PROJECT SPECIAL PROVISIONS

CITY OF ROCKY MOUNT TRAFFIC SIGNAL SYSTEM UPGRADE/EXPANSION PROJECT

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Nash & Edgecombe Counties

Prepared for:

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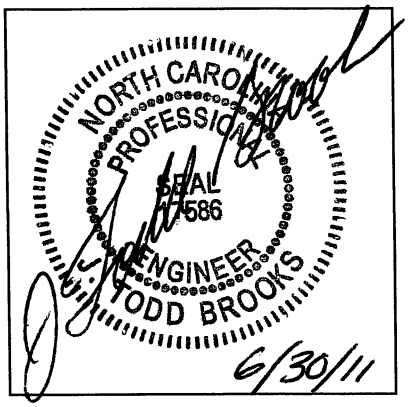

Project Special Provisions

Based On

NCDOT ITS and Signals Project Special Provisions

Version 06.7

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1. GENERAL REQUIREMENTS

1.1. DESCRIPTION

(A) Summary of Work

The purpose of this project is to rehabilitate and expand the existing City of Rocky Mount, North Carolina's computerized traffic signal system. Work will be primarily comprised of communications system replacement and expansion, field equipment upgrades, replacement of the existing CLMATS™ closed-loop traffic signal system with a new distributed processing traffic control system, enhancement of the Traffic Management Center, and the expansion of the video monitoring system. This project includes:

- Signal display upgrades at selected locations and replacement of existing controllers and cabinets with new Model 2070L controllers housed in Model 332 or 336S cabinets for the approximately 150 signalized intersections that will comprise the expanded system;
- Replacement of an existing single-mode and multimode fiber-optic serial communications system with a new Ethernet-based, predominantly fiber-optic communications system comprised of approximately 46 roadway miles of fiber-optic cable along with some wireless communications links; and
- Expanding the existing video surveillance system from 5 existing CCTV cameras to 19 CCTV cameras and replacing the central video equipment and software.
- Replacing the existing closed-loop signal system software and central computers with new distributed processing software and new computer workstations and servers.

Most of the existing signals have NEMA controllers and cabinets that are to be replaced with Model 2070L controllers in Type 332 or 336S cabinets under this project. However, there are some existing independent arterial closed-loop systems that have existing Model 2070L controllers in Type 332/336S cabinets and are linked by existing fiber-optic communications cable. These existing 2070 closed-systems and their fiber-optic communications cable will be incorporated into the expanded and upgraded Rocky Mount Signal System primarily by installing an IP-version of the Department's OASIS™ local controller software on the existing Model 2070L controllers and by replacing the existing fiber-optic transceivers in the controller cabinets with new Ethernet edge switches.

New fiber-optic communications cable will be installed primarily by overlashing to the existing fiber-optic communications cable but also by lashing to new messenger cable, installing in existing underground conduit/duct systems, and installing in new underground conduit/duct systems. To migrate from the existing to the new communications system while minimizing disruptions to signal system operations, the existing fiber-optic communications system will be progressively decommissioned as the new Ethernet-based fiber-optic communications system is progressively built-out and brought online.

Provide a complete, fully functional and fully integrated traffic signal system, video surveillance system, and Ethernet communications system. Perform the following major tasks under this contract, as shown in the Plans (the list that follows is not meant to be all-inclusive):

- Furnish and install a new Ethernet-based fiber-optic communications system for the traffic signal system comprised of fiber-optic cable, fiber-optic drop cables, and fiber-optic splice centers (i.e., splice enclosures, interconnect centers, etc.), Ethernet switches and related electronics;
- Furnish and install underground conduit/duct, junction boxes, risers with heat shrink tubing, risers with weatherheads, messenger cable, fiber-optic cable storage racks, wood poles, and pole guy assemblies with guy guards;
- Furnish and install managed Ethernet switches and Ethernet edge switches;
- Install new cabinets and ancillary equipment, extending existing field wiring as and if necessary;
- Modify existing cabinet foundations and install new cabinet foundations;
- Install new traffic signal controllers;
- Upgrade existing traffic signal displays;
- Remove existing control equipment and cabinets;
- Remove existing fiber-optic communications cable, including associated risers, splice cabinets and junction boxes, where designated in the Plans;
- Furnish and install detector loops, junction boxes, and lead-in cables;
- Furnish and install signal cable;
- Furnish and install CCTV camera assemblies and CCTV cabinets;
- Furnish and install digital video encoders and decoders;
- Modify existing electrical services and install new electrical services and associated grounding;
- Fully integrate all components into a fully-functioning Ethernet-based, fiber-optic communications network.
- Fully integrate wireless communications links, including wireless broadband service installed by the City at remote locations, into the Ethernet-based communications network.
- Fully integrate all traffic signal controllers, system detectors, software, computers and servers into a fully functioning distributed processing traffic control system.
- Fully integrate all CCTV cameras, video components and software into a fully functioning video monitoring system.

Traffic signals and fiber-optic communications cable being installed by others under separate NCDOT TIP and City road improvement contracts will be integrated into the upgraded and expanded Rocky Mount Signal System. These projects include but may not be limited to the following:

<u>NCDOT TIP Projects</u>:

- Northern Connector - from Winstead Avenue to Wesleyan Boulevard (R-2823)
- Hunter Hill Road Widening - from Winstead Avenue to Benvenue Road (U-3621B)
- Winstead Avenue Road Widening- from Sunset Avenue to Hunter Hill Road (U-4019)

<u>City of Rocky Mount Project</u>:

- Downtown Streetscape Improvements Project – Main Street

While some of the traffic signal work on the above projects may be complete by the time construction begins on this signal system project, some work may still be ongoing when signal system construction begins. Contractors for different traffic signal projects who are working within the same area shall coordinate and cooperate with each other. Each contractor shall conduct his work so as not to interfere with or hinder the progress of the work being performed by the other contractors.

(B) Specifications and Special Provisions

Conform to these Project Special Provisions and the North Carolina Department of Transportation (NCDOT) *Standard Specifications for Roads and Structures*, dated July 2006, hereinafter referred to as the "*Standard Specifications*". Conform to the Codes and Regulations described in Section 1700 of the *Standard Specifications*.

Within these Project Special Provisions, the "Department" refers to the North Carolina Department of Transportation, and the "City" refers to the City of Rocky Mount Engineering Department's Transportation Division.

(C) Coordination of Plans, Specifications, and Special Provisions

The *Standard Specifications*, the Plans and these Project Special Provisions are essential parts of the contract, and a requirement occurring in one is as binding as though occurring in all. They are complementary and provide and describe the complete contract. In case of a discrepancy or conflict, the following will apply in ascending order:

- Calculated dimensions shall govern over scaled dimensions;
- Plans shall govern over *Standard Specifications* and *Roadway Standard Drawings*;
- Project Special Provisions shall govern over Standard Special Provisions, *Standard Specifications* and *Roadway Standard Drawings*.

In the event of a contradiction within the Project Special Provisions as to the measurement and payment of any pay item, the text of the respective Measurement and Payment subsection for the pay item in question shall govern.

The contractor shall not take advantage of any apparent error or omission in the contract. In the event such errors or omissions are discovered, the Engineer will make such corrections and interpretations as may be determined necessary for the fulfillment of the intent of the contract.

1.2. MATERIALS

(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.

ITS & Signals Qualified Products List (QPL) is available on the North Carolina Department of Transportation's website. 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, http://www.ncdot.org/doh/preconstruct/traffic/ITSS/SMS/qpl , to obtain pre-approval procedures.

(B) Submittal Requirements

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.

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 or electrical 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 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.

Do not fabricate or order material until receipt of the Engineer's approval.

(C) Observation Period

Prior to final acceptance, all Contractor-furnished equipment and software shall successfully complete a 60-day Observation Period.

The 60-day Observation Period is considered to be part of the work included in the total contract time and must be completed prior to final acceptance of the project.

Final acceptance will occur following the successful completion of the 60-day Observation Period and after all documentation requirements have been fully satisfied.

Refer to the "Testing and Acceptance" section of these Project Special Provisions for additional requirements.

(D) 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 or that are at least one year in length, whichever is greater, from the date of final acceptance of the project by the Department. 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.

For light emitting diode (LED) traffic signal modules, provide a written warranty against defects in materials and workmanship for a period of 60 months after installation of the modules. During the warranty period, the manufacturer must provide replacement modules within 45 days of receipt of modules that have failed at no cost to the Department.

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 and will support user-definable parameters for setting the start and end dates for daylight savings time.

Upon receipt of the Department's written final acceptance of project, transfer manufacturer's warranties with proper validation by the manufacturer to the Department.

(E) 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 software/firmware performance upgrades that occur during the contract period up through final acceptance of the project are furnished to the Department at no additional cost.

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

Provide licensed copies of all software/firmware to the Department. The Department shall have the right to install any and all software/firmware for maintenance and support on all hardware provided under this contract. This shall include but not be limited to all servers for the Signal System, CCTV System, LAN System, traffic signal controllers and network. Provide software/firmware for maintenance and support of workstations, laptop computers, system support software, utility software, traffic signal controllers, and CCTV systems and controllers, and all other programmable devices.

(F) 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 and existing self-supporting communications cable.

(G) Painting

Where painting of 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 or for such items as weatherheads and CCTV camera mounting plates field-installed on existing metal poles. In such cases, apply two field coats of the same color and grade enamel as the original paint to the scratched or marred portions and to the weatherhead and mounting plate. For the aforementioned unfinished components that require field painting, prepare the surface to receive the paint in accordance with the coating manufacturer's instructions, including application of primer.

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.

Identify and label all field wiring (e.g., signal conductors, pushbutton wires, loop detector lead-ins, etc.) in existing controller cabinets prior to disconnecting any field wiring.

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 on the Plans are approximate.

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

Ensure that an IMSA certified, or equivalent, Level II traffic qualified signal technician is standing by to provide emergency maintenance services whenever work is being performed on traffic signal controller cabinets and traffic signal controller cabinet foundations. Standby status is defined as being able to arrive, fully equipped, at the work site within 30 minutes ready to provide maintenance services.

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.

Avoid trimming (i.e., pruning) trees wherever possible. Removal of trees is strictly prohibited. Trimming or pruning of trees that have been designate "historic trees" by the Rocky Mount City Council is prohibited without prior written approval by the City Manager. A historic tree file with corresponding map of historic tree locations is maintained as a public record in the office of the City Clerk. Pruning Contractor will be assessed civil penalties (i.e., fines) for any tree trimming performed by anyone other than an ISA Certified Arborist, for any unauthorized tree trimming, for excessive tree trimming and for any tree removal. Comply with the City of Rocky Mount Code of Ordinances, Chapter 19, Article V at all times.

(B) Work within Historic Districts

Several signalized intersections, some proposed CCTV camera sites and several fiber-optic communications cable routes lie within or adjacent to historic districts. The Department has coordinated with the agencies that have jurisdiction over these historic districts and has received the permits and certificates for the work called for in the Plans in these historic districts. Do not deviate from the work called for in the Plans within a historic district without the prior approval of the Engineer and the agency/agencies that have jurisdiction over the historic district. Where construction work must deviate from the Plans, notify the Engineer in advance so that the Department can request/apply for the appropriate approvals for such changes prior to the Contractor performing work at that location.

Avoid damaging or removing sidewalks and curbs within designated historic districts whenever possible. Do not damage, disturb or remove any existing granite curbs. Where granite curbs conflict with the installation of underground conduit and cable, bore (drill) conduit underneath granite curb. Do not bore through granite curbs. Replace any granite curb damaged due to construction of this project at no cost to the Department.

Where removal and replacement of concrete sidewalk and concrete curb is unavoidable, replace them with concrete materials that match the finish, appearance and color of the adjacent existing sidewalk as close as technically feasible as determined by the Engineer. Finishes may include but are not limited to water-washed, broom and trowel. The dimensions and the profile (i.e., shape) of the new curbing shall match that of the adjacent existing curbing.

Where removal and replacement of sidewalk constructed of materials other than concrete is unavoidable, replace the sidewalk with in-kind materials that match the finish, appearance and color of the adjacent existing sidewalk as close as technically feasible as determined by the Engineer. If the sidewalk is constructed of materials such as brick, stone or pavers, carefully remove and subsequently reinstall the bricks, stones or pavers using methods approved by the Engineer. Take photographs and make sketches to record the pattern of the existing materials prior to removal. Replace any bricks, stones or pavers damaged due to construction on this project with approved in-kind, matching materials.

Repair and replacement of existing sidewalk will be measured and paid for in accordance with the "Signal Cabinet Foundations" section of these Project Special Provisions.

Complete all repairs with in-kind materials to all sidewalks removed for construction and reopen the repaired and restored sidewalk to pedestrian traffic within five consecutive calendar days following initial removal. If the Contractor fails to repair and reopen a sidewalk in accordance with these Project Special Provisions within the time frame specified, the Department reserves the right to make the necessary repairs, and all expenses incurred by the City in making the repairs and restoring the sidewalk will be deducted from payment due the Contractor, plus $500 liquidated damage per occasion, per day, or any portion thereof, until corrected.

Do not trim, remove or damage tree limbs within historic districts. Hand-lashing of aerial cables to messenger cable may be required in some areas due to overhanging and protruding tree limbs along the cable route.

(C) Work within the Central Business District (CBD)

The central business district (CBD) in downtown Rocky Mount may experience large volumes of vehicular and pedestrian traffic generated by special events. The CBD is defined as the area in downtown Rocky Mount bounded by Franklin Street on the west, Falls Road/Goldleaf Street on the north, Arlington Street/Atlantic Avenue on the east and Raleigh Road on the south inclusive. The CBD is occasionally the site of festivals and parades and other cultural events and celebrations. Traditionally, two major festivals, one during the Spring and the second during the Fall (currently, the Eastern Carolina BBQ Throw Down in October) are held within the CBD.

Do not perform any work within the CBD without prior approval of the Department. Submit to the Department for review and approval two weeks in advance a schedule for proposed work that will require narrowing or closing a lane, road, sidewalk or pedestrian crossing within this area.

(D) Regulations and Codes

Furnish material and workmanship conforming to the *National Electric Code* (NEC), *National Electric Safety Code* (NESC), Underwriters Laboratories (UL), or other listing agencies approved by the North Carolina Department of Insurance, 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 the Plans, all previously referenced specifications, and all applicable local ordinances and regulations before and during all stages of the electrical work.

When required by the local ordinances and governmental agencies, upon completion of the work, have all systems inspected and approved in writing by the authorized governmental electrical inspector for the area. Furnish written certification of the authorized inspector's approval to the Engineer. Inspection by the authorized governmental electrical inspector must neither eliminate nor take the place of the inspections by the Engineer. Upon the Engineer's receipt of written certification and the Contractor's written request for a final inspection of the installations, the Engineer will perform a final inspection.

Where required, conform to ITE, AASHTO, and ASTM standards 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, unless otherwise instructed herein.

Install meter bases and service disconnects as required by the NESC, NEC, local utility companies, and local ordinances. Install standoffs only when required and approved by the local utility companies. Where a standoff must be used, obtain the local utility company's approval prior to installing the standoff.

(E) Utility Services

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

When electrical, telephone, and telecommunication service is not furnished by the Department or the City 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 for Department-owned locations and in the City's name for City-owned locations. Make application for service in the Department's name for Department-owned locations and in the City's name for City-owned locations.

The Department and the City 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.

Coordinate all work involving electrical service with the appropriate electric utility company. Coordinate with the utility company to ascertain the feasibility of installing electrical service at each location before performing any work. Obtain all required local permits before beginning work.

(F) Maintenance and Repair of Material

Ensure that an IMSA certified, or equivalent, Level II traffic qualified signal technician is standing by to provide emergency maintenance services whenever work is being performed on traffic signal controller cabinets and traffic signal controller cabinet foundations. Standby status is defined as being able to arrive, fully equipped, at the work site within 30 minutes ready to provide maintenance services.

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.

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. This requirement for maintaining and repairing said equipment shall remain in effect in the event of a natural disaster such as flood, ice storm, tropical storm or hurricane.

Make entries into the maintenance diaries housed inside each traffic signal controller cabinet upon each visit to the controller cabinet. Maintain these diaries through final acceptance of the project.

For all failures, malfunctions, damages to equipment, or errors in workmanship affecting signal operation, begin necessary repairs within four hours of notification. Complete repairs within eight 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 equipment furnished by other contractors within the construction limits of separate NCDOT TIP projects that have not yet been formally accepted by the Department. Maintenance and repair of equipment within the construction limits of NCDOT TIP projects will be the responsibility of the respective TIP project contractors until the Department's final acceptance of those TIP projects.

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.

In the event the Contractor fails to perform in accordance with the Plans and Project Special Provisions 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 damages per occasion, per day, or any portion thereof, until corrected.

Perform yearly maintenance on all traffic signal conflict monitors. The year shall be defined as beginning on the date of installation of the controller and cabinet at the intersection. Use a signal conflict monitor tester that is capable of interfacing with Intel®-based notebook computer for input/output. The tester shall test signal conflict monitor displays, timing and voltage functions and input/output combinations of either true or false conflicts. All outputs shall be in plain English. It shall be possible to generate a hard copy printout or to store the results to a file on computer disc. A "No Faults Detected" indication shall be displayed as appropriate.

Ensure that the signal conflict monitor tester is maintained and calibrated per the manufacturer's recommendation. Provide to the Engineer a copy of the manufacturer's certification that the signal conflict monitor tester has been certified before testing any traffic signal conflict monitors. Perform 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 controller 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 within the project limits until final acceptance of the project.

