upon receipt of the traffic signal controller cabinets and controllers in Greensboro, set up the designated cabinet/controller for each intersection at your facility in Greensboro. Load all local phase timings and coordinated system parameters onto the controllers prior to beginning the test period.

Test controllers and cabinets for proper operation, color sequence, flashing operations (including late night flash) and phase timings. Demonstrate that malfunction management programming cards are properly programmed before installation at intersections. Demonstrate that simultaneous inputs to conflicting phases will cause the malfunction management unit to revert the cabinet to flashing operation.

Connect and test each unit to ensure that controllers and cabinets operate without malfunction for at least eight (8) hours in the workshop before installation at an intersection. Following this test, and prior to installation, the Engineer will inspect the equipment in operation to insure conformance to the requirements of the Plans and these Project Special Provisions. These inspections by the Engineer will be made in minimum size lots of five (5) cabinets.

Demonstrate to the Engineer that all of the equipment furnished, installed or modified at each location operates in full compliance with the Plans and these Project Special Provisions.

35.3. SYSTEM OPERATIONAL TEST

All equipment and software provided in this project shall be fully installed and operational prior to the start of the system operational test. These test procedures shall demonstrate that all equipment is fully integrated and operational, and is properly controlling the system.

Testing of the software and hardware at the TOC, Signal Shop, PTRTMC, Emergency Management Center, Division 7 Office, and other necessary locations shall include demonstrating proper operation based on these project special provisions. These tests shall also demonstrate the proper function of the CCTV surveillance system, including camera selection, pan/tilt/zoom functions, and remote monitoring of video images. These tests shall also demonstrate the proper operation of the new intersections on the graphics display system, the full functionality of the installed operator workstation, and demonstrating proper reception of video signals on the monitor, video equipment, including multiplexers, screen splitters, and control panels.

Submit a system acceptance test procedure to the Engineer for review and approval before any tests are to be conducted.

Submit a System Operational test plan a minimum of sixty (60) days prior to the scheduled start

of the test. Within thirty (30) days of receipt, the test plan will be reviewed by the Engineer, and either approve it or indicate changes that are required for approval. The Contractor shall then submit the revised test plan. This process shall be repeated until the Engineer is able to approve the test plan.

Provide an operational test matrix at least four weeks prior to the scheduled beginning of the system operational test. The test matrix shall include columns for a description of the test, a summary of the test procedures, a column with sufficient space for comments and a status (pass/fail) column.

Repair or replace any component or software module that fails the System Operational Test. Retest repaired or replaced component(s) or software module.

The testing shall include, but not be limited to, the following:

- Demonstration of all key functions of the distributed processing signal system software, including but not limited to:
 - Uploading and downloading of controller data
 - Remote access and paging
 - All monitoring functions
 - Detector logging
 - Traffic responsive operations
 - Event scheduler
 - Security functions
 - Graphic displays
 - Reports
- Power failure recovery, auto re-boot, and start-up of the distributed processing signal system software
- Database access, modification, storage, and retrieval
- Database backup and restoration from archived backup
- Dial-up and remote access to the signal system software and CCTV software
- Local Area Network operations

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- Demonstrate that all features of the CCTV central software operates as called for with all field equipment

A. Intersection Operational Tests

The Department will conduct complete intersection inspections and operational tests for each project intersection. These inspections and tests will determine whether all the field equipment at each location is installed and permanently labeled properly, and that all functions are in conformance with the Contract Documents. The intersection operational tests will be a non-central controlled functional test of the local controller, including the time-base coordination, emergency vehicle preemption and railroad preemption functions, system detectors, and the full operation of the intersection. All work at the intersection except fiber optic cable installation and termination must be completed for the operational test. This work includes the installation of risers, conduit, junction boxes, conduit entrance into the existing foundation, and fiber optic interconnect center.

B. CCTV and Wi-Fi Operational Tests

The Contractor shall be required to perform a stand alone test of each CCTV camera and Wi-Fi access point installation to demonstrate that each site is fully operational. The test will be conducted at each location utilizing Contractor-supplied software and hardware. The tests shall demonstrate the full control and display capabilities of CCTV cameras, and the full wireless capabilities of the Wi-Fi access points.

C. Cable and Communication Tests

Fiber optic cable tests shall be performed on all cable after installation, splicing and termination. All of the fibers shall pass these tests.