(G) Inspections

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

(H) Removal of Existing Equipment and Material

Remove all Department-owned and City-owned signal. CCTV and communications related equipment and material that will not be used. Signal, CCTV and communications equipment and materials to be removed under this project include, but are not limited to: signal controllers and cabinets and the equipment housed therein; signal and lead-in cables; CCTV cameras and mounting brackets; CCTV cabinets and equipment housed therein; CCTV central equipment housed in the City's TMC and Signal Shop; poles; splice cabinets; cabinet foundations; junction boxes; messenger cable; communications cable; and guy assemblies. Assume ownership of removed poles (including stub poles), messenger cable, junction boxes, interconnect cable, communications cable, and supporting hardware. Return all other Department-owned equipment and material between 8:00 a.m. and 12:00 p.m., Monday through Thursday, to the Division 4 Traffic Services Office located at 509 Ward Boulevard in Wilson, North Carolina, 27895. Return all other City-owned equipment and material between 8:00 a.m. and 12:00 p.m., Monday through Thursday, to the City Signal Shop located at 720 Albermarle Avenue in Rocky Mount (27801). Contact the City to determine which CCTV equipment and material the City wants to retain and deliver the requested equipment to the City. Return all other CCTV equipment and material that the City does not wish to retain to the Department. The Department will deduct the cost of Department-owned and City-owned equipment damaged by the Contractor from money due to the Contractor.

(I) Water Conservation

Be advised that the City of Rocky Mount may be under water restrictions at the time of construction and that the use of potable water from the City of Rocky Mount system for construction activities on this project may be prohibited. As part of ongoing efforts to improve water supply management and promote conservation, permanent water conservation rules that restrict or prohibit the use of potable water from the City's system for work on this project and that apply even when water restrictions are not in effect could be adopted. When preparing a bid for this project, the Contractor shall take into consideration the possibility of water restrictions, including those more restrictive than the ones in force at the time that the bid is prepared. It shall be the Contractor's responsibility to become familiar and comply with the City's water conservation rules and practices at the time of bid and at all times during construction.

General information concerning the City's conservation efforts and current restrictions may be found on the City's website at www.rockymountnc.gov/utilities/water.html. For additional information and answers to questions, contact the City of Rocky Mount Director of Water Resources at (252) 972-1291 or via email at wayne.hollowell@rockymountnc.gov. Detailed information on potential restrictions during various water shortage conditions may be found in the City of Rocky Mount's Code of Ordinances, Chapter 2, Article V, "Water Conservation".

(J) Railroad Preemption

Where railroad preemption is required, coordinate all work with the railroad. Do not place signals into operation until signal and railroad company 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.

Conduct a railroad-highway interconnection preemption inspection for each intersection prior to placing new signal equipment into steady operation. The inspection shall be performed with all appropriate Division, City and Railroad personnel in attendance. The signal shall pass all requirements of the preemption inspection before it can be accepted under the project by the Engineer. The railroad preemption inspection form is available on the NCDOT ITS & Signals Unit website:

www.ncdot.org/doh/preconstruct/traffic/itss/

The Contractor along with other appropriate personnel shall conduct additional preemption inspections annually as long as the signal is in operation under the Contractor's jurisdiction until the signal is accepted by the Engineer.

(K) Vehicle Preemption Systems

Where required, implement and install vehicle preemption systems. Coordinate vehicle preemption work with the City of Rocky Mount Engineering Department. Contact the proper operating authority and schedule installation of preemption equipment.

(L) Timing of Signals

Implement timing values for signal controllers. Modify proposed phasing and timing of existing controllers. 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 or supply the Contractor with revised timing plans if the Department requires the Contractor to implement the timing changes.

Verify time-base coordination in 2070L controllers that upon installation will not be immediately connected to communicate with the new signal system over the new Ethernet fiber-optic cable network. Verify time-base coordination in existing 2070L controllers that upon

disconnection from existing coordinated communication will not be immediately connected to the signal system over the fiber-optic cable network. Reset the controller's clock to the common time source if it has drifted. Ensure that controllers' internal clocks are all synchronized at least once per week to the same date and time of day. Maintain the time synchronization in all controllers during any time that communication with the TMC is interrupted.

Record the time and date of each visit, the activity performed and name of person who visited the cabinet and performed the clock maintenance activity. Maintain a record 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 liquidated damages of $1,500 per visit not performed.

(M) 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.

Splice all electrical wire and cable: 1) inside cabinets at nickel-plated brass, recessed-screw, barrier-type terminal blocks or using gel-filled splice connectors; 2) in junction boxes using gel-filled splice connectors; or 3) in condulets using gel-filled splice connectors. 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.

Place permanent labels on all wires and cables to clearly identify each one. Use an indelible black ink marker or approved labeling devices to write on the permanent labels when required.

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.

(N) Electrical Services and Grounding

Where electrical services do not include an external electrical service disconnect, modify service to include electrical service disconnect and a new grounding electrode system.

Provide a grounding electrode system at all new electrical services. In addition to NEC requirements, test grounding electrode resistance for a maximum of 20 ohms. Furnish and install additional ground rods to grounding electrode system as necessary to meet test requirements.

Modify existing electrical services, as necessary, to meet the grounding requirements of the NEC, these Project Special Provisions and the Plans. Remove any ground rods in the cabinet foundation and install a new grounding electrode system. Cut off abandoned ground rods in the cabinet foundation flush with the foundation surface. Where a grounding electrode system is connected to the electrical service in accordance with the NEC, test grounding electrode resistance for a maximum of 20 ohms. Grounding electrode resistance test must be verified or witnessed by the Engineer or the Engineer's designated representative. Furnish and install additional ground rods to grounding electrode system as necessary to meet the Project Special Provisions and test requirements.

Follow test equipment's procedures for measuring grounding electrode resistance. When using clamp-type ground resistance meters, readings of less than 1 ohm typically indicate a ground loop. Rework bonding and grounding circuits as necessary to remove ground loop circuits and retest. If a ground loop cannot be identified and removed to allow the proper use of a clamp-type ground resistance meter, use the three-point test method.

Submit a completed Inductive Loop & Grounding Test Form available on the Department's website. The form is located on the Department's website at:

www.ncdot.gov/doh/preconstruct/traffic/ITSS/ws/signal_data.xls

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

(O) Electrical Bonding

Using an approved termination means, connect a number 14 AWG minimum 19-strand copper conductor (Type THW) with green insulation to serve as an equipment grounding conductor to metal poles, vehicular and pedestrian signal pedestals, and other metallic components which are not otherwise bonded, through means approved by the Engineer.

(P) Traffic Signal Activation

Do not place signal in steady (stop-and-go) mode until inspected and authorized by the Engineer.

(Q) Requirements for Cables Crossing Railroads

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

(1) Railroad Crossings

Application has been made with CSX Transportation, Inc. (CSX) and Nash County Railroad (NCYR), herein called the Railroad Company(ies), for the encroachment agreements necessary under this Contract. Do not commence cable routings over or under railroad-owned facilities until notification and coordination with Engineer and the appropriate Railroad Company has occurred. Install fiber-optic communications cable as shown on the Plans. All work associated with the crossing is to conform to the Railroad Company's specifications.

Cable crossings include the following locations:

Plan Sheet	Location	Railroad Company
CL-50	Hammond Street west of Grace Street / Crossing #626 207N	NCYR
CL-58	Winstead Avenue south of Winstead Road / Crossing #626 215F	NCYR
CL-111	Franklin Street east of Grace Street / Crossing #626 201X	NCYR
CL-125	Kingston Avenue/Sutton Road east of Church Street / No Crossing # CSX Rail Yard near traffic signal 04-0166	CSX
CL-134	Nash Street/ Marigold Street east of Main Street / Crossing #630 087G*	CSX
CL-139	Cokey Road north of Fairview Road/ Crossing #629 776E	CSX

Plan Sheet	Location	Railroad Company
CL-149	Grand Avenue east of Church Street/ Crossing #630 082X	CSX
CL-158	NC 43 Business (Fairview Road) south of Tarboro Street /Crossing #629 779A	CSX

*Nash Street/Marigold Street will be handled under an existing agreement as maintenance.

(2) Insurance Requirements

Provide any required railroad liability insurance in the amount specified prior to commencing any work. If required by the railroad, pay for railroad personnel to be present when work is performed.

In addition to any other forms of insurance or bonds required under the terms of the Contract and the *Standard Specifications*, take out and keep in force from the commencement of all construction on railroad right-of-way until the final inspection and acceptance of the project by the Engineer, insurance of the following kinds and amount. It is understood that the amounts specified are minimum amounts and that larger amounts may be carried if so desired. Any insurance taken out due to these requirements shall be subject to the approval of the Engineer, and the Railroad Companies as to form and amount. Furnish satisfactory policies prior to beginning of the work on railroad right-of-way.

Railroad Company	Railroad Protective Liability Insurance		Public Liability and Property Damage Liability Insurance	Protective Public Liability and Property Damage Liability Liability Insurance
CSX Transportation	$5,000,000 each occurrence $10,000,000 aggregate		$3,000,000 per occurrence	$3,000,000 per occurrence
Nash County Railroad	Tracks Not Carrying Passenger Trains	Tracks Carrying Passenger Trains	$2,000,000 per occurrence	$2,000,000 per occurrence
	$2,000,000 each occurrence $6,000,000 aggregate	$5,000,000 each occurrence $10,000,000 aggregate		

Refer to the following web links for more specific insurance requirements and requirements for working on the rights-of-way of each railroad company. In the event of a conflict between the requirements of one or more railroad companies and the requirements contained in the Plans or these Project Special Provisions, the requirements of the railroad company shall govern.

CSX Transportation, Inc.:

http://www.csx.com/index.cfm/customers/non-freight-services/propertyreal-estate/permitting-utility-installations-and-rights-of-entry/COS_Facility_Application_Information_Packet[1].pdf

Nash County Railroad Company:

http://www.omegarail.com/

The insurance requirements for Nash County Railroad crossings will be indicated more specifically in the encroachment agreements.

Public Liability and Property Damage Liability Insurance

Furnish evidence to the Engineer that with respect to the operations you perform on the railroad right-of-way, you carry regular Contractor's Public Liability and Property Damage Liability Insurance providing for bodily injury, death, and property damage in the amount specified in the table above. If any part of the work is sublet, similar insurance in the same amounts and evidence thereof as required of the Prime Contractor shall be provided by or on behalf of the Subcontractor to cover his operations on the railroad right-of-way.

Endorse the Contractor's and Subcontractor's Public Liability and Property Damage Liability Insurance policies to provide Contractual Liability Coverage only in respect to obligations assumed for Contractor/Subcontractor's construction machinery left unattended at the project site, such insurance being without an exclusion denying coverage for operations conducted within 50 feet of any railroad hazard. Type the following information on the Contractual Liability Coverage endorsement:

NCDOT Project No. C-5112 Nash/Edgecombe County

Construction on the right-of-way of the <<RAILROAD COMPANY>> in Rocky Mount and Nash/Edgecombe County, North Carolina

Keep such insurance in force until final inspection of the project, or that portion or portions within the railroad right-of-way, by the Engineer or, in the case of Subcontractors, until you furnish a letter to the Engineer stating that the Subcontractor has completed his subcontracted work within the railroad right-of-way to your satisfaction, and that you will accomplish any additional work necessary on the railroad right-of-way with your own forces.

Protective Public Liability and Property Damage Liability Insurance

If any part of the work is sublet, furnish evidence satisfactory to the Engineer that, with respect to the operations performed for you by Subcontractors on railroad right-of-way, that you also carry, in your own behalf, regular Contractor's Protective Public Liability and Property Damage Liability Insurance providing for bodily injury, death, and property damage in the amount specified in the above table.

Railroad Protective Liability Insurance

In addition to the above insurance, furnish evidence to the Engineer that, with respect to the operations you or any of your Subcontractors performs, you have provided for, and on behalf of the Railroad Company as their respective interest may occur, the limits of liability for the

Railroad Protective Liability Policy, Coverage A. Protective Bodily Injury Liability, B. Protective Property Damage Liability, C. Physical Damage to Property Liability Insurance, provided for in the amount specified in the table above. The Railroad Protective Liability Policy is to be prepared in accordance with the requirement of the U.S. Department of Transportation on Federal Highway Administration Federal Aid Highway Program Manual, Volume 6, Chapter 6, Section 2, Subsection 2, and any subsequent supplement thereto or revisions thereof.

Termination of Insurance and Policies to be Submitted

Any insurance policies given hereunder shall cover all work performed by you in connection with the work in the introductory paragraph within railroad right-of-way, but shall not be liable for accidents occurring after acceptance of the completed project by the City. Such policies shall contain a clause requiring 30 days written notice be given to the Engineer and to the appropriate Railroad Company, prior to cancellation or change.

Submit to the Engineer the original and one copy of the Railroad Company's Railroad Protective Liability Policy, one certified duplicate copy of all other policies, and certificates of insurance in an original and two copies as required by these Project Special Provisions.

No extra allowance will be made for the insurance required hereunder. The entire cost shall be included in the contract unit price bids for other pay items.

The named insured under the Railroad Protective Liability Policy is the respective Railroad Company, and the designation of the job site description of work is as follows: All construction on the <<RAILROAD COMPANY>> right-of-way on NCDOT Project No. C-5112 in Rocky Mount and Nash/Edgecombe County, North Carolina.

(3) Flagging Protection or Watchman Service

Provide 30 days advance notice to the Railroad Company in order that flagging service can be arranged and provided. Do not undertake any work within the Railroad Company right -of - way until the flagman is at the job site.

(4) Delays Caused by Operations of Others

Neither the Department 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 or the Railroad Company for any inconvenience, delay, or additional cost incurred by him on account of such operations by others.

(5) Time Extensions

No time extensions related to railroad encroachments will be allowed until the related work becomes the controlling factor relative to overall project completion.

(6) 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.

(7) Authority of Railroad Engineer

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

(8) 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, first submit the method of doing such work to the Railroad Engineer for approval. However, such approval will 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, may at the expense of the Contractor, require or provide such provisions as may be deemed necessary.

(9) Directional Drilling beneath CSX Tracks

Prior to the commencement of horizontal directional drilling (HDD) beneath railroad tracks either owned or operated by CSX:

a. Submit a Boring Plan for review and approval by CSX that describes the anticipated rig capacity, the proposed equipment, and the method for advancing the bore hole through expected soil conditions, angles, depth, and exact location for the exit ditch, the pilot hole diameter, the proposed reaming plan, and the contingency equipment and plans for dealing with soil conditions that a soil engineer could reasonably expect to be encountered at the proposed HDD installation site. The Boring Plan will also address the anticipated hours of operation during the HDD bore hole drilling and installation process, the minimum number of personnel, and their responsibilities on-duty and on-site during all HDD drilling operations. Consideration for working hours must be given to minimize risk to railroad operations during drilling operations. See "Bore Plan: Additional Guidelines" on page 3 of 3 at the following website:

   http://www.csx.com/index.cfm/customers/non-freight-services/propertyreal-estate/permitting-utility-installations-and-rights-of-entry/CSXT_Interim_Guidelines_for_HDD_Projects_V3a[1].pdf

b. Submit a detailed Fracture Mitigation (frac-out) Plan, including method of monitoring quantity and capturing the return of drilling fluids with particular attention to variation from the proposed plan (i.e., volumes, pressure, or consistency).

c. Establish a Survey Grid Line and provide a program of monitoring and documenting the actual location of the bore hole during drilling operations.

An engineering inspector is required to monitor the ground and track for movement during the drilling, reaming, and pullback processes. The engineering inspector will be provided by CSX at the contractor's sole cost and expense. The installation process and all train movement must be immediately stopped if track movement is detected. The damaged area must be immediately repaired. The installation process must be reviewed and modified as required before the installation may proceed. The Contractor must pay the CSX's expenses for review and inspection.

Upon completion of the HDD installation work, prepare and provide to CSX an accurate as-built drawing of the installed HDD segment. As-built drawings will include both horizontal and profile plans. The latitude and longitude coordinates of the entry, exit, and return points shall be provided on the as-built drawings.

(10) Storage of Materials

Do not store materials and equipment 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. Such permission will be with the understanding that the Railroad Company will not be liable or 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.

(11) 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 and the Railroad Company, the Department will be notified of the Railroad Company's acceptance in writing by the Railroad Company.

1.4. CONSTRUCTION STAGING/MIGRATION

(A) Introduction

This section addresses the general flow of construction in regards to communications throughout the life of the project. It is essential that the Contractor make every effort to minimize communications downtime to the traffic signals.

Follow the outline of construction described below. Submit a detailed field migration plan (including details of controller cabinet change-outs) and schedule to the Department for review and approval at least two weeks prior to the onset of work, and no later than 60 days after Notice to Proceed. Include a detail of controller cabinet change-outs, listing every intersection, existing and future control zone, and existing and future communication zone, and a schedule of the migration. Include information explaining how the following situations will be handled:

- Existing pole-mount cabinet converted to base-mount,
- Existing cabinet foundation retained,
- Base-mount cabinet on new foundation,
- Installation and splicing of 6-fiber drop cable assemblies,
- Installation of drop cable assemblies into risers with existing fiber-optic cable,
- Removal of existing fiber-optic cable once a controller cabinet has been changed out;
- Transitioning the City's existing Peek CLMATS® closed-loop system over to the new signal system software, changing out the controllers and switching from the existing fiber-optic communications system to the new Ethernet-based fiber-optic communications, and
- How to coordinate with others at the time new cabinets are set to make the necessary signal changes at the TMC to get the controller online.

Submit the System Design Report to the Engineer for Department review and approval prior to beginning any migration from the existing signal system and communications system to the

new signal system and new Ethernet communications system. Submit the System Design Report in both hard copy and electronic form. Refer to "Submittal Data" section of these Project Special Provisions for additional requirements.

(B) TMC Migration

The central block diagram for the new signal system, as shown on the Plans, depicts the existing equipment to be retained and the new equipment to be installed. The proposed sequence is described below.