Following the fiber optic cable installation, test the entire length of each fiber in each cable using an optical time domain reflectometer (OTDR) at both 1310 nm and 1550 nm. The Engineer or his representative will witness all OTDR tests. Provide the Engineer with durable, labeled plots of the results for each fiber. Also provide these plots on electronic media. Submit calculations demonstrating that the OTDR results for each fiber meet the attenuation requirements of these Project Special Provisions, and that the installation process has not impaired the optical properties of the cable.

If the OTDR results indicate that the cable, splices, or terminations do not meet the attenuation specifications, or if they indicate that the optical properties of the cable have been impaired during installation, then, at your expense, take such action as the Engineer may approve to correct the problem. This may entail complete replacement of the fiber optic cable.

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At a minimum, include the following documentation and tests in the fiber optic cable testing program:

- List of test equipment.
- Cable attenuation measurements in both directions, including average link losses, for every fiber in every segment of every cable.
- Loss for each splice and connection.
- OTDR trace for each fiber with every event annotated.

Wireless radio test shall be performed on all wireless links installed in the system. The test shall confirm that the Signal Strength (dBm), Fade Margin (dB), Signal-to-Noise Ratio, and Data Integrity (poll test) of the links are within the manufacturer's recommendations.

35.4. OBSERVATION PERIOD

Upon successful completion of the System Operational Test and the correction of all known deficiencies, including minor construction items and punch-list items developed by the Engineer, a 120 day Observation Period shall commence. The purpose of this period is to determine that all components of the signal system function in accordance with the Plans and these Project Special Provisions over an extended length of time.

System or component failures that occur during the 120 day Observation Period shall be responded to by the Contractor within two (2) hours, and corrected within twenty-four (24) hours. Failures that affect any of the major system components defined below for more than seventy-two (72) hours shall suspend the timing of the 120 day Observation Period beginning at the time when the failure occurred. After the cause of such failures has been corrected, timing of the 120 day observation period shall resume. System or component failures that necessitate a redesign of any component, and failures in any of the major system components exceeding a total of three (3) like major system components in any thirty (30) day period for the entire complement of major system components, shall terminate the 120 day Observation Period and shall cause the 120 day Observation Period to be restarted from zero when the redesigned component has been installed and/or the failures corrected. The major system components are:

- Local controllers and cabinets
- Fiber Optic Communication Network
- System hardware and software
- CCTV System

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- Local Area Network and Ethernet Switches

The 120 day Observation Period is considered to be a part of the work included in the total contract time and must be completed prior to acceptance of the Project. All documentation required by these Project Special Provisions shall be completed prior to the end of the 120 day Observation Period.

Final Acceptance will occur at the successful completion of the 120 day Observation Period and after all documentation requirements have been fully satisfied.

35.5. FINAL ACCEPTANCE

After all equipment and software comprising the system has been accepted, satisfactory completion of the system acceptance test, and after the training is complete, a 120-day observation period begins. This observation period shall serve to evaluate full-scale operation of the system under normal conditions. The City will be responsible for operating the system during this period. The goal of the observation period is to demonstrate that the system has been properly installed and integrated, performs properly, and complies with the Contract Documents.

Upon successful completion of the observation period, the Department will accept the system, providing that all errors and omissions in documentation supplied have been fixed, and all other requirements of the Contract Documents have been met. Final acceptance will be in writing from the Department.

35.6. MEASUREMENT AND PAYMENT

Testing will not be measured for separate payment. Include the cost of all required testing in the unit bid price for other items furnished on this project.

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36. TRAINING**36.1. DESCRIPTION**

Provide training for the installation, operation and maintenance of the computerized traffic system.

36.2. MATERIALS

Provide training to properly install, operate, maintain, diagnose and repair each piece of equipment and the software associated with the system. Provide approved manufacturer's representatives or other qualified personnel to conduct training courses. Provide training for a minimum of fifteen City and Department personnel.

Prior to beginning the training course, submit detailed course curricula, draft manuals, handouts, and resumes of the instructors for review and approval. The Engineer may request modification of the material and request courses desired by the City and Department.

For all training programs, a staff of engineers, technicians, and maintenance personnel familiar with traffic signal systems will be the training participants. A "day" of training shall consist of training conducted between the hours of 8:30am and 4:30 pm. For each session, provide training materials (manuals, notebooks, hand-outs, etc.) as specified in the Documentation Section of these Project Special Provisions.

Qualified instructors shall present all training courses, lectures, and demonstrations in person. The Engineer shall approve all instructors.

Unless otherwise specified, accommodate a minimum of fifteen (15) persons at each session. Limit all hands-on computer exercises to two participants per computer. Furnish additional networked computers (equivalent to those furnished with the project) as necessary to maintain that ratio of two participants per computer.