(1) Step 1

Maintain the operation of the existing CCTV and signal systems. Install the head end communications racks, core switch, server(s), monitors, workstations, and all necessary equipment at the TMC, TMC Server Room and the Signal Shop. Run conduit and cabling to locations within City Hall as shown on the Plans.

Install all software. Configure the central software applications. Setup a test facility to configure local equipment. Configure the core switch for the permanent IP addresses, VLANS, and other configuration data before its installation.

Begin building the device database. Convert the signal timing data and build the system and intersection graphics.

(2) Step 2

Construct the field communications as described in the Plans. Move traffic signals and CCTV cameras from the existing multi-mode/single mode fiber-optic cable communications to the new Ethernet over single-mode fiber-optic cable by connecting to the Ethernet core switch.

(C) Field Infrastructure

The approach to maintaining and maximizing communications to all signals throughout the long construction process requires that the new fiber-optic communications infrastructure be constructed while the existing fiber-optic infrastructure remains in place and operational. This will allow the intersections, even those in close proximity to one another, to function on the existing fiber-optic system until such time as they are migrated to the new Ethernet fiber-optic communications system. The new Ethernet fiber-optic communications network is comprised of:

1) New aerial cable overlashed to existing fiber-optic cable while the existing fiber-optic cable remains in use. The overlashed existing fiber-optic cable will be abandoned in place after construction. Certain aerial routes are on new pole lines or deviate from the course of the existing mixed mode fiber-optic cable. Existing fiber-optic cable that is not overlashed (e.g., in risers, where route changes, etc.) will be removed along with existing splice cabinets, unused risers and abandoned junction boxes, after communications have completely migrated to the new fiber-optic cable and the existing fiber-optic cable is no longer in use.
2) New underground cable in a new trenched, drilled or bored conduit. In certain situations, as shown in the Plans, the fiber-optic cable will be installed in an existing spare conduit that runs alongside the conduit containing the existing fiber-optic cable. In some cases, as shown in the Plans, the fiber-optic cable will be installed inside the same conduit that contains the existing fiber-optic cable.

3) Certain segments of existing NCDOT fiber-optic cable, namely that being installed under TIP projects R-2823, U-3621B and U-4019, will be spliced into the new fiber-optic network.

(1) General Requirements

Configure the edge switches for the permanent IP addresses, VLANS, and other configuration data before their field installation.

Start at the outer edges of the local Fast-E network/rings (i.e., circuits) where possible and work inward toward the TMC. The existing fiber-optic communications cable will be progressively decommissioned as the new Ethernet-based fiber-optic communications system is progressively built-out and brought online, starting at the outer reaches of the system boundaries and working inward toward the TMC.

Group the work by the existing Control Zones, allowing intersection migration to take place in discrete packages. The boundaries of the existing Control Zones are documented in the "System Boundaries and Control Sections Technical Memorandum (Task 7.1)", dated December 2010, a copy of which may be obtained from the Engineer upon request. Interrupt communications, replace cabinets and controllers, and migrate signals from the existing fiber-optic network to the new fiber-optic communications network. If communication conversion in the subject Control Zone interrupts the communication in another Control Zone, the Contractor must re-establish communication continuity in the adjacent Control Zone before any work can continue. As each new cabinet and controller are installed, and prior to the end of the work day, establish Ethernet connectivity from the edge switch to the core switch, and re-establish communication to all signals still connected to the existing fiber-optic network.

Upon successful testing, integrate into the central system software under Ethernet communications.

Complete the migration of all the signals in one Control Zone before moving to the next Control Zone. Complete the intersection migrations in a Control Zone within the number of workdays equal to no more than the number of signalized intersections in the Control Zone. Exceptions to the requirements in this section must be approved by the Engineer.

Notify the Department at least two weeks prior to the commencement of work on a particular Control Zone to ensure that time-base coordination will be operating and effective during the time of communications interruption.

In addition to grouping work by existing Control Zones, further organize work by proposed communications ring. Once migration begins on a given communications ring, continue migrating signals along that ring until at least "half" the communications ring is complete before beginning the migration of signals residing along another communications ring. Establish the second half of the ring (redundant path) as soon as possible.

Migrate communications between the TMC and the Signal Shop over to the new Ethernet communications system as early as possible using the redundant communications path until the primary path via Church Street and Franklin Street can be established.

As each Fast-E circuit is completed and lit, test intersection communications as per the requirements of "Testing and Acceptance" section of these Project Special Provisions.

Prior to the end of any work day, ensure that communication between the TMC and existing signal controllers still connected to the existing mode fiber-optic cable is reestablished and working correctly.

Construct and splice drop cables to existing and proposed CCTV cameras while maintaining the existing communications. Migrate the existing and proposed cameras as the adjacent traffic signals are migrated to new system whenever possible.

(2) Franklin Street and Church Street in Downtown Rocky Mount

To avoid premature disruption of existing homerun fiber-optic communications, migration of the several traffic signals in downtown Rocky Mount along Franklin Street and Church Street generally between Hammond Street and Falls Road cannot occur until late in the construction. That is because the existing homerun cables in the existing underground duct banks on Franklin Street and Church Street loop in and out of the existing controller cabinets and are spliced within the existing cabinets. Therefore, to keep the existing fiber-optic communications system functioning for as long as possible, these signals need to be among the last migrated to the new system.

In addition, migration of these signals along Franklin Street and Church Street is contingent upon the controller and cabinet change-outs, which also entail modification of the existing underground electric services and replacement of the existing cabinet foundations. This is particularly true of the intersection of Church Street and Thomas Street where new fiber-optic communications cable cannot be installed until a new conduit stub-out is constructed with the new cabinet base. This new stub-out completes the link between the existing underground duct to the south and new directionally drilled conduit to the north on Church Street and must be in place before the new communications cable can be installed. Furthermore, it is desirable to minimize the number of times the existing manholes must be pumped out and entered to install new fiber-optic cable and to remove existing fiber-optic cable.

Therefore, follow the general sequence of construction staging and migration for Franklin Street and Church Street in downtown Rocky Mount as presented below.

Step A

Install the new fiber-optic trunk cables (homerun cables) in the existing underground duct system along Franklin Street from south of Hammond Street to Gay Street and along Gay Street between Franklin Street and Church Street. Install the new fiber-optic trunk cables in the new directionally drilled underground conduit along Church Street from Gay Street to north of Falls Road.

Concurrent with the installation of the new trunk cables in this area, pull the new 6-fiber drop cable that eventually link the signals in this area to the new trunk cable via a proposed splice at the intersection of Gay Street and Church Street. Pull the 6-fiber drop cables into the existing controller cabinets, then coil and store sufficient slack fiber to facilitate later splicing of the drop cable in interconnect centers mounted in the new controller cabinets when the cabinets are changed out a later date.

Pull the two new 48-fiber trunk cables and the new 36-fiber trunk cables into the City Hall Building through existing conduit system and fusion splice these three cables to two new plenum-rated cables from the TMC Server Room.

Maintain the existing fiber-optic cables and existing communications while pulling the new cables into the existing underground ducts.

Step B

The work to change-out the controllers and cabinets will disrupt the existing fiber-optic communications cable in the underground ducts along Franklin Street and Church Street, including the existing communications link along Nash Street that crosses over the CSX double-track railroad mainline to provide communications to many of the signals on the Edgecombe County side of the project area. Prior to beginning the controller and cabinet change-outs, migrate all signals on the Edgecombe County side of the project area to the new Ethernet communications system using the Grand Avenue portion of the communications rings to cross these railroad tracks in lieu of the Nash Street link.

Place the signals at the following 10 intersections along Franklin Street and Church Street between Hammond Street and Gay Street in downtown Rocky Mount on time-base coordination.

- Franklin Street at Hammond Street
- Franklin Street at Nash Street
- Franklin Street at Western Avenue
- Franklin Street at Sunset Avenue
- Franklin Street at Thomas Street
- Church Street at Hammond Street
- Church Street at Nash Street
- Church Street at Western Avenue
- Church Street at Sunset Avenue
- Church Street at Thomas Street

For the above 10 intersections, the underground electrical power service must be reworked and cabinet foundation must be removed and replaced simultaneously with the controller and cabinet change-outs.

NOTE: Starting from the date that communication within the downtown area is discontinued as described above, complete the following work at these 10 intersections within **30 calendar days:**

- Controller, cabinet and foundation replacement and reworking of electrical service at all 10 intersections identified above.
- Splicing the 6-fiber drop cable at the 5 intersections along Franklin Street as well as into the trunk cable at the intersection of Church Street and Gay Street.
- Establishing Ethernet communications via the new fiber-optic network and migrating the 5 Franklin Street signals only over to the new signal system.

Failure to complete the work within the specified time will result in damages due to public inconvenience, obstruction and delay to traffic, safety and other considerations. For each consecutive calendar day in excess of the contract time specified, the Contractor shall pay, or have withheld monies due, a sum of **$500.00 per calendar day**. This will be adjusted and assessed on a monthly basis at the time of each partial payment request based on the Contractor's progress in comparison with the approved project schedule.

Be advised that some or all of the work required in the "Electrical Service and Cabinet Foundations for Downtown Traffic Signals" section of these Project Special Provisions is part of the work that must be accomplished during the 30-day period due to its potential disruption of the existing signal operation.

Once the cabinet change-outs are completed, splice the previously installed 6-fiber drop cable in the interconnect centers inside the new controller cabinets along Franklin Street between Hammond Street and Gay Street and splice the 6-fiber drop cable to the trunk cable at the intersection of Gay Street and Church Street. Migrate these Franklin Street signals only to the new Ethernet communications system and integrate them into the new signal system.

Step C

Install both the 24-fiber trunk cable and 6-fiber drop cable in the underground duct along Church Street from Gay Street southward to Hammond Street and from Church Street eastward along Nash Street. Remove the existing fiber-optic cable from the existing underground ducts within these limits while installing the new cables in the existing ducts.

Splice the 6-fiber drop cable to the trunk cable at the Church Street/Gay Street intersection and at the remaining 5 intersections along Church Street. Migrate these Church Street signals only to the new Ethernet communications system and integrate them into the new signal system. Establish communications with signals east of the railroad tracks via the communications trunk cable installed on Nash Street.

This will complete the migration of all intersections in the underground duct area along Church Street and Franklin Street in downtown Rocky Mount.

Step D

Remove the remaining old fiber-optic cable out of the underground conduit system from City Hall to Franklin Street, along Franklin Street from south of Nash Street to Gay Street, and along Gay Street between Franklin Street and Church Street.

Remove any remaining materials called for in the Plans including the old head-end equipment (servers, workstations, video switch and etc).

(D) Intersection Parameters and Database

The Contractor shall submit requests for intersection timing parameters and data to the Engineer at least two weeks (10 business days) prior to need for same. The City will provide all intersection parameters, database and timing plans in Peek CLMATS™ format electronically as portable document format (PDF) files only. The Contractor shall be responsible for converting City-furnished timing data to OASIS™-formatted data and for loading the OASIS™-formatted data into the Model 2070L controllers.

(E) Time-Based Coordination (TBC)

Before the existing communication is interrupted within a control zone, verify the time-based coordination plans installed in all the intersection controllers within the control zone. (If necessary, time-based plans will be provided electronically by the Engineer for the Contractor to implement.)

Verify the time reference on each controller at least once per week (by synchronizing with a National Standard Time source while time-based coordination is in use and make any corrections necessary to maintain proper coordination. Reset the controller's clock to the common time source if it has drifted. Ensure that the controllers' internal clocks are all synchronized at least once per week to the same date and time of day. Maintain the time synchronization in all controllers during any time that communication with the TMC is interrupted.

Record the time and date of each visit, the activity performed and name of the person who visited the cabinet and performed the clock maintenance activity. Maintain a record 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 liquidated damages of $1,500 per visit not performed.

The Engineer reserves the right to make, or have the Contractor make, field timing changes necessary for the pattern optimization and to eliminate identifiable, potential hazards to the motoring public. Then Engineer will notify the Contractor of timing changes made or supply the Contractor with revised timing plans if the Department requires the Contractor to implement the timing changes.

Ensure that the time-based coordination plans from existing controllers are transferred to the replacement controllers at those same locations.

1.5. DOCUMENTATION

(A) General

Provide all as-built documentation. All as-built plans and documentation shall be reviewed and accepted by the Engineer prior to final acceptance of the project. All documentation, except as otherwise specifically approved by the Engineer, must meet the following requirements:

1. Provide any documentation that exceeds the size of 11" x 17" paper in a reproducible format 22" x 34" in size.
2. No documentation for as-built plans smaller than 8.5" x 11" will be accepted.
3. Do not fold or crease reproducibles.

As a minimum, provide the documentation described in the paragraphs below.

(B) Plan of Record Documentation

Provide as-built drawings that depict any changes of components, measurement or layout of the Plans. Show 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., in detail in a reproducible format. Submit as-built construction changes as soon as a change is complete. Note and date each change on the drawings. Failure to revise as-built documentation to reflect current work may result in withholding of payments until the as-built documentation is brought current. The submitted as-built documentation 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. Include all field installation including the SMFO cable network installed on the drawings.

For underground conduit systems that house communications cable, furnish the Engineer with a plan of record drawing detailing the locations of the conduit system, including junction

boxes and their corresponding GPS coordinates. For directionally-drilled underground conduit systems, identify the vertical location (i.e., depth) of the conduits along the run.

Store documentation for signal installations in a manila envelope placed in a weatherproof holder inside the cabinet drawer. Store all documentation furnished with the controllers and cabinets, including manuals, electrical schematic diagram, and cabinet wiring diagram inside the envelope in the weatherproof holder. Provide two marked-up "redline" copies of the signal plan and the electrical and programming detail, placing one copy in the weatherproof holder inside the cabinet drawer immediately upon installation of the cabinet and giving the second copy to the Engineer.

For CCTV camera assemblies, provide two copies of a parts list(s) that includes serial and model numbers of all Contractor-furnished equipment prior to final acceptance. All equipment and appurtenances shall be identified by name, model number, serial number, technical support and warranty telephone numbers, and any other pertinent information required to facilitate equipment maintenance.

The Department will provide the Contractor one electronic copy of the Plans for his use in developing the as-built drawings. Modify the original electronic file such that all changes are marked with callout boxes or other method approved by the Engineer. Any other base maps that may be necessary for the Contractor to prepare the as-built drawings in accordance with these Project Special Provisions will be the Contractor's responsibility. Use CADD conventions that are consistent with those used on the original plans.

Within 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-built drawings on 22"x 34" bond plan sheets.

Upon receipt of review comments from the Engineer, correct any errors and make all necessary revisions to the draft as-built plans prior to final 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 or DVD.

(C) Manuals

Provide at least five hard copies along with one electronic copy (on CD or DVD) of the following manuals:

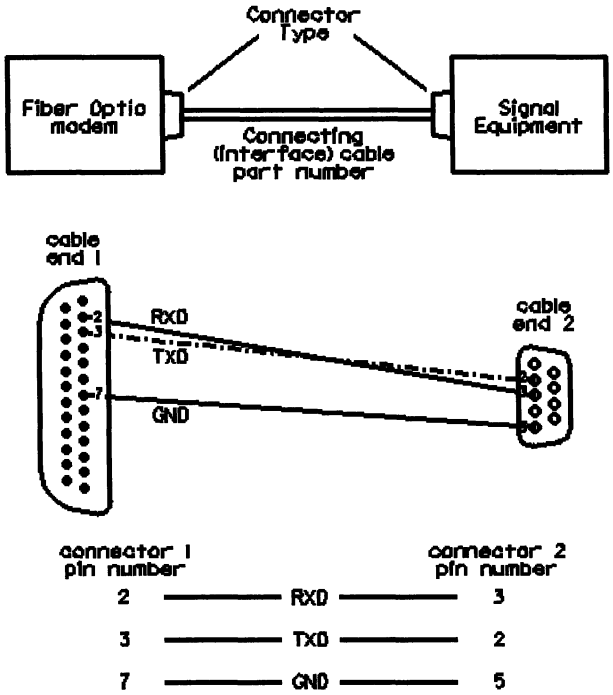
- Operator's manuals containing detailed operating instructions for each different type of model of equipment. Ensure that manuals contain instructions for possible modification to equipment.
- Maintenance procedures manuals containing detailed preventative and corrective maintenance procedures and troubleshooting procedures for each different type of model of equipment.
- Installation, operations and training manuals for all Contractor-provided software.

The manuals provided above shall be in addition to manuals provided with and stored inside each control equipment cabinet.

(D) Wiring Diagrams

Provide detailed wiring diagrams that include interconnection (wired and wireless) of equipment with pin-out configurations, pin functions, and cable parts numbers. This includes configuration at each field equipment cabinet or equipment cabinet 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. Provide one electronic copy of the wiring diagrams in MicroStation format.

Example:



(E) Splice Diagrams

Prepare as-built splice diagrams that depict the communications cable plant as constructed. Depict the splices made at each splice enclosure by identifying spliced fiber and buffer tube. Ensure the splice diagram is in a similar format to those provided with the project plans. Identify all expressed fibers, spare fibers, used fibers and capped fibers.

Original splice diagrams will be provided in electronic format in MicroStation format. Designate any changes to these diagrams by using a method approved by the Engineer. Furnish as-built splice diagrams in MicroStation format on CD or DVD and in hard copy.

1.6. 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. Include the incidental costs for furnishing and/or installing materials and equipment expressly required under the contract for successful completion of the contract, but whose measurement and payment is not specifically stated under any of the contract pay items, into the unit cost(s) for the various items in the contract.

2. MOBILIZATION

2.1. DESCRIPTION

This work consists of preparatory work and operations, including but 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 which must be performed for costs incurred prior to the beginning of work on the various items on the project site.

2.2. COMPENSATION

All work covered by this section will be paid for at the lump sum price for "Mobilization."

Partial payments for the item of "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 for "Mobilization" 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 the portion exceeding 5 percent will be paid on the last partial pay estimate.