Conduct all training courses at a location provided by the Contractor within the city of Greensboro and at a time mutually agreed upon, but not later than the start of system acceptance testing. Provide training material, manuals, and other handouts to serve not only as subject guidance, but also as quick reference for use by the students. Deliver course material in reproducible form immediately following the course.

A. Subject Areas

Provide the training sessions at the required durations as listed in the Table below. A more

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detailed description of the required content of each training session is provided in the following sections. As part of the Project Implementation Schedule, propose the time of occurrence of each such training schedule.

Subject	Minimum Duration
System Overview	1 Day
Computer Hardware, Traffic Control Center LAN and Peripherals – Session 1	1 Day
Computer Hardware, Traffic Control Center LAN and Peripherals – Session 2	1 Day
Traffic Control Applications Software – Session 1	3 Days
Traffic Control Applications Software – Session 2	2 Days
2070L Controller Programming, TBC Operation, TR Operation, Controller Hardware and Cabinet Hardware Assemblies, Utility Software (for Signal Timing Personnel and Maintenance Personnel)	3 Occurrences at 5 Days Each
Fiber Optic, Twisted Pair, and Wireless Radio Communications System	2 Occurrences at 3 Days Each
Central and Field Communications Equipment	3 Days
CCTV System – Session 1	1 Day
CCTV System – Session 2	1 Day
Wi-Fi Access Point Units	1 Day
Microwave Vehicle Detection System	1 Day

B. Required Content and Format**B.1. Traffic Control System Overview**

This training session shall consist of a lecture and discussion on the overall. The purpose of the session is to provide an overview of the traffic control system. This training session shall have a minimum duration of one (1) day.

B.2. Computer Hardware, Control Center LAN and Peripherals

The training session shall consist of classroom training and workshops regarding the operation of each of the traffic control system hardware elements and the operator interface. Conduct training by experienced vendor personnel.

The first session shall involve the operation and maintenance procedures for each element of the traffic control system hardware. As part of this session, stress the precautions that must be observed

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when operating the equipment. As a minimum, cover the following subjects in this segment of the training session:

- Overview of equipment functions and interactions.
- Computer system operation; restart, cold start.
- Functional operation of the servers, Ethernet Control Center LAN and DAT backup system (including maintenance, paper replacement, etc.)
- Traffic Control Center and Signal Shop workstation and printer operation, maintenance, paper replacement, etc.
- Central communication operation.
- Troubleshooting and problem identification of equipment.

At a minimum, the second session shall consist of the following:

- Operating system, including network operating system
- Operating system commands, including loading and executing programs, and archiving data to the backup system
- Detection of abnormal conditions within the operating system and hardware
- File management and disk organization
- Techniques for creating and editing files, including those used for the traffic control system databases

Each of these two training sessions shall have a minimum duration of one (1) day (lectures and/or workshops).

B.3. Traffic Control Applications Software

These two (2) sessions of training for NCDOT and City staff shall include the basic theory and functional application and operation of the traffic control software supplied by the Contractor, including the interface between the application program and the microcomputer operating system. This training system shall include but not be limited to:

B.3.1. Session 1

The first session shall cover the fundamentals of the traffic control software supplied by the Contractor. This shall include, but not be limited to:

- Time-of-day operation and event scheduling

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- Reporting capabilities
- Interactive database manipulation
- Theory and application of traffic responsive operation
- Traffic responsive pattern selection algorithms
- Special function features

The training shall emphasize operation of the system including recommended procedures. Allow sufficient time to answer NCDOT and City questions. This session shall consist of a mixture of lectures and “hands-on” workshops and shall have a minimum duration of three (3) days. Course material shall include the software documentation and the system user’s manuals.

B.3.2. Session 2

The second session shall cover the creation, placement and operation of the dynamic portions of the graphics display of the traffic control applications software. Upon completion of this session the NCDOT and City personnel shall be able to prepare dynamically functioning graphics for the traffic control applications software. The second session shall also cover the theory and operation of the signal timing applications, including Synchro and TS/PP with GPS. This second session shall include lecture and classroom exercises and shall have a minimum of duration of two (2) days. Course material shall include the software documentation and the system user’s manuals.

Maintain the order of these sessions as described above. The length of the sessions may vary with the mutual consent of the City NCDOT and the Contractor.