Payment will be made under:

Pay Item	Pay Unit
Mobilization	Lump Sum

3. PAVEMENT MARKINGS

3.1. DESCRIPTION

Furnish and install pavement markings in accordance with the plans.

Remove existing pavement markings in accordance with the plans.

3.2. MATERIALS

(A) General

Refer to and fully comply with Section 1087 of the *Standard Specifications*.

(B) Material Qualification

Use pavement markings which are on the Department's Approved Products List or are traffic qualified by the Signing and Delineation Unit.

(C) Historical Performance

Historical performance of the pavement marking material will be used in determining future use of the material by the Department, even if material has been traffic qualified. Poor past or poor current performance of pavement marking material at any site, whether or not related to a specific contract may be grounds for non-acceptance of a product on any project under contract.

3.3. CONSTRUCTION METHODS

(A) General

Refer to and fully comply with Section 1205 of the *Standard Specifications*.

Do not use handliners or any other non-truck mounted pavement marking machine to install pavement markings for long line applications of any one line longer than 1000 feet.

All pavement marking materials and placement will be tested according to Materials and Test Unit Testing Procedure PM 1.0 as shown in the *NCDOT Construction Manual*. Install pavement markings in order to meet the retroreflectivity requirements as measured by an LTL 2000, LTL-X or Department approved mobile retroreflectometer.

(B) Application Equipment

Use pavement marking application equipment such that all parts that come in contact with pavement marking material are constructed for easy accessibility during cleaning and maintenance.

Keep the marking guns of the application device in full view of the operators at all times. Use applicators that are mobile and maneuverable to the extent that straight lines can be followed and all standard curves can be made in true arcs.

(C) Weather Limitations and Seasonal Limitations

Do not place pavement markings when moisture tests conducted on the pavement show signs of moisture presence on the pavement, or it is anticipated that damage causing moisture may occur during the installation and drying periods. See Section 12 of the *Construction Manual* for details.

(D) Time Limitations for Replacement

Multi-lane roadways (3 or more lanes) and ramps	Center Line, Lane Line, Railroad symbols, & school symbols	By the end of each workday's operation if the lane is opened to traffic (temporary paint may be used)
	Edge Lines, gore lines & all other symbols	By the end of the 3rd calendar after obliteration
Two-lane, two-way roadways	All centerline markings, railroad, & school symbols	By the end of the 5th calendar day after obliteration
	Edge Lines & all other symbols	By the end of the 15th calendar day after obliteration

A multilane facility is defined as any roadway having more than two lanes to include a two-lane / two-way roadway with a center two-way left turn lane.

(E) Premarking

Premark each installation of pavement marking materials prior to application on new pavement and when required to replace pavement marking, except when existing markings are visible. Use premarking to guide in the placement of pavement markings. Get the premarking inspected and approved before placing the pavement marking materials.

Review and record the existing pavement markings prior to resurfacing and reestablish the new pavement markings using the record of existing markings in conjunction with the Standard Drawings, unless otherwise directed. In order to assure compliance with this specification, submit a pavement marking plan 7 calendar days before any pavement marking is placed.

(F) Surface Preparation and Curing Compound Removal

Prepare the pavement to accept pavement markings to insure maximum possible adhesion. Clean, seal and remove curing compound as necessary to insure that the markings adhere to the pavement. Obtain approval for all surface preparation methods prior to implementing.

Pavements shall be free of grease, oil, mud, dust, dirt, grass, loose gravel and other deleterious material, prior to applying pavement markings.

Prepare the pavement surface, including removal of curing compound, a minimum of 2" wider than the pavement markings to be placed, such that, an additional 1" of prepared area is on all sides of the pavement markings after they are applied.

Remove all curing compound and surface laitance on Portland cement concrete pavements where long-life pavement markings will be placed. Perform curing compound removal by high-pressure water or shot blasting methods. Ensure that the surface is free of all residue, laitance and debris prior to applying the pavement marking.

When surface preparation and curing compound removal operations are completed, blow the pavement surface clean by compressed air to remove residue or debris.

Curing compound removal will be paid for at the applicable contract unit price. All other surface preparation will be considered incidental to the work covered by this specification.

If required, apply a primer sealer to pavement surfaces before applying pavement marking material as recommended by the manufacturer. Apply primer sealer in a continuous film in such a way as to not cause any noticeable change in the appearance of the pavement markings. Submit a sample of the primer sealer to the Engineer, prior to application.

Conduct all pavement surface preparation including curing compound removal in such a manner that the pavement or joint material is not damaged or left in a condition that will mislead or misdirect the motorist. Repair any damage caused to the pavement, or joint materials caused by surface preparation or the removal of curing compound by acceptable methods and at no additional cost to the Department.

Where pavement surface preparation results in obscuring existing pavement markings of a lane occupied by traffic, immediately remove the residue, including dust, by approved methods.

(G) Application of Pavement Markings

Install pavement marking material that has a uniform thickness, a smooth surfaced cross section throughout its entire length, width and length not less than the dimensions specified in the plans and that does not exceed the dimension by more than 1/2".

Do not apply pavement marking materials over a longitudinal joint. See Roadway Standard Drawing No. 1205.01, Sheet 2 of 2 for details.

Install pavement marking lines that are straight or have uniform curvature and conform with the tangents, curves, and transitions as specified in the plans.

Produce finished lines that have well defined edges and are free of horizontal fluctuations. Do not exceed 1/2" in lateral deviation from the proposed location alignment at any point. Any greater deviations may be cause for requiring the material to be removed and replaced at no additional cost.

Apply all longitudinal pavement marking lines 8" or less in width with one pass of the pavement marking equipment. Pavement marking lines greater than 8" in width and pavement marking symbols may be applied with multiple passes of the pavement marking equipment

The stem portion of straight arrows shall be applied in a single pass and the stem portion of turn arrows is to be applied in a maximum of 2 passes of the application equipment. Arrowheads may be applied by multiple passes of the application equipment, not to exceed three passes.

Install all pavement marking lines, characters, and symbols that require multiple passes of the application equipment such that there are no gaps separating the application passes.

Install characters and symbols so that they conform to the sizes and shapes shown in the plans.

Use pavement marking material that is capable of accepting an overlay of compatible material.

Protect the pavement markings until they are track free. Remove any markings tracked by a vehicle by acceptable methods and at no additional expense to the Department.

Reapply any molten pavement marking that is crossed by a vehicle. Payment will only be made for 1 application of molten pavement marking.

Remove all pavement marking materials spilled on the road surface by acceptable methods at no additional expense to the Department.

Use yellow, white, and black pavement markings, without drop-on glass beads, that visually match the color chips that correspond to the Federal Test Standard Number 595a for the following colors. Use markings that when subjected to accelerated weathering as described in U.S. Federal Specification No. (TT-P-115F) are within the tolerance limits of the color chips listed below:

- WHITE: Color 17886
- YELLOW: Color 13538
- BLACK: Color 37038

(H) Pavement Markings Observation Period

This pavement markings observation period shall be a separate entity than the signal system observation period defined in these Project Special Provisions.

Maintain responsibility for the pavement markings for a 180-day observation period beginning upon the satisfactory completion of all work required in the plans. Guarantee the markings under the payment and performance bond in accordance with Article 105-17 of the *Standard Specifications*.

Have traffic operating on the facility during the entire 180-day pavement markings (PM) observation period unless otherwise directed.

During the 180-day PM observation period provide pavement marking material that shows no signs of failure due to blistering, excessive cracking, chipping, bleeding, staining, discoloration, oil content of the pavement materials, smearing or spreading under heat, deterioration due to contact with grease deposits, oil, diesel fuel, gasoline drippings, spilling, poor adhesion to the pavement materials, loss of reflectivity, vehicular damage, or normal wear.

Replace, at no additional expense to the Department, any pavement markings that do not perform satisfactorily under traffic during the 180-day PM observation period.

(I) Removal of Pavement Markings

This work includes the removal of all types of pavement marking lines, symbols, and characters including removal for long life marking preparation. This work does not include removal of removable tape pavement markings.

Remove pavement marking lines, characters, and symbols by acceptable methods to the Engineer that will not materially or structurally damage the surface or the texture of the pavement. Leave the pavement surface in a condition that will not mislead or misdirect the motorist.

Where existing pavement markings are to be removed and replaced by other pavement markings, do not begin removal until adequate provisions have been made to complete the installation of the replacement markings. Remove pavement markings such that the surface is in proper condition for adequate bonding of the new markings. Promptly remove any material deposited on the pavement as a result of removing pavement markings as the work progresses by acceptable methods. Provide the equipment necessary to control dust and the accumulation of

debris resulting from the removal process. The removal equipment shall provide dust control and the capture of the removed material shall be done utilizing a separate vacuum equipped vehicle or other approved system. Perform the recovery process within the same operation as the removal. Do not let traffic use the lane where the removal is taking place until the recovery system is finished. Should the recovery system fail, cease removal operations until the recovery system is properly operating. The Contractor is responsible for all cleanup and proper disposal of all removed debris from the project site.

When using a grinding method for pavement removal, the equipment shall have multiple heads working in tandem to provide adequate preparation of the surface to accept the new marking material.

Do not apply polyurea pavement markings over existing pavement marking materials having less adherence than the polyurea. Application over existing pavement marking materials other than polyurea will require the existing pavement marking material to be removed, so that a minimum of 85 percent of the existing pavement marking is removed. However, if pavement is less than 6 months old and one 15 mils application of paint was placed on the pavement initially, do not remove the existing paint pavement markings.

Do not apply thermoplastic pavement markings over existing pavement marking materials having less adherence than the thermoplastic. Application over existing pavement marking materials other than thermoplastic will require the existing pavement marking material to be removed so that a minimum of 85 percent of the existing pavement marking surface is removed. Before applying thermoplastic pavement markings over the existing thermoplastic pavement markings, remove a minimum of 25 percent of the oxidized existing thermoplastic. However, if pavement is less than 6 month old and one 15 mil application of paint was placed on the pavement initially, do not remove the existing paint pavement markings.

Use black color #37038 in paint or tape, as determined by Contractor, to cover any remaining conflicting pavement marking after removal from asphalt pavement surfaces. Do not use black paint or tape on concrete pavement surfaces. The black paint will not have a defined shape or edges with a width not exceeding double of the existing lines. No direct payment will be made for black paint or tape.

(J) Pavement Marking Installer Qualifications

Have at least one member of every pavement marking crew certified through the NCDOT Pavement Marking Technician Certification Process. Keep the certification current throughout the life of the project. The certified crewmember is not required to be the same person throughout the life of the contract.

3.4. THERMOPLASTIC (Alkyd/Maleic)

(A) Application Equipment

Use equipment to install hot thermoplastic pavement marking material that includes the following features:

Premelting Kettle: oil-jacketed or air-jacketed utilized for uniform heating and melting of the thermoplastic material. Use a kettle that is equipped with an automatic thermostat control device to provide positive temperature control and continuous mixing and agitation of the thermoplastic material. Do not premelt thermoplastic material in handliner type equipment.

Applicator Storage Kettle: Equip long line pavement marking vehicles with an automatic thermostat control device to maintain the thermoplastic material at the application temperature and provide continuous mixing and agitation of the thermoplastic material during installation. Construct the equipment so that all mixing and conveying parts, up to and including the application apparatus, maintains the thermoplastic pavement marking material at the specified installation temperature and which has a capacity of a minimum of 1500 lbs. of molten thermoplastic pavement marking material. Hand transfer is not allowed.

Hand Liner type application vehicles may contain the premelting and applicator storage functions in the same kettle. Agitation and mixing can be done manually. Drag box type and bucket type application is not allowed.

Use premelting and applicator storage kettles that meet the requirements of the National Board of Fire Underwriters, the National Fire Protection Association, and State and local authorities.

Use application equipment that is constructed to assure continuous uniformity in the thickness and width of the thermoplastic pavement marking.

Use application equipment that provides multiple width settings ranging from 4" to 12" and multiple thickness settings to achieve the pavement marking thickness ranging from 0.090" to 0.120". Special thickness equipment may be required for in lane or shoulder transverse rumble strip pavement markings.

Do not use spray thermoplastic unless approved by the Department's Signing and Delineation Unit.

(B) Weather Limitations and Seasonal Limitations

Do not apply thermoplastic pavement markings on existing or new pavements unless the ambient air temperature and the temperature of the pavement is 50°F or higher.

Do not apply thermoplastic pavement markings between December 15 and the following March 16.

Exception to the above: When traffic is maintained on a portion of roadway and thermoplastic pavement marking will not be placed within 30 calendar days due to seasonal limitations, place pavement marking paint and beads in accordance with Subarticle 1205-8(C) of the *Standard Specifications*.

(C) Application

Use only thermoplastic markings that are of the hot, machine applied type. Apply Alkyd/Maleic thermoplastic pavement markings by extrusion methods only. Extrusion may be accomplished using either conventional extrusion equipment or ribbon gun extrusion devices.

Apply Drop-on Beads uniformly to the surface of the molten thermoplastic material so that the beads are partially embedded and at a rate to immediately obtain the minimum reflectance values. At the time of installation, produce in place markings with the minimum retroreflective values shown below, as obtained with a LTL 2000 Retroreflectometer or Department approved mobile retroreflectometer. Maintain the retroreflective values shown below for a minimum of 30 days from the time of placement of the marking material.

- White: 375 mcd/lux/m2

- Yellow: 250 mcd/lux/m2

Ensure that the marking is uniformly retroreflective upon cooling and has the ability to resist deformation caused by traffic throughout its entire length.

A thin layer of pavement marking paint at the proper width may be placed prior to applying the thermoplastic markings. If this option is chosen, when not specified in the plans or by the Engineer, direct payment for the paint will not be made. Cover any such thin layer of pavement marking paint with thermoplastic pavement marking within 30 calendar days of placement. Apply the thin layer of pavement marking paint and beads at the rate necessary to produce a dry film thickness of 5 - 8 mils. Apply drop-on glass beads at a rate of 1-3 pounds per gallon of paint.

Provide drainage openings at intervals of 250 feet in edge lines placed on the inside of curves and in edge lines on the low side of tangents. Provide openings that are a maximum of 12" and a minimum of 6" in length.

Produce a cross sectional thickness of the thermoplastic markings above the surface of the pavement as follows:

- 240 mils: In-lane and shoulder-transverse pavement markings (rumble strips) may be placed in 2 passes.
- 120 mils: Center lines, skip lines, transverse bands, mini-skip lines, characters, and crosswalk lines.
- 90 mils Edge lines, gore lines, diagonals, and arrow symbols.

(D) Testing

Retroreflective measurements will be taken within 30 days prior to the end of the 180-day pavement markings observation period. Maintain minimum retroreflective values as shown below throughout the 180 day pavement markings observation period.

- White: 325 mcd/lux/m2
- Yellow: 200 mcd/lux/m2

At the end of the Pavement Markings Observation Period, the thermoplastic pavement marking material shall be within 10 mils of the initial pavement marking thickness as required in the plan. Take the thickness measurements as specified by Materials and Tests Unit Procedure PM-1.0. See the *Construction Manual* for details.

3.5. MAINTENANCE

Replace pavement markings that prematurely deteriorate, fail to adhere to the pavement, lack reflectorization, or are otherwise unsatisfactory, during the life of the project or during the 180-day PM observation period as determined by the Engineer at no cost to the Department.

Upon notification from the Engineer, winterize the existing pavement markings on the project by placing an additional application of markings. The markings shall be suitable for use in winter periods whether in a temporary or final pattern. Payment will be made under the pay item for the type of marking placed.

3.6. MEASUREMENT AND PAYMENT

Pavement marking lines will be measured and paid for as the actual number of linear feet of pavement marking lines that have been satisfactorily placed and accepted. The quantity of solid lines will be the summation of the linear feet of solid line measured end-to-end of the line. The quantity of skip or broken lines will be the summation of the linear feet derived by multiplying the nominal length of a line by the number of marking lines satisfactorily placed.

Pavement marking symbols will be measured and paid for as the actual number of pavement marking symbols that have been satisfactorily place and accepted.

Removal of pavement marking lines will be measured and paid for as the actual number of linear feet of pavement marking lines that have been satisfactorily removed and accepted by the Engineer. The quantity of solid lines will be the summation of the linear feet of solid line measured end-to-end of the line. The quantity of skip or broken lines will be the summation of the linear feet derived by multiplying the nominal length of a line by the number of marking lines satisfactorily removed. No payment will be made for the removal of removable pavement marking tape.

Removal of pavement marking symbols & characters will be measured and paid for as the actual number of pavement marking symbols and characters that have been satisfactorily removed and accepted.

Payment at the contract unit price for the various items in the contract will be full compensation for all the items covered by this section. No direct payment will be made for: the work involved in applying the lines, including surface preparation; reapplication of molten pavement marking crossed by a vehicle; and removal of all pavement marking materials spilled on the roadway surface.

Payment will be made under:

Pay Item	Pay Unit
Thermoplastic Pavement Marking Lines, 4", 120 mils	Linear Foot
Thermoplastic Pavement Marking Lines, 8", 120 mils	Linear Foot
Thermoplastic Pavement Marking Lines, 24", 120 mils	Linear Foot
Thermoplastic Pavement Marking Symbol, 90 mils	Each
Removal of Pavement Marking Lines, 4"	Linear Foot
Removal of Pavement Marking Symbols & Characters	Each

4. SIGNAL HEADS

4.1. DESCRIPTION

Furnish, install and relocate vehicle and pedestrian LED signal heads, visors, interconnecting brackets, wire entrance fittings, mounting assemblies, signal cable, lashing wire, pedestrian pushbuttons, pedestrian signal signs, pushbutton posts, grounding systems, and all necessary hardware.

4.2. MATERIALS

(A) General

Fabricate vehicle signal head housings and end caps from die-cast aluminum, unless the Plans specify polycarbonate signal heads. For locations where the Plans call for polycarbonate vehicle signal heads, fabricate the signal head housings from ultraviolet and heat-stabilized virgin polycarbonate material.

Fabricate 16-inch pedestrian signal head housings and end caps from die-cast aluminum. Provide visor mounting screws, door latches, and hinge pins fabricated from stainless steel. Provide interior screws, fasteners, and metal parts fabricated from stainless steel or corrosion resistant material.

Fabricate tunnel and traditional visors for die-cast aluminum signal heads from sheet aluminum. Fabricate tunnel and traditional visors for polycarbonate signal heads from ultraviolet and heat-stabilized virgin polycarbonate material.

Paint all surfaces inside and outside of signal housings and doors. Paint outside surfaces of tunnel and traditional visors, messenger cable mounting assemblies, pole and pedestal mounting assemblies, and pedestrian pushbutton housings. Use electrostatically-applied, fused-polyester paint a minimum of 2.5 to 3.5 mils thick. Do not apply paint to the latching hardware or rigid vehicle signal head mounting brackets for mast arm attachments.

Paint the signal housings black (Federal Standard 595C, Color Chip Number 17038) when:

- The pedestrian or vehicle signal will be mounted on metal poles or mast arms that currently have a black finish.
- The existing pedestrian and vehicle signals at the intersection where the new signals will be installed are painted black.

For signals at all other locations, paint the signal housings highway yellow (Federal Standard 595C, Color Chip Number 13538).

Have the interior surfaces of tunnel and traditional visors painted an alkyd urea black synthetic baking enamel with a minimum gloss reflectance and that meets the requirements of MIL-E-10169, "Enamel Heat Resisting, Instrument Black."

For pole mounting, provide side of pole mounting assemblies with framework and all other hardware necessary to make complete, watertight connections of the signal heads to the poles and pedestals. Fabricate the mounting assemblies and frames from aluminum with all necessary hardware, screws, washers, etc. to be stainless steel. Provide mounting fittings that match the positive locking device on the signal head with the serrations integrally cast into the brackets.

Provide upper and lower pole plates that have a 1¼-inch vertical conduit entrance hubs with the hubs capped on the lower plate and 1½-inch horizontal hubs. Ensure that the assemblies provide rigid attachments to poles and pedestals so as to allow no twisting or swaying of the signal heads. Ensure that all raceways are free of sharp edges and protrusions, and can accommodate a minimum of ten Number 14 AWG conductors. Furnish pole-mounting assemblies that are the same color as the housing of the pedestrian or vehicle signal head that will be attached to them (e.g., furnish black assemblies for black signal heads and yellow assemblies for yellow signal heads). Comply with the painting requirements for signal heads listed above.

For pedestal mounting, provide a post-top slipfitter mounting assembly that matches the positive locking device on the signal head with serrations integrally cast into the slipfitter. Provide stainless steel hardware, screws, washers, etc. Provide a minimum of six 3/8 X 3/4-inch long square head bolts for attachment to pedestal. Provide a center post for multi-way slipfitters. Furnish post-top slipfitter mounting assemblies that are either the same color as the housing of the pedestrian or vehicle signal head that will be attached to them (e.g., furnish black assemblies for black signal heads and yellow assemblies for yellow signal heads) or which have a natural aluminum finish. Comply with the painting requirements for signal heads listed above.

For light emitting diode (LED) traffic signal modules, provide the following requirements for inclusion on the ITS & Signals Qualified Products List (QPL) for traffic signal equipment.

1. Sample submittal,
2. Third-party independent laboratory testing results for each submitted module with evidence of testing and conformance with all of the Design Qualification Testing specified in Section 6.4 of each of the following Institute of Transportation Engineers (ITE) specifications:
   - Vehicle Traffic Control Signal Heads – Light Emitting Diode (LED) Circular Signal Supplement
   - Vehicle Traffic Control Signal Heads – Light Emitting Diode (LED) Vehicle Arrow Traffic Signal Supplement
   - Pedestrian Traffic Control Signal Indications – Part 2: Light Emitting Diode (LED) Pedestrian Traffic Signal Modules.

     (Note: The Department currently recognizes two approved independent testing laboratories. They are Intertek ETL Semko and Light Metrics, Incorporated with Garwood Laboratories. Independent laboratory tests from other laboratories may be considered as part of the QPL submittal at the discretion of the Department.
3. Evidence of conformance with the requirements of these specifications,
4. A manufacturer's warranty statement in accordance with the required warranty, and
5. Submittal of manufacturer's design and production documentation for the model, including but not limited to, electrical schematics, electronic component values, proprietary part numbers, bill of materials, and production electrical and photometric test parameters,
6. Evidence of approval of the product to bear the Intertek ETL Verified product label for LED traffic signal modules.

In addition to meeting the performance requirements for the minimum period of 60 months, provide a written warranty against defects in materials and workmanship for the modules for a

period of 60 months after installation of the modules. During the warranty period, the manufacturer must provide replacement modules at no cost to the City within 45 days of receipt of modules that have failed. Repaired or refurbished modules may not be used to fulfill the manufacturer's warranty obligations. Provide manufacturer's warranty documentation to the Department during evaluation of product for inclusion on the Department's QPL.

(B) Vehicle Signal Heads

Comply with the ITE standard "Vehicle Traffic Control Signal Heads". Provide housings with provisions for attaching backplates.

Provide visors that are 8 inches in length for 8-inch vehicle signal head sections. Provide visors that are 10 inches in length for 12-inch vehicle signal heads.

Provide a termination block with one empty terminal for field wiring for each indication plus one empty terminal for the neutral conductor. Have all signal sections wired to the termination block. Provide barriers between the terminals that have terminal screws with a minimum Number 8 thread size and that will accommodate and secure spade lugs sized for a Number 10 terminal screw.

Mount termination blocks in the yellow signal head sections on all in-line vehicle signal heads. Mount the termination block in the red section on five-section vehicle signal heads.

Furnish vehicle signal head interconnecting brackets. Provide one-piece aluminum brackets less than 4.5 inches in height and with no threaded pipe connections. Provide hand holes on the bottom of the brackets to aid in installing wires to the signal heads. Lower brackets that carry no wires and are used only for connecting the bottom signal sections together may be flat in construction.

For messenger cable mounting, provide messenger cable hangers, wire outlet bodies, balance adjusters, bottom caps, wire entrance fitting brackets, and all other hardware necessary to make complete, watertight connections of the vehicle signal heads to the messenger cable. Fabricate mounting assemblies from malleable iron and provide serrated rings made of aluminum. Provide messenger cable hangers and balance adjusters that are galvanized before being painted. Fabricate balance adjuster eyebolt and eyebolt nut from stainless steel or galvanized malleable iron. Provide messenger cable hangers with U-bolt clamps. Fabricate washers, screws, bolts, clevis pins, cotter pins, nuts, and U-bolt clamps from stainless steel.

For mast arm mounting, provide rigid vehicle signal head mounting brackets and all other hardware necessary to make complete, watertight connections of the vehicle signal heads to the mast arms and to provide a means for vertically adjusting the vehicle signal heads to proper alignment. Fabricate the mounting assemblies from malleable iron or aluminum, and provide serrated rings made of aluminum.

Provide LED vehicular traffic signal modules (hereafter referred to as modules) that consist of an assembly that uses LEDs as the light source in lieu of an incandescent lamp for use in traffic signal sections. Use LEDs that are aluminum indium gallium phosphorus (AlInGaP) technology for red and yellow indications and indium gallium nitride (InGaN) for green indications. Install the ultra bright type LEDs that are rated for 100,000 hours of continuous operation from -40°F to +165°F. Design modules to have a minimum useful life of 60 months and to meet all parameters of this specification during this period of useful life.

For the modules, provide spade terminals crimped to the lead wires and sized for a #10 screw connection to the existing terminal block in a standard signal head. Do not provide other types of crimped terminals with a spade adapter.

Ensure the power supply is integral to the module assembly. On the back of the module, permanently mark the date of manufacture (month & year) or some other method of identifying date of manufacture.

Tint the red, yellow and green lenses to correspond with the wavelength (chromaticity) of the LED. Transparent tinting films are unacceptable. Provide a lens that is integral to the unit with a smooth outer surface.

(1) LED Circular Signal Modules:

Provide modules in the following configurations: 12-inch circular sections, and 8-inch circular sections. All makes and models of LED modules purchased for use on this project shall appear on the current NCDOT ITS & Signals Qualified Products List (QPL).

Provide the manufacturer's model number and the product number assigned by the Department for each module that appears on the 2006 or most recent ITS & Signals QPL. In addition, provide manufacturer's certification in accordance with Article 106-3 of the *Standard Specifications,* that each module meets or exceeds the ITE "Vehicle Traffic Control Signal Heads – Light Emitting Diode (LED) Circular Signal Supplement" dated June 27, 2005 (hereafter referred to as VTCSH Circular Supplement) and other requirements stated in this specification.

Provide modules that meet the following requirements when tested under the procedures outlined in the VTCSH Circular Supplement:

Module Type	Max. Wattage at 165° F	Nominal Wattage at 77° F
12-inch red circular	17	11
8-inch red circular	13	8
12-inch green circular	15	15
8-inch green circular	12	12

For yellow circular signal modules, provide modules tested under the procedures outlined in the VTCSH Circular Supplement to insure power required at 77° F is 22 Watts or less for the 12-inch circular module and 13 Watts or less for the 8-inch circular module.

Note: Use a wattmeter having an accuracy of ±1% to measure the nominal wattage and maximum wattage of a circular traffic signal module. Power may also be derived from voltage, current and power factor measurements.

(2) LED Arrow Signal Modules

Provide 12-inch omnidirectional arrow signal modules. All makes and models of LED modules purchased for use on this project shall appear on the current NCDOT ITS & Signals Qualified Products List (QPL).

Provide the manufacturer's model number and the product number (assigned by the Department) for each module that appears on the 2006 or most recent ITS & Signals QPL. In addition, provide manufacturer's certification in accordance with Article 106-3 of the *Standard Specifications,* that each module meets or exceeds the requirements for 12-inch omnidirectional

modules specified in the ITE "Vehicle Traffic Control Signal Heads – Light Emitting Diode (LED) Vehicle Arrow Traffic Signal Supplement" dated July 1, 2007 (hereafter referred to as VTCSH Arrow Supplement) and other requirements stated in this specification.

Provide modules that meet the following requirements when tested under the procedures outlined in the VTCSH Arrow Supplement:

Module Type	Max. Wattage at 165° F	Nominal Wattage at 77° F
12-inch red circular	12	9
12-inch green circular	11	11

For yellow arrow signal modules, provide modules tested under the procedures outlined in the VTCSH Arrow Supplement to insure power required at 77° F is 12 Watts or less.

Note: Use a wattmeter having an accuracy of ±1% to measure the nominal wattage and maximum wattage of an arrow traffic signal module. Power may also be derived from voltage, current and power factor measurements.

(C) Pedestrian Signal Heads and Pushbuttons

Provide pedestrian signal heads with international symbols that meet the MUTCD. Do not provide letter indications.

Comply with the ITE standard for "Pedestrian Traffic Control Signal Indications" and the following sections of the ITE standard for "Vehicle Traffic Control Signal Heads" in effect on the date of advertisement:

- Section 3.00 - "Physical and Mechanical Requirements"
- Section 4.01 - "Housing, Door, and Visor: General"
- Section 4.04 - "Housing, Door, and Visor: Materials and Fabrication"
- Section 7.00 - "Exterior Finish"

Provide a double-row termination block with three empty terminals and number 10 screws for field wiring. Provide barriers between the terminals that accommodate a spade lug sized for number 10 terminal screws. Mount the termination block in the hand section. Wire all signal sections to the terminal block.

Where required by the Plans, provide 16-inch pedestrian signal heads with traditional three-sided, rectangular visors, 6 inches long.

Design the LED pedestrian traffic signal modules (hereafter referred to as modules) for installation into standard pedestrian traffic signal sections that do not contain the incandescent signal section reflector, lens, eggcrate visor, gasket, or socket. Provide modules that consist of an assembly that uses LEDs as the light source in lieu of an incandescent lamp. Use LEDs that are of the latest aluminum indium gallium phosphorus (AlInGaP) technology for the Portland Orange hand and countdown displays. Use LEDs that are of the latest indium gallium nitride (InGaN) technology for the Lunar White walking man displays. Install the ultra bright type LEDs that are rated for 100,000 hours of continuous operation from -40°F to +165°F. Design modules to have a minimum useful life of 60 months and to meet all parameters of this specification during this period of useful life.

Provide modules in the following configuration: 16-inch displays which have the solid hand/walking man overlay on the left and the countdown on the right. All makes and models of

LED modules purchased for use on this project shall appear on the current NCDOT ITS & Signals Qualified Products List (QPL).

Provide the manufacturer's model number and the product number (assigned by the Department) for each module that appears on the 2006 or most recent ITS & Signals QPL List. In addition, provide manufacturer's certification in accordance with Article 106-3 of the *Standard Specifications,* that each module meets or exceeds the ITE "Pedestrian Traffic Control Signal Indications – Part 2: Light Emitting Diode (LED) Pedestrian Traffic Signal Modules" dated March 19, 2004 (hereafter referred to as PTCSI Pedestrian Standard) and other requirements stated in this specification.

Design all modules to operate using a standard 3 - wire field installation. Provide spade terminals crimped to the lead wires and sized for a #10 screw connection to the existing terminal block in a standard pedestrian signal housing. Do not provide other types of crimped terminals with a spade adapter.

Ensure the power supply is integral to the module assembly. On the back of the module, permanently mark the date of manufacture (month & year) or some other method of identifying date of manufacture.

Provide module lens that is hard coated or otherwise made to comply with the material exposure and weathering effects requirements of the Society of Automotive Engineers (SAE) J576. Ensure all exposed components of the module are suitable for prolonged exposure to the environment, without appreciable degradation that would interfere with function or appearance.

Design the walking man and hand as a solid display. Ensure the hand/walking man symbols for the 16-inch display module meet the dimension requirements cited in PTCSI Pedestrian Standard Table 1 *"Dimensions of Signal Sizes"* for Class 3 or Class 4.

Provide the countdown number display that is at least 9 inches high by 6 inches wide. Ensure the minimum luminance value for the countdown number display is 1,400 cd/m^2. Provide the countdown number display that will conform to the chromaticity requirements of the hand symbol as specified by section 4.2 (Chromaticity) of the PTCSI Pedestrian Standard. Furnish the countdown display to continuously monitor the traffic controller to automatically learn the pedestrian phase time and update for subsequent changes to the pedestrian phase time. Design the countdown display as a double row of LEDs or with a minimum thickness of 0.5 inch. Ensure the countdown display blanks-out during the initial cycle while it records the countdown time. Ensure that the countdown display is operational only during the flashing don't walk, clearance interval. Blank-out the countdown indication after it reaches zero and until the beginning of the next flashing don't walk indication. Design the controlling circuitry to prevent the timer from being triggered during the solid hand indication. Ensure the countdown display discontinues and goes dark immediately upon activation of a preemption transition. Ensure the countdown display begins normal operation upon the completion of the preemption sequence and no more than one pedestrian clearance cycle.

Provide modules that meet the following requirements when tested under the procedures outlined in the PTCSI Pedestrian Standard:

Module Type	Max. Wattage at 165° F	Nominal Wattage at 77° F
Hand Indication	16	13
Walking Man Indication	12	9
Countdown Indication	16	13

Note: Use a wattmeter having an accuracy of ±1% to measure the nominal wattage and maximum wattage of a pedestrian signal module. Power may also be derived from voltage, current and power factor measurements.

Provide 2-inch diameter pedestrian pushbuttons with weather-tight housings fabricated from die-cast aluminum and threading in compliance with the NEC for rigid metal conduit, except for locations where the Plans call for installation of accessible pedestrian signals (APS). Provide a weep hole in the housing bottom and ensure that the unit is vandal resistant. Where the plans call for installation of accessible pedestrian signals, refer to the "Pushbutton Integrated Accessible Pedestrian Signal (APS)" section of these Project Special Provisions."

Provide pushbutton housings that are suitable for mounting on flat or curved surfaces and that will accept 1/2-inch conduit installed in the top. Provide units that have a heavy duty pushbutton assembly with a sturdy, momentary, normally-open switch. Have contacts that are electrically insulated from the housing and pushbutton. Ensure that the pushbuttons are rated for a minimum of 5 mA at 24 volts DC and 250 mA at 12 volts AC. Furnish pushbuttons with housings that are the same color as the housing of the corresponding pedestrian signal installed at a given location (e.g., furnish black pushbutton housings for black pedestrian signal heads and yellow pushbutton housings for yellow pedestrian signal heads). Comply with the painting requirements for signal heads listed above. Stainless steel pushbutton housings are an acceptable alternative to painted or powder-coated aluminum housings for all locations.

Provide standard R10-3e signs with mounting hardware that comply with the MUTCD in effect on the date of advertisement.

(D) 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. IMSA specification 19-1 will not be acceptable. Provide a cable jacket labeled with the IMSA specification number and provide conductors constructed of stranded copper.

4.3. CONSTRUCTION METHODS

(A) General

Bag new pedestrian and vehicle signal heads with burlap bags or bags made of non-ripping material specifically designed for covering signal heads until signal heads are placed in operation. Do not use trash bags of any type.

When new signal heads are placed into operation, immediately bag and remove signals heads that are not to be reused.

Adjust each signal head vertically and horizontally so that light output will be of maximum effectiveness for traffic and pedestrians. Do not tilt signal heads forward.

Reposition signal heads as required for various construction phases.

(B) Vehicle Signal Heads

Install vehicle signal heads at the heights required in the *North Carolina Supplement to the MUTCD* in effect on the date of advertisement.

Where vehicle signal heads are installed on messenger cable, install mounting hardware consisting of messenger cable hanger, balance adjuster, bottom cap, wire entrance fitting bracket, and insulating bushings.