B.4. 2070L Controller Programming

Hold three identical controller training sessions for maintenance personnel. Each of the identical training sessions shall consist of five (5) consecutive days, beginning on a Monday. **Conduct one of these training sessions prior to the installation of any new controllers and cabinets on the project.**

These three sessions include training for NCDOT and City traffic engineering, signal timing, and maintenance personnel on controller and internal TBC operation and cabinet assemblies.

B.4.1. Controller and Controller Laptop Utility Software (2 Days)

The controller training session for signal timing engineers and technicians shall consist of formal classroom presentation of the functional operation of the 2070L controller furnished by the Contractor, followed by a “hands-on” workshop focusing on actual entry of timing data. The formal presentation and workshop shall have a combined duration of two (2) days. This session shall be

taught by experienced vendor personnel who thoroughly understand both the traffic engineering aspects of signal timing and the entry of timing into the controller and internal TBC's. This session shall cover the entry and editing of:

- All local intersection timing parameters
- All coordination timing parameters
- All parameters and threshold levels associated with traffic responsive operation.

Conduct this session after the system software and test controller are operational and include opportunities for "hands-on" entry and editing of the timing and use of local controller utility software.

B.4.2. Cabinet Assemblies (2 Days)

A minimum of two days shall be provided for this session. A field service specialist(s) employed by the traffic signal controller manufacturer shall conduct the classes. Each maintenance training class shall consist of a formal classroom presentation which covers routine maintenance and troubleshooting procedures for each type of signal controller cabinet assembly furnished by the Contractor, followed by a "hands-on" workshop wherein maintenance personnel will troubleshoot simulated controller and cabinet assembly faults to the component level.

The training shall cover all aspects of wiring the cabinet, inspecting the cabinet, the cabinet assemblies (PDA, input file, output file(s), output load switches, etc.) cabinet maintenance and troubleshooting,

B.4.3. Conflict Monitors and Detectors (1 Day)

The controller maintenance training shall include a session on signal monitors and a session on detector amplifiers. The conflict monitor training shall cover theory of operation, routine maintenance, troubleshooting procedures, and periodic testing to verify that conflict conditions are reliably detected. Detector training shall cover the functional operation, routine maintenance, and troubleshooting procedures for the detector hardware furnished under this contract by the Contractor, including the detector sensor units, lead-in cables, and the loop wire. The training shall include "hands-on" experience in troubleshooting simulated detector problems including malfunctioning sensor units, lead-in cable problems, and roadway loop problems. The training shall include a full description of the detector test procedures.

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B.5. Fiber Optic Communications System

Provide two (2) identical training sessions on the maintenance of the fiber optic communications system shall be held. Each shall be presented by field service specialist(s) employed by the vendors of both the active and passive elements of the fiber optic system. Each identical session shall consist of one (1) formal classroom presentation and one (1) workshop. The training shall cover the procedures for cable terminations and troubleshooting problems in the communications cable network such as the location of cable breaks, emergency (mechanical) splicing procedures, permanent (fusion) splicing procedures, identifying problems associated with the field electronics and the use of the fiber optic test equipment furnished by the Contractor. Each of the identical sessions shall have a minimum duration of three (3) days. These two identical sessions shall be held a minimum of two (2) weeks apart from each other.

B.6. Central and Field Communications Equipment

Provide a training session, conducted by experienced vendor personnel and consisting of both operation and maintenance training of the Central Communication Equipment for the signal system. As a minimum, this session shall include the following subjects:

- Operational theory
- Operational procedures
- Troubleshooting procedures
- Communications validation
- IP/Ethernet theory, configuration, and network management
- Local Area Network Hardware/Software

Provide a workshop session to reinforce the lectures and demonstrate troubleshooting and problem identification of equipment to the component level as well as validation of communications.

This lecture/workshop training session shall have a minimum duration of three (3) days.

B.7. CCTV Central and Field Equipment

Provide two sessions for the CCTV central and field equipment training. The first session shall address the maintenance of the CCTV equipment. The training shall address the preventative maintenance and trouble shooting procedures for all the field and central equipment including the video codec units.

This session shall consist of a mixture of lecture and hands-on workshops and shall have a

minimum duration of one (1) day.

The second session shall address the operational theory and procedures of the CCTV system. This training shall be oriented towards users of the system. The training shall address the use of, but not limited to, the following devices:

- Video Server
- Central Video software
- Network Video Recorder

Include "hands-on" training workshop with a minimum duration of one (1) day as part of this session. The CCTV training sessions shall be presented by field service specialist(s) employed by the suppliers of the CCTV system components.

36.3. MEASUREMENT AND PAYMENT

Training will not be measured, and will be paid on a lump sum basis.

Training.....Lump Sum