Where vehicle signal heads are installed on mast arms, install mounting hardware consisting of rigid vehicle signal head mounting brackets.

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 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.

(C) Pedestrian Signal Heads and Pushbuttons

Install new countdown pedestrian signal heads at locations shown in the plans.

Install new pedestrian signal pushbuttons and new pedestrian signal signs at all locations where new pedestrian signal heads are being installed (including locations where existing pedestrian signal heads are being replaced), unless the pedestrian movement is non-actuated (i.e., pretimed) or the Plans call for installation of accessible pedestrian signals. Do not provide and install pushbuttons and pedestrian signal signs for non-actuated (i.e., pre-timed) pedestrian movements unless the Plans call for installation of accessible pedestrian signals. Install R10-3e signs above pushbuttons for countdown pedestrian signal heads.

Install the pedestrian pushbutton on a signal pole or pedestal located within the intersection radius that is adjacent to the accessible ramp and/or pedestrian crossing that the pushbutton and associated pedestrian signal serve and that is directly accessible from the sidewalk by a pedestrian using a wheelchair or other walking aid. Mount the pushbutton with its center approximately 3.5 feet but no more than 4 feet above the adjacent sidewalk or pedestrian path. Install the pushbutton adjacent to a level surface. Do not install the pushbutton in a location that requires the pedestrian to traverse a cut or fill slope (i.e., embankment), berm or ditch to access the pushbutton. Place the pushbutton on a side of the pole or pedestal that it is facing the

sidewalk/pedestrian path and parallel to the crosswalk it serves. Do not place the pushbutton in a location that requires the pedestrian to leave the sidewalk to access the pushbutton. Do not mount the pushbutton underneath a pole-mounted cabinet or any other location that is difficult to reach or find.

Install the pedestrian pushbutton between the edge of the crosswalk line (extended) farthest from the center of the intersection and the side of the curb ramp (if present), but not greater than 5 feet from said crosswalk line. Install the pedestrian pushbutton between 1.5 feet and 6 feet from the edge of the curb, shoulder or pavement, whenever feasible, but no greater than 10 feet from the edge of the curb, shoulder or pavement. Where two pushbuttons are located on the same corner of the intersection, install the pedestrian pushbuttons at least 10 feet apart, unless physical constraints make doing so impractical. Refer to MUTCD Figure 4E-4, "Typical Pushbutton Locations" for additional guidance on placement of pushbuttons.

Install signs with mounting hardware immediately above pedestrian pushbuttons.

Connect new pushbutton (where there is no exiting pushbutton) to controller cabinet using a new lead-in cable separate from any lead-in cable for any other pushbutton. Bond pushbutton housing and all metal components to cabinet ground using cable ground.

Reuse existing wiring to connect a replacement pushbutton. In cases where conduit and wiring from an existing pushbutton connect to an existing pedestrian signal head mounting bracket, extend the conduit and replace the wiring as necessary to maintain the approximate 3.5-foot (4-foot maximum) mounting height of the pushbutton above grade/sidewalk.

(D) Modify Existing Vehicle Signal Heads

Modify existing vehicle signal heads by removing incandescent lamp hardware and replacing with new LED modules with all necessary hardware.

4.4. MEASUREMENT AND PAYMENT

Vehicle signal head (_____) and *Pedestrian signal head (16", 1 section w/countdown)* will be measured and paid for as the actual number of signal heads of each type, size, and number of sections furnished, installed, and accepted.

No measurement will be made of visors, wire entrance fittings, interconnecting brackets, mounting assemblies, pedestrian pushbuttons, and pedestrian signal signs as these will be considered incidental to furnishing and installing signal heads. Similarly, no measurement will be made of lead-in cable and conduit where new pushbuttons are installed to replace existing pushbuttons as these are considered incidental to furnishing and installing pedestrian signal heads.

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.

No measurement will be made for drip loops, coiled sections, or lashing wire as these will be considered incidental to furnishing and installing signal cable.

Pedestrian pushbutton post will be measured and paid for as the actual number of pedestrian pushbutton posts furnished, installed and accepted.

No measurement will be made for concrete foundations for pedestrian pushbutton posts and conduit stub-outs from the foundations as these will be considered incidental to furnishing and installing the pedestrian pushbutton post. Similarly, no measurement will be made of

transformer-style pedestal bases, associated pedestal foundations, and conduit stub-outs from the pedestal foundations as these will also be considered incidental to furnishing and installing the pedestrian pushbutton post.

Modify existing vehicle signal head will be measured and paid for as the actual number of existing vehicle signal heads modified and accepted.

No measurement will be made of replacing existing pedestrian pushbuttons where the corresponding pedestrian signal heads are being replaced as such work will be considered incidental to furnishing and installing new pedestrian signal heads.

Payment will be made under:

Pay Item	**Pay Unit**
Vehicle Signal Head (_____)	Each
Pedestrian Signal Head (16", 1 Section w/Countdown)	Each
Signal Cable	Linear Foot
Modify Existing Vehicle Signal Head	Each

5. MESSENGER CABLE

5.1. DESCRIPTION

Furnish and install messenger cable (span wire) with cable clamps, machine bolts, eyebolts, 3-bolt clamps, eye nuts, split-bolt connectors, metal pole clamps, stainless steel bands, and all necessary hardware.

5.2. MATERIALS

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

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.

Provide galvanized metal pole clamps and stainless steel banding hardware for attaching pole line hardware (e.g., strandvises, three-bolt clamps, etc.) to metal signal poles.

5.3. CONSTRUCTION METHODS

Install guy assemblies before installing messenger cable.

Use 3/8-inch messenger cable for spans supporting vehicle signal heads, and/or signs.

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

For messenger cable crossing over railroad tracks, provide a minimum of 27 feet of vertical clearance, unless otherwise specified.

For permanent installations, 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 match sag of surrounding utilities. Otherwise, allow 3 to 4 percent sag of the span length between poles.

Provide three-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.

Attach messenger cable to metal signal poles using approved galvanized metal pole clamps or stainless steel bands to attach strandvises and three-bolt clamps. Do not drill holes in metal poles to attach messenger cable. Do not attach messenger cable to metal poles that are owned by anyone other than the City or the Department without prior approval of the Engineer and the pole owner. Where such attachments are approved, use attachment methods and hardware approved by the pole owner.

Maintain electrical continuity at all splices.

Messenger Cable for Signal Heads or Loop Lead-In Cable: For messenger cable attached to joint use poles, install a new grounding system that complies with Article 1720-3 of the *Standard Specifications* 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 parallel groove clamps at each end.

Messenger Cable for Communications Cable: For messenger cable attached to joint use poles, bond messenger cable to existing pole ground using number 6 AWG minimum solid bare copper grounding wire terminated with split bolt connectors or parallel groove clamps at each end and at 1300-foot intervals. If existing poles do not have a grounding system, install new grounding system that complies with the Construction Methods for "Wood Poles' section of these Project Special Provisions 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 parallel groove clamps and terminate to pole ground.

On joint use poles at signal and ITS equipment installations (i.e., Controller Cabinets, CCTV Cabinets, Communications Hub Cabinets, DMS Cabinets, etc.), do not use existing utility company grounds. Install a ground system for the signal and ITS equipment.

5.4. MEASUREMENT AND PAYMENT

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, three-bolt assemblies, eye nuts, split bolt connectors, metal pole clamps, stainless steel banding hardware, and pole grounding systems as these will be considered incidental to furnishing and installing messenger cable.

Payment will be made under:

Pay Item	Pay Unit
Messenger Cable (1/4")	Linear Foot
Messenger Cable (3/8")	Linear Foot

6. UNDERGROUND CONDUIT

6.1. 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. Furnish and install inner duct conduits inside outer duct conduits.

6.2. MATERIALS

(A) General

Except for HDPE conduit, material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

Refer to the following articles of the *Standard Specifications*:

Backfill 1018-2

Graded Stone 545-2 and 545-3

Use conduit bodies, boxes, and fittings that meet UL Standard 514B Conduit, Tubing, and Cable Fittings for electrical and communications installations.

(B) Conduit Types

(1) 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.

(2) 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 and HDPE Conduit. Provide Schedule 40 conduit unless otherwise specified.

(3) High Density Polyethylene Conduit (HDPE)

Provide conduit that meets UL Standard 651B Continuous Length HDPE Conduit.

Provide HDPE conduit with an outer diameter to minimum wall thickness ratio that complies with ASTM D 3035, Standard Dimension Ratio (SDR) 11 or better (thicker wall) **for use in railroad rights-of-way**. Provide HDPE conduit with an outer diameter to minimum wall thickness ratio that complies with ASTM D 3035, Standard Dimension Ratio (SDR) 13.5 for all other applications.

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 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 or smooth 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.

(C) Conduit Plugs, Sealing Putty, 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 moldable sealing putty that has the following characteristics:

- Contains no asbestos;
- Designed for use with electrical and telecommunications cables house in conduits
- Adheres to various conduit materials, including PVC, HDPE and galvanized steel;
- Forms a moisture barrier;
- Requires no mixing or additives (single-component) and requires no volatile solvents; and
- Can be applied by hand.

Furnish 1/2", pre-lubricated, woven polyester tape, pull line with minimum rated tensile strength of 2,500 lb.

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

Furnish non-detectable underground marker tape with the wording "WARNING – Fiber-Optic Cable" in all trenches containing one or more conduits that will house fiber-optic communications cable.

Comply with Subarticle 1400-2(H) Duct and Conduit Sealer of the *Standard Specifications*.

(D) Mechanical Couplings for HDPE Conduit

Provide mechanical couplings that are both watertight and airtight for joining two segments of HDPE conduit of like diameter. Provide couplings designed to accommodate pneumatic methods of cable installation. Provide couplings suitable for burial underground and which meet the following requirements:

- The coupling shall not fail by leakage when subjected to sustained internal pressure testing as noted in ASTM F 2176.
- The coupling shall not fail by leakage when subjected to sustained external pressure testing as noted in ASTM F 2176.
- The coupling assemblies tested shall be able to comply with the tensile loading requirements as specified in ASTM F 2176.
- As specified in ASTM F 2176, the coupling shall not fail when conditioned at low temperature conditions of 10° F and tested by an impact with a force of 20 ft-lb using Type "B" as described in Test Method ASTM D 2444.

(E) Innerduct Conduit

Furnish innerduct conduit systems, also known as multiduct conduit, comprised of multiple HDPE conduits of the number and size specified in the Plans for installation in outerduct conduits.

Furnish innerduct conduit organizer plugs at each end of the outerduct conduit segment that houses the innerduct. Furnish innerduct organizer plugs with evenly spaced ports that provide a watertight seal around the individual innerduct conduits and a watertight barrier between the innerducts and the outerduct. Furnish innerduct conduit organizer plugs that are appropriately sized for outerduct and the number of innerducts being installed in the outerduct and which. If the innerduct organizer plug being furnished has more conduit ports (i.e., holes) than the number of innerducts being installed, provide watertight, mechanical duct plugs to fill the spare ports (i.e., holes). Provide innerduct organizer plugs that are removable and reusable.

6.3. CONSTRUCTION METHODS

(A) General

Except where the Plans call for a specific installation method or where the Engineer directs otherwise, underground conduit may be installed by either trenching, directional drilling or plowing at the option of the Contractor.

Refer to Section 1 of these Project Special Provisions for additional requirements concerning work within and adjacent to historic districts.

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

Where cable is not immediately installed or where conduit is for future use (spare), seal the ends of the conduit with a duct plug immediately upon installation of the conduit. 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.

All conduits installed in a common trench or bore must be the same size and all conduits in a continuous longitudinal run must be the same size. Do not intermix different size conduits in the same run.

Install a minimum of two conduits (i.e., at least one for fiber-optic cable plus one dedicated spare) for all underground routes unless the Plans show otherwise. Exceptions on plans may include short runs to CCTV cameras, short PVC runs to controller cabinets from main trunk line, or installations under railroad tracks.

Install the number of inner duct conduits specified on the plans inside each outer duct conduit bored beneath a railroad right-of-way, but no less than two inner-duct conduits. Install only one outer duct conduit beneath railroad rights-of-way.

Install junction boxes in underground conduit runs as shown on the Plans. Do not exceed 1500 feet between junction boxes in any underground conduit route that conveys communications cable without the prior approval the Engineer.

(1) Conduit Entering Junction Boxes

Terminate conduits installed for communications cables in oversized or special-sized, heavy-duty junction boxes as shown on the Plans. Do not install other conduits in these junction boxes 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 or moldable sealing putty. Seal conduits containing signal cable and loop lead-in wire with moldable sealing putty.

(2) Tracer Wire

Install tracer wire in all conduits containing fiber-optic cable, unless otherwise indicated on the Plans or the Engineer directs otherwise. 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. Splice tracer wire only in junction boxes using waterproof butt splice connectors. Coil and store 3 feet of spare tracer wire in junction boxes. Label all tracer wires entering an equipment cabinet. For a given tracer wire run between two controller cabinets, bond the tracer wire to the equipment ground inside the controller cabinet at one end of run only; do not bond both ends of the tracer wire in a continuous run to cabinet grounds at each end of the run. Establish a consistent convention for which end the tracer wire will be bonded along a give roadway or corridor. For example, bond the end of the tracer wire closest/to (in the direction of) the Rocky Mount TMC.

(3) Ground Surface Restoration

Upon completion of conduit installation and backfilling of all trenches and other excavations, restore the disturbed ground to its original condition as determined and approved by the Engineer. For paved areas, replace removed or damaged pavement with in kind materials, matching the elevation, color, texture/finish and general appearance of the surrounding

pavement. Refer to Section 1 of these Project Special Provisions for additional requirements concerning sidewalks and curbs in historic districts. For unpaved areas, backfill excavations with removed material, tamp the backfilled material and rake smooth the top 1½ inches. Finish unpaved areas flush with surrounding natural ground and to match the original contour of the ground. Seed with same type of grass as surrounding area and mulch the newly seeded area. If unpaved area was not grassed, replace the original ground cover in kind as directed by the Engineer.

Complete repairs to and restoration of all ground (paved and unpaved) disturbed by construction within five consecutive calendar days following initial removal. If the Contractor fails to repair and restore the ground in accordance with these Project Special Provisions within the time frame specified, the Department reserves the right to make the necessary repairs, and all expenses incurred by the Department in making the repairs and restoring the ground will be deducted from payment due the Contractor, plus $500 liquidated damages per occasion, per day, or any portion thereof, until corrected.

(4) Plan of Record Drawings

Upon completion of the conduit system for communications, furnish the Engineer with a plan of record drawing detailing both the horizontal and vertical (i.e. depth) locations of the conduit system.

(B) Trenching

(1) General

Install PVC, HDPE, or rigid metallic conduit for all underground runs as specified in the Plans. Install rigid metallic conduit for all underground runs located inside railroad right-of-way, unless otherwise specified. 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 longitudinally in the trench 6 to 12 inches below the unpaved ground surface or below the underside of the paved surface.

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.

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 of the *Standard Specifications*. 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 re-installed.

Use HDPE conduit in trenched areas unless otherwise specified in the Plans. Use 2-inch PVC or rigid galvanized conduit between junction boxes adjacent to the controller cabinet and the 2-inch conduit stub-outs from the cabinet foundation.

(2) Unpaved Trenching

Install conduit in unpaved areas. Rake smooth the top 1-1/2 inches and seed with same type of grass as surrounding area. Restore damaged grassed areas. Seed and mulch, using methods and material approved by the Engineer, within five consecutive calendar days following initial damage to grassed areas, unless the Engineer approves otherwise due to weather and soil conditions. If the Contractor fails to repair the grassed areas in accordance with these Project Special Provisions within the time frame specified, the Department reserves the right to make the necessary repairs, and all expenses incurred by the Department in making the repairs and restoring the grassed area will be deducted from payment due the Contractor, plus $500 liquidated damages per occasion, per day, or any portion thereof, until corrected.

Adapt operations to variations in weather of soil conditions as necessary for the successful establishment and growth of the grasses. When the Engineer determines that weather and soil conditions are unfavorable, including but not limited to extremely wet or frozen soil, do not distribute any limestone or fertilizer and do not sow any seed. During seasons of the year when temperatures are not conducive to germination and growth of the type of grass seed to be planted, seed and mulch the disturbed areas with temporary seeding that will germinate and grow under the prevailing temperatures until such time that permanent seeding can be established, as approved and directed by the Engineer.

As directed by the Engineer, apply additional seed or completely reseed areas which have been previously seeded and mulched but which have been damaged, have failed to successfully establish a stand of vegetation or have an unsatisfactory cover of vegetation. Perform supplemental and repair seeding promptly at all locations and times as directed by the Engineer.

(3) Paved Trenching

On concrete surfaces, replace the entire joint of concrete and match the original concrete as to color and finish unless otherwise specified. On all other surfaces, neatly cut and replace the width of trench with like material. Refer to Section 1 of these Project Special Provisions for additional requirements concerning sidewalks and curbs in historic districts. Place graded stone material to temporarily maintain pedestrian traffic where repairs cannot be performed immediately. Comply with Article 545-4 of the *Standard Specifications.*

Complete repairs to all paved areas removed for construction within five consecutive calendar days following initial removal. If the Contractor fails to repair the paved area in accordance with these Project Special Provisions within the time frame specified, the Department reserves the right to make the necessary repairs, and all expenses incurred by the Department in making the repairs and restoring the paved area will be deducted from payment due the Contractor, plus $500 liquidated damages per occasion, per day, or any portion thereof, until corrected.

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 of the *Standard Specifications*.

(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.

(D) Directional Drilling

(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. For installations in railroad right-of-way, minimum cover (measured from the base of the rail to the top of the pipe) shall be 15 feet, with a minimum of 15 feet below the finished grade of ditch lines. 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 60" or less	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
Railroad tracks	15' minimum between base of rail to top of pipe; 15' minimum below finished grade of ditch line.

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. Disposal on public or railroad right-of-way or railroad drainage ditches/facilities is prohibited. Immediately remove all drilling fluids/slurry that are accidentally spilled.

(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.

Place drill rig so that launching and receiving pits are outside railroad right-of-way if possible. If not possible, ensure the pits are outside the railroad influence zone. The railroad influence zone (also referred to as the embankment line) begins at a point on the existing grade 10 feet horizontally from center line of track and extends downward on a 1 ½ (H) to 1 (V) slope away from tracks.

At all times, have alternate drill heads available in case the soil conditions do not match expected conditions.

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, unless in railroad right-of-way. In railroad right-of-way the drill head must be sized no more than 1.5 times the outside diameter of the conduit being installed. Direct drill to obtain proper depth and desired destination. 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. Within railroad right-of-ways, mark the location and depth 10 foot intervals and when traversing underground utilities and 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 [or 1.5 times the outside diameter in railroad right-of-way]) to simultaneously facilitate back reaming of drill hole and installation of conduit. Use back reamer that 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 Project Special Provisions 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, unless in railroad right-of-way. Within railroad right-of-way, the diameter of the bore hole may not exceed 1.5 times the outside diameter of the specified conduit. This enlarged diameter may be accomplished either 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.

(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. Disposal on public or railroad right-of-ways or within public or railroad drainage ditches/facilities is prohibited.

(E) Maximum Length of Directional Drill

The length of a directional drill shall not exceed 1500 feet measured horizontally along the route of the directionally drilled conduit(s), unless otherwise approved by the Engineer. For routes longer than 1500 feet, begin a successive directional drill where the first directional drill reaches 1500 feet and install an oversized heavy-duty junction box where the two directional drilled conduit runs meet. The spacing of junction boxes in a directionally drilled route shall not exceed 1500 feet.

(F) Splicing and Coupling of HDPE Conduit

Install a continuous HDPE conduit free from splices or couplings between junction boxes whenever possible. However, splicing or coupling of HDPE conduit may be permitted, subject to the prior approval of the Engineer, to complete an underground HDPE conduit run when the end of an HDPE reel is reached. However, splicing in the middle of a directional drill operation is prohibited.

Join the HDPE conduit ends by installing mechanical couplings in accordance with the manufacturer's instructions or by splicing the conduits using either a butt-fusion welder or an electro-fusion welder. Submit the proposed method of coupling or splicing the conduits to the Engineer for review and approval prior to joining any HDPE conduits.

Otherwise, install an oversized, heavy-duty junction box where the ends of the HDPE conduits meet in lieu of joining the ends through splicing and coupling. Install an oversized, heavy-duty junction box where the number of conduits in the underground run changes and where a directionally drilled conduit meets a trenched conduit. For example, install an oversized, heavy-duty junction box where two directionally drilled conduits meet a single run of trenched conduit.

(G) Innerduct Installation in Outerduct

Simultaneously install the individual HDPE conduits in the outerduct conduit. Install the innerduct 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 innerducts are in motion. Once the innerduct system is installed in the outerduct, install the duct organizer plugs in the ends of the outerduct.

Extend the ends of the innerduct conduit such that upon completion of the installation, the conduits will extend a minimum of 2 inches beyond the end of the outerduct or 4 inches above crushed stone bases inside the junction box, whichever is greater.

After installation of the innerduct 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.

Install continuous innerduct conduit systems free from splices or couplings between junction boxes. Splicing or joining of the innerduct conduit is prohibited.

Install duct plugs into any unused ports in the innerduct organizer plugs and any unused innerduct conduits.

6.4. 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.

Underground conduit (qty)(size) will be measured in horizontal linear feet of underground conduit installation of each type furnished, installed, and accepted, without regard to the installation method. Measurement will be along the approximate centerline of the conduit system. Payment will be in linear feet.

Directional drill (qty)(size) will be measured 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. When directional drilling is used where the Plans call for "Underground Conduit", directional drilling will be measured and paid for as Underground Conduit.

No measurement will be made of vertical segments, non-metallic conduit, metallic conduit, mechanical sealing devices or moldable sealing putty, pull lines, and miscellaneous fittings, as these will be considered incidental to conduit installation.

No measurement will be made of restoration of paved roadways/driveways and unpaved ground surfaces with like materials, including but not limited to backfill, graded stone, paved materials, seeding and mulching, as this work will be considered incidental to conduit installation. No measurement will be made of removing, stockpiling and resetting existing granite curb as such work will be considered incidental to conduit installation. The Department will make no payment for a given underground conduit run until all repairs to paved and unpaved surfaces damaged/disturbed during the installation of the underground conduit have been completed and accepted.

Repair and replacement of existing sidewalk will be measured and paid for in accordance with the "Signal Cabinet Foundations" section of these Project Special Provisions.

No measurement will be made of horizontal segments between the base of a riser and an adjacent junction box or base-mounted cabinet foundation that are 10 feet or less in length measured from the center of the riser to the center of the junction box or from the center of the riser to the center of the vertical sweep through the cabinet foundation as these will be considered incidental to riser installation.

Innerduct HDPE conduit systems (i.e., multiducts) installed inside larger diameter conduits (i.e., outerducts) will be measured and paid for as *Underground Conduit*, regardless of the material and diameter of the outerduct conduit. The installation of outerduct conduits will be measured and paid for separately as *Directional Drill* in accordance with the respective paragraphs above. No measurement will be made of any organizer plugs required for installation of the innerduct conduits as they will be considered incidental to directional drilling the outerduct conduit.

No measurement will be made of conduit segments between adjacent traffic signal system junction boxes that are 10 feet or less in length measured from center of junction box to center of junction box as these will be considered incidental to furnishing and installing the junction boxes.

Conduit will be paid for per linear foot based on quantity and size of conduits. As examples, an installation of a single 2" HDPE conduit would be paid as:

Directional Drill (1)(2") Linear Foot

No measurement or payment will be made for furnishing and installing and subsequently removing graded stone material for temporary maintenance of traffic where a portion of existing pavement has been removed as such work will be considered incidental to furnishing and installing underground conduit.

Payment will be made under:

Pay Item	**Pay Unit**
Tracer Wire	Linear Foot
Underground Conduit (1)(1")	Linear Foot
Underground Conduit (1)(2")	Linear Foot
Underground Conduit (2)(2")	Linear Foot
Directional Drill (1)(2")	Linear Foot
Directional Drill (2)(2")	Linear Foot
Directional Drill (1)(5")	Linear Foot

7. JUNCTION BOXES

7.1. DESCRIPTION

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

7.2. MATERIALS

(A) General

Comply with Article 1411-3 Electrical Junction Boxes, except as follows:

Provide junction box covers with standard *Traffic Signal* or *City of Rocky Mount Fiber-optic* logos, pull slots and stainless steel pins. For standard size junction boxes, provide covers with *Traffic Signal* logo. Provide covers with *Traffic Signal* logo on oversized heavy-duty junction boxes used to intercept, splice and extend existing field wiring for a traffic signal. Provide covers with *City of Rocky Mount Fiber-optic* logo on all oversized and special-sized, heavy-duty junction boxes that house fiber-optic communications cable.

Do not provide sealant compound between junction boxes and covers.

Except for special-sized, heavy-duty junction boxes, material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

Refer to Section 545, "Graded Stone," of the *Standard Specifications*.

(B) Standard Size Junction Boxes

Provide standard size 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-sized, Heavy-Duty Junction Boxes

Provide special-sized heavy-duty junction boxes and covers with minimum inside dimensions of 36"(l) x 24"(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.

7.3. CONSTRUCTION METHODS

(A) General

Comply with Article 1411-3 Electrical Junction Boxes of the *Standard Specifications*, except as follows:

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

Upon completion of junction box installation and backfilling of all excavations, restore the disturbed ground to its original condition as determined and approved by the Engineer. For

paved areas, replace removed or damaged pavement with in kind materials, matching the elevation, color, texture/finish and general appearance of the surrounding pavement. Refer to Section 1 of these Project Special Provisions for additional requirements concerning sidewalks and curbs in historic districts. For unpaved areas, backfill excavations with removed material, tamp the backfilled material and rake smooth the top 1½ inches. Finish unpaved areas flush with surrounding natural ground and to match the original contour of the ground. Seed with same type of grass as surrounding area and mulch the newly seeded area. If unpaved area was not grassed, replace the original ground cover in kind as directed by the Engineer.

Complete restoration of all ground disturbed during junction box installation within five consecutive calendar days following initial removal and excavation. If the Contractor fails to repair and restore the disturbed ground in accordance with these Project Special Provisions within the time frame specified, the Department reserves the right to make the necessary repairs, and all expenses incurred by the Department in making the repairs and restoring the ground will be deducted from payment due the Contractor, plus $500 liquidated damage per occasion, per day, or any portion thereof, until corrected.

Install junction boxes where underground splicing of cable is necessary and where transitioning from below ground to above ground installation or vice-versa.

Install oversized heavy-duty junction boxes in underground fiber-optic communications cable runs where the conduit run transitions from directionally drilled conduit to trenched conduit.

Install oversized heavy-duty junction boxes in underground fiber-optic communications cable runs at maximum intervals of 1500 feet, or where shown in the Plans, whichever is less.

Install special-sized, heavy-duty junction boxes at all underground splice enclosure locations.

Install standard size junction boxes in underground runs of signal cable and lead-in cable at maximum intervals of 250 feet or where shown in the Plans, whichever is less.

(B) GPS Coordinates

Provide real world coordinates for all junction boxes and equipment cabinets installed or utilized under this project. Provide the coordinates in feet units using the North Carolina State Plane coordinate system (1983 North American Datum also known as NAD '83). Furnish coordinates that do not deviate more than 1.7 feet in the horizontal plane and 3.3 feet in the vertical plane. Global positioning system (GPS) equipment able to obtain the coordinate data within these tolerances may be used. Submit cut sheets on the GPS unit proposed to collect the data for approval by the Engineer.

Provide both a digital copy and hard copy of all information regarding the location (including to but not limited to manufacturer, model number, City system ID number and NCDOT inventory number) in the Microsoft Excel spreadsheet using the format shown in example below.

City Sys ID#	NCDOT Inv #	Name	Location	Latitude	Longitude	Manufacturer	Model #
	05-0134	Equipment Cabinet	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5500	35.6873	McCain	Type-332
	05-0134	Junction Box # 1 (Phase 2 Side)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5516	35.6879	Quazite	PG1118BA12(Box) PG118HA00(Cover)
	05-0134	Junction Box # 2 (Phase 2 Side)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5506	35.6876	Quazite	PG1118BA12(Box) PG118HA00(Cover)
	05-0134	Junction Box # 3 (Near Cabinet)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5501	35.6873	Quazite	PG1118BA12(Box) PG118HA00(Cover)
	05-0134	Junction Box # 4 (Phase 6 Side)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5486	35.6873	Quazite	PG1118BA12(Box) PG118HA00(Cover)
	05-0134	Junction Box # 5 (Phase 6 Side)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5493	35.6876	Quazite	PG1118BA12(Box) PG118HA00(Cover)
	05-0134	Junction Box # 6 (Phase 4 Side)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5503	35.6879	Quazite	PG1118BA12(Box) PG118HA00(Cover)

7.4. 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.

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

No measurement will be made of restoration of paved roadways/driveways and unpaved ground surfaces with like materials, including but not limited to backfill, graded stone, paved materials, seeding and mulching, as this work will be considered incidental to junction box installation. The Department will make no payment for a given junction box until all repairs to paved and unpaved surfaces damaged/disturbed during the installation of the junction box have been completed and accepted.

Repair and replacement of existing sidewalk will be measured and paid for in accordance with the "Signal Cabinet Foundations" section of these Project Special Provisions.

No measurement will be made of collecting and recording GPS coordinates for junction boxes and compiling this data in the prescribed Microsoft Excel spreadsheet as such work will be considered incidental to furnishing and installing junction boxes.

Payment will be made under:

Pay Item	Pay Unit
Junction Box (Standard Size)	Each
Junction Box (Over-sized, Heavy-Duty)	Each
Junction Box (Special-Sized, Heavy-Duty)	Each

8. EXTENSION OF EXISTING FIELD WIRING AT CONTROLLER CABINETS

8.1. DESCRIPTION

Furnish and install terminal splice cabinets to splice and extend existing signal and loop lead-in cables (i.e., field wiring) to new controller cabinets and furnish and install gel-filled splice connectors to splice and extend existing conductors inside new controller cabinets.

8.2. MATERIALS

(A) Terminal Blocks

Provide terminal block (i.e., terminal strips) constructed of electrical grade thermoplastic or thermosetting plastic with the terminals recessed between molded barriers for splicing and extending existing field wiring. Provide terminal blocks with the number of terminals required in these provisions or with a sufficient number to accommodated splicing and extending of incoming existing field wiring conductors. Each terminal shall have two terminal screws that have a minimum outside diameter of 3/16 inches. A removable shorting bar shall be provided between the screws of each terminal. Both the screws and shorting bar shall be made of corrosion resistant nickel-plated brass. Provide separate terminal blocks for signal conductors and loop lead-in conductors.

(B) Terminal Splice Cabinets

Provide NEMA Type 3 or Type 4 enclosures fabricated of sheet steel or sheet aluminum with continuous weld construction and with a drip shield top. The steel enclosures shall be stainless steel. Aluminum enclosures shall have a standard mill finish.

Provide an enclosure with a terminal block having at least 20 terminals with each terminal having two terminal screws. Mount the terminal block on the back wall of the enclosure in such a manner that no mounting screws, nuts, etc., protrude through the enclosure. Center the terminal block both horizontally and vertically on the back wall of the enclosure in line with the long dimension of the enclosure. Install additional terminal blocks as necessary.

Provide an enclosure of sufficient size to accommodate entrances for a minimum of four 2-inch galvanized rigid metal conduits in the bottom of the enclosure. The dimensions of the enclosure shall not be less than 16" wide x 20" high x 8" deep. The enclosure shall have a hinged front door which opens to the side and which is secured by a Corbin No. 2 lock and latch. A door handle is not required.

Provide conduit entrances in the bottom of the cabinet only which are of the size and number required for the specific location where cabinet will be installed. Conduit entrances in the top or sides of the cabinet are prohibited. Conduit entrances may either pre-drilled or field-drilled, but shall not exceed the number required for the location. Extra or spare entrances, capped or otherwise, are not acceptable. Field-verify the required number, size and position of entrances prior to drilling.

Provide all necessary hardware and mounting brackets for attaching the terminal splice cabinet on the pole. Such hardware shall provide for mounting the cabinet to metal or wood signal poles using at least two stainless steel bands (straps) of the size recommended by the manufacturer, one near the top of cabinet and one near the bottom.

Furnish 2-inch rigid galvanized conduit, fittings and conduit outlet bodies along with new pull boxes where required to replace existing short risers. Furnish conduit fittings and outlet bodies as required to install existing risers into base of new terminal splice cabinet.

(C) Gel-Filled Splice Connectors

Furnish gel-filled connectors of the appropriate wire gauge to butt splice and extend the existing conductors of signal cables and loop lead-in cables inside controller cabinets.

(D) Signal Cable and Loop Lead-In Cable

Furnish new traffic signal cables and loop lead-in cables for extending existing cables from new terminal splice cabinet. Furnish equivalent size conductor signal cable. Furnish loop lead-in cable which complies with the "Loop Lead-In Cable" section of these Project Special Provisions.

8.3. CONSTRUCTION METHODS

(A) General

Prior to splicing and extending existing conductors or rerouting existing conductors through new conduits and risers, place permanent labels on all incoming and outgoing conductors in the controller cabinet using a naming convention such as Phase 1 Green, Phase 2 Yellow, Loop 2A, etc., unless the conductors are already labeled. Where there are existing labels on the conductors, confirm that they are labeled correctly and replace any labels that are incorrect.

Place similar permanent labels on the ends of all new conductors used to extend the existing conductors.

Perform standard megger tests on loops after splicing and extending loop lead-ins. Upon approval of the Engineer, replace lead-in cables or loop and lead-in cable assemblies that do not pass standard megger tests.

(B) Inside Controller Cabinets

Where a new controller cabinet is being mounted over existing conduit stubouts on an existing foundation or over existing riser bases at a pole-mounted location and the existing field wiring will not reach the terminal blocks provided inside the new cabinet, splice and extend the incoming and outgoing signal and loop lead-in conductors inside the controller cabinet using gel-filled butt splice connectors.

(C) External to Controller Cabinets

Where new controller cabinets are being installed in a different location from the existing cabinet location and the Plans do not call for re-cabling of the intersection, install, as shown on the Plans, a terminal splice cabinet to splice and extend existing signal and loop lead-in conductors as required to reach the new controller cabinet through new risers and conduits.

Do not splice and extend conductors external to the controller cabinet where the existing field wiring is of sufficient length to reach the new cabinet in its new location. An example would be where the Plans call for the new cabinet to be placed on a new foundation located at the same or lesser distance from the adjacent signal pole as the existing base-mounted cabinet and foundation. At such locations, pull the existing cables out of the existing cabinet, risers and conduit and reroute them to the new cabinet via the new risers and conduits.

Use a terminal splice cabinet when an existing pole-mounted cabinet is being replaced with a new base-mounted cabinet and the Plans do not call for re-cabling the intersection. Use a terminal splice cabinet where an existing base-mounted cabinet is being replaced with a new base-base mounted cabinet on a new foundation in a new location and the existing cabling is not long enough to reach the base of the new cabinet and the Plans do not call for re-cabling the intersection.

Do not route electrical service wire through the terminal splice cabinet.

(D) Terminal Splice Cabinets

Disconnect the conductors from the existing cabinet, remove the existing pole-mounted controller cabinet, but retain the existing risers, conduit outlet bodies and cables housed therein. Install the new terminal splice cabinet on the pole at same location as removed cabinet with bottom of splice cabinet at the same vertical height as the bottom of the removed cabinet. Install conduit entry holes into base of new cabinet and attach existing risers. Adjust existing conduits and modify/add conduit outlet bodies as necessary to attach to new cabinet. Splice the existing signal cables and loop lead-in cables to the new cables on the terminal splice block and extend new signal cables and new lead-in cables to new base mounted cabinet via two separate, new 2-inch rigid galvanized short risers and underground conduits as shown in the Plans. Bond the terminal splice cabinet to the equipment ground in the controller cabinet using a 14 AWG stranded THHN copper wire with green insulation. Do not put loop grounds and other grounds with neutral conductors.

At certain intersections with existing pole-mounted controller cabinets, existing lead-in cables or pedestrian signal cables are routed underground to existing pole-mounted cabinets and enter the bottom of existing cabinet via a short riser. A short riser is defined as a short section of vertical conduit between the bottom of a pole-mounted cabinet and the ground below that conveys cables between an underground conduit and the cabinet. Where these short risers are attached to the face of the pole, attach the short riser into a conduit entrance on the bottom of the new terminal splice cabinet and splice the existing cables to the new cables on the terminal block in the cabinet.

Where the existing short riser is "freestanding" (i.e., it is offset horizontally more than one inch from the face of the signal pole and is not secured to the face of the signal pole) or is damaged (i.e., crimped or severely bent), replace the existing short riser with a new short riser attached to the face of the pole as shown in the Plans. Feed the existing cables through the new conduit and short riser and into the new terminal splice cabinet. Splice the existing conductors to the new conductors on the terminal block.

(E) Terminal Splice Cabinet Where Existing Cabinet is Base-Mounted

Mount the terminal splice cabinet on the pole with the center of the cabinet 48 inches above the ground at the base of the pole. Install new risers to the terminal splice cabinet and short risers from the terminal splice cabinet to the underground conduits leading to the new controller cabinet foundation. Disconnect field wiring from existing base-mounted controller cabinet, carefully pull the cables out of the tops of the existing risers and reroute the existing cables through new risers to a terminal splice cabinet. Splice the existing signal cables and loop lead-in cables to the new cables on the terminal splice block and extend new signal cables and new lead-in cables to new base mounted cabinet via two separate, new 2-inch rigid galvanized short risers and underground conduits as shown in the Plans. Bond the terminal splice cabinet to the

equipment ground in the controller cabinet using a 14 AWG stranded THHN copper wire. Do not put loop grounds and other grounds with neutral conductors.

Where a loop lead-in cable or pedestrian signal cable enters the existing cabinet foundation directly via an existing underground conduit instead of through a riser, take care to protect the existing cables and the conduit stubout so as not to damage them when removing the existing controller cabinet and its existing foundation. Pull the cables back out of the foundation stubouts from a junction box, handhole, or transformer base, if available, before removing the cabinet foundation. Upon removal of the cabinet foundation, install a junction box over the conduit stubouts and install new underground conduit(s) from the junction box to a stubout in the new cabinet foundation. Splice the loop lead-in cable to new lead-in cable in the junction box in accordance with Roadway Standard Drawing No. 1725.01 and run the new lead-in cable from the junction box directly to the new controller cabinet via the new underground conduit. Do not splice and extend existing pedestrian signal cable. Remove the existing pedestrian signal cable and install new, continuous pedestrian signal cable from the pedestrian signal to the new controller cabinet via the existing and new underground conduits.

Where these short risers are attached to the face of the pole, attach the short riser into a conduit entrance on the bottom of the new terminal splice cabinet and splice the existing cables to the new cables on the terminal block in the cabinet.

8.4. MEASUREMENT AND PAYMENT

Terminal Splice Cabinet will be measured and paid for as the actual number of terminal splice cabinets, furnished, installed, and accepted.

New full-height risers attached to the bottom of terminal splice cabinet will be measured and paid for as "Riser with Weatherhead" in accordance with the "Riser Assemblies" section of these Project Special Provisions.

No measurement will be made of replacement of existing conduit bodies and fittings, and installation of new conduit bodies and fittings as these will be considered incidental to furnishing and installing terminal splice cabinets

No measurement will be made of new short risers that replace of existing short risers as they will be considered incidental to furnishing and installing terminal splice cabinets.

When required to intercept existing underground conduit, new junction boxes will be paid for in accordance with the "Junction Boxes" section of these Project Special Provisions as approved by the Engineer.

No measurement will be made of additional signal cable/conductors and loop lead-ins, as the splicing of all existing signal conductors and loop lead-ins in the splice cabinet, extending them through new risers and conduits and connecting them to the new controller cabinet will be considered incidental to furnishing and installing terminal splice cabinets.

No measurement will be made of gel-filled splice connectors and additional signal and loop lead-in cable/conductors as the splicing and extending of conductors inside the controller cabinet will be considered incidental to furnishing and installing the new controller and cabinet.

No measurement will be made of testing of loops after splicing and extending lead-in cables as performing standard megger tests will be considered incidental to splicing and extending the lead-in cables.

Engineer-approved replacement of loops will be paid as provided for under *Inductive Loop Sawcut* in accordance with the "Inductive Detection Loops" section of these Project Special Provisions. Engineer-approved replacement of loop lead-ins will be paid as provided for under *Lead-In Cable* in accordance with the "Loop Lead-In Cable" section of these Project Special Provisions.

Payment will be made under:

Pay Item	Pay Unit
Terminal Splice Cabinet	Each

9. WOOD POLES

9.1. DESCRIPTION

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

9.2. MATERIALS

(A) General

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

Furnish treated timber poles that meet the requirements of ANSI O5.1, except the timber shall be treated Southern Pine or treated Douglas Fir. Unless otherwise specified in the plans, use Class 3 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.

Treat poles in accordance in accordance with Standard C4 of the American Wood-Preserver's Association with be applicable to the treatment of poles, except that the required retention of preservative will be as below.

Give all poles a preservative treatment of either pentachlorophenol, or chromated copper arsenate. The same type of preservative shall be used throughout the entire length of the project.

Minimum retention for poles treated with pentachlorophenol will be 0.45 lb. by assay of dry chemical per cubic foot of wood. Minimum retention for poles treated with chromated copper arsenate will be 0.6 lb. by assay of dry chemical per cubic foot of wood.

(B) Wood Poles for Signals and Aerial Cable Routes

Unless otherwise specified in the Plans, furnish Class 3 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.

(C) CCTV Wood Poles

Furnish Class 3 or better wood poles to mount CCTV cameras and cabinets that are of sufficient length to permit the CCTV camera to be mounted at the mounting height specified in the Plans. For mounting heights of up to 35 feet above the ground at the base of the pole, provide CCTV wood poles that are at least 50 feet in length. For locations, where mounting heights are greater than 35 feet above the ground at the base of the pole, provide CCTV wood poles that are at least 75 feet long.

The Contractor is encouraged to visit the site of the proposed CCTV poles to confirm the length of pole required to attain the specified mounting prior to ordering the CCTV poles.

9.3. CONSTRUCTION METHODS

Install poles at locations shown on the Plans. Mark final pole locations and receive approval from the Engineer before installing poles. Unless otherwise shown in the Plans (i.e., dimensions from a known point or physical feature), locate poles in accordance with the following table:

Speed Limit	Desirable Minimum Setback Distance	
	from face of curb in curb & gutter section	from edge of travel way in shoulder section (no curb)
≤ 40 mph	12 feet	14 feet
45-50 mph	16 feet	18 feet
≥ 55 mph	22 feet	22 feet

Within intersection radii, install poles a minimum of 7 feet behind face of curb or 10 feet from the edge of travel way where there is no curb. Field conditions may require the pole to be located at setback distances less than those listed above, subject to the approval of the Engineer, but in no case shall the pole be installed closer than 1.5 feet from face of curb. Measure the setback distance from the face of curb or edge of travel lane to the face of the pole.

Drill or auger a hole for placement of pole and to allow for compacting. Set poles for signals and aerial cable routes at the manufacturer's recommended depth or at a depth equal to 10% of the pole length plus 2 feet, whichever is greater, but in no case less than of 5 feet deep. Set CCTV wood poles at a minimum depth of 10 feet. Ensure the pole is within 2 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 or City-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.

9.4. MEASUREMENT AND PAYMENT

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

CCTV wood pole (____) will be measured and paid for as the actual number of CCTV wood poles of each length 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:

Pay Item	Pay Unit
Wood Pole	Each
CCTV Wood Pole (50')	Each
CCTV Wood Pole (75')	Each

10. GUY ASSEMBLIES

10.1. DESCRIPTION

Furnish and install guy assemblies with all necessary hardware.

10.2. MATERIALS

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

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 triple-eye attachment, screw anchor with extension rod and triple-eye attachment, or expanding rock anchor with triple-eye 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 triple-eye guy attachments constructed of hot-dipped galvanized steel. Anchor assemblies with double-strand eyes may be used in lieu of those with the triple-eye feature when only one guy cable is to be attached. Ensure anchor assemblies are 7 feet minimum in length.

For type of anchor assembly furnished, ensure the following:

Expanding anchor - provide steel construction with protective paint or heat shrink of 6 mil plastic to protect 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 the "Messenger Cable" section of these Project Special Provisions.

10.3. CONSTRUCTION METHODS

(A) General

Comply with *Roadway Standard Drawing* (RSD) No. 1721.01 when constructing guy assemblies.

(B) 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 existing pole ground and to the messenger cable using split bolt connector or parallel groove clamp. If existing City or NCDOT poles do not have a grounding system, 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. Do not use guy anchors as grounding electrodes.

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

When proposed guy assembly replaces an existing guy assembly, remove the existing guy assembly, including guy anchor if not reused for the new guy assembly.

(C) 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.

Bond guy assembly to existing pole ground and to the messenger cable using split bolt connector or parallel groove clamp. If existing City or NCDOT poles do not have a grounding system, 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. Do not use guy anchors as grounding electrodes.

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

When proposed guy assembly replaces an existing guy assembly, remove the existing guy assembly, including guy anchor if not reused for the new guy assembly.

10.4. MEASUREMENT AND PAYMENT

Guy assembly will be measured and paid as the actual number of direct down guy (i.e., standard guy) assemblies furnished, installed, and accepted.

Guy assembly (____) will be measured and paid as the actual number of guy assemblies of each type (aerial or sidewalk) furnished, installed, and accepted.

No measurement will be made of guy cable, guy guards, anchors, clamps, strandvises, 2" galvanized pipe, pole plates, grounding system, other fittings, or the removal of existing guy assemblies as these will be considered incidental to furnishing and installing guy assemblies.

Payment will be made under:

Pay Item	Pay Unit
Guy Assembly	Each
Guy Assembly (Aerial)	Each
Guy Assembly (Sidewalk)	Each

11. RISER ASSEMBLIES

11.1. DESCRIPTION

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

11.2. MATERIALS

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

Provide rigid metallic conduit for risers. Refer to Subarticle 1098-4(B)(1) Rigid Metallic Conduit of the *Standard Specifications*.

Provide Schedule 40 PVC female adapter to connect an underground run of PVC conduit to the threaded end of a rigid metallic elbow/sweep at the base of a rigid metallic riser. Provide PVC adapters that have the same nominal diameter as the riser to join underground conduit of the same diameter to the riser. The interior surface of one end of the PVC female adapter shall be compatibly threaded to connect it to the threaded end of the rigid metallic riser without the aid of additional fittings, hardware or adhesives. The opposite end of the adapter shall be non-threaded to permit a slip fit, glued connection to the underground PVC conduit.

Provide heat shrink tubing for the installation of fiber-optic cable in new risers.

Provide heat shrink tubing retrofit kits for the installation of new fiber-optic cable or coaxial cable in existing riser with existing fiber-optic or coaxial cables.

11.3. CONSTRUCTION METHODS

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 pedestrian signals.

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

Use separate 2-inch riser with heat shrink tubing for coaxial cable for an Ethernet radio antenna.

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 cable and twisted-pair communications cable. Install condulet on all risers for lead-in cable.

Use a separate riser with heat shrink tubing for fiber-optic communications cables and coaxial cable. For pole-mounted cabinets only, use 1-inch risers with heat shrink tubing for all new risers that will contain fiber-optic communications drop cables. Connect 1-inch risers with fiber-optic communications drop cables to the bottom of the pole-mounted cabinet using a pair of standard 90-degree elbows to form a 180-degree sweep up into the bottom of the cabinet. Standard 90-degree elbows for 1-inch conduit have a 5.75-inch radius and equal horizontal and vertical legs that measure approximately 8 inches each. Smaller elbows are prohibited. Larger elbows may only be used if approved by the Engineer. For all other locations use 2-inch risers

with heat shrink tubing. Install risers with heat shrink tubing so that fiber-optic cable can be installed without violating its minimum bending radius. Install fiber-optic cables so that they do not share a riser with any other non-fiber-optic 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 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.

Remove existing weatherheads, sealing bushings, heat shrink tubing and riser caps and install heat shrink tubing retrofit kits on existing risers according to the installation procedures above.

Transition from rigid galvanized steel risers to underground PVC conduits using an approved rigid galvanized steel sweeping elbow with PVC female adapter. Use PVC female adapters that have the same nominal diameter as the riser to join underground conduit of the same diameter to the riser. Apply Teflon thread tape to the threads of rigid metal riser before screwing the PVC adapter onto the threaded end of the riser. Connect the threaded female end of the PVC adapter to the threaded male end of the rigid metallic riser without the using of additional fittings, hardware or adhesives. Connect the opposite, non-threaded end of the adapter to the underground PVC conduit using a slip fit, glued connection.

Bond all new risers, a minimum of 10 feet above grade, to the pole ground using a minimum number 6 AWG solid bare copper wire and an approve pipe clamp and split-bolt connector or parallel groove clamp. Install grounding wire and clamps so as to minimize damage from vandalism. On pole-mounted cabinets where the risers are connected to the cabinet, bond risers in the cabinet using ground bushings with a minimum number 6 AWG solid bare copper wire to the cabinet ground bus.

If a pole ground exists on a joint-use pole, bond new riser to the existing pole ground using number 6 AWG minimum solid bare copper wire terminated with split-bolt connectors or parallel groove clamp.

If the existing pole does not have a grounding system, install new grounding system consisting of a numbers 6 AWG solid bare copper wire that is exothermically welded to a ground rod. Install ground wire so as to minimize damage from vandalism. Install ground wire up pole to a point adjacent to the upper most span, using hot-dipped galvanized wire staples to secure the ground wire to the pole. Install one ground rod at the base of the pole.

11.4. 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.

No measurement will be made of weatherheads, heat shrink tubing, conduit outlet bodies such as condulets, elbows, conduit fittings, pole attachment fittings and grounding as these will be considered incidental to furnishing and installing risers.

No measurement will be made for horizontal sections of underground conduit that connect the riser to stub-outs in an adjacent cabinet foundation or to an adjacent junction box and that measure 10 feet or less in horizontal length from the center of the riser to the center of junction box or from the center of the riser to the center of the vertical sweep through the controller cabinet foundation. Such conduit will be considered incidental to furnishing and installing the riser assembly.

No measurement will be made for vertical conduit segments (i.e., short risers) extending from an entrance in the bottom of a pole-mounted cabinet to ground level below the cabinet to tie directly onto an underground conduit as such conduits will be considered incidental to furnishing and installing the pole-mounted cabinet.

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 of removing existing weatherheads, sealing bushings, heat shrink tubing and riser caps from existing risers as such removals will be considered incidental to furnishing and installing heat shrink tubing retrofit kits.

Payment will be made under:

Pay Item	**Pay Unit**
1" Riser with Weatherhead	Each
2" Riser with Weatherhead	Each
1" Riser with Heat Shrink Tubing	Each
2" Riser with Heat Shrink Tubing	Each
Heat Shrink Tubing Retrofit Kit	Each

12. INDUCTIVE DETECTION LOOPS

12.1. DESCRIPTION

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

12.2. MATERIALS

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.

(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" Conduit

(C) Conduit

Comply with the "Underground Conduit" section of these Project Special Provisions for non-metallic conduit.

12.3. CONSTRUCTION METHODS

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

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. Do not sawcut or drill holes for conduit or wires through granite curb. See additional requirements for work in historic districts in Section 1 of these Project Special Provisions.

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 at www.ncdot.org/doh/preconstruct/traffic/ITSS/.

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 the points where loop conductor pairs leave the saw cut in pavement and enter a junction box, 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.

12.4. MEASUREMENT AND PAYMENT

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

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:

Pay Item	Pay Unit
Inductive Loop Sawcut	Linear Foot

13. LOOP LEAD-IN CABLE

13.1. DESCRIPTION

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

13.2. MATERIALS

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

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

- Ensure conductor is twisted with a maximum lay of 2.0 inches, resulting in a minimum of 6 turns per foot.
- Provide a ripcord to allow cable jacket to be opened without using a cutter.
- Provide length markings in a contrasting color showing sequential feet and within one percent of actual cable length. Ensure character height of the markings is approximately 0.10 inch.

13.3. 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 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.

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. After successful completion of megger test, test loop system resistance using an electronic ohmmeter to verify loop system resistance is less than 0.00885 ohms per foot.

13.4. 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:

Pay Item	Pay Unit
Lead-in Cable	Linear Foot

14. FIBER-OPTIC CABLE

14.1. DESCRIPTION

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

14.2. MATERIALS

(A) SMFO Communications Cable

For all cables except for cables specified to plenum-rated, furnish single-mode fiber-optic communications cable that is pre-approved on the Department's QPL. For plenum-rated cables, provide single-mode fiber optic cables that comply with the "Plenum-rated SMFO Communications Cable" subsection below. Furnish fiber-optic cable that is all-dielectric and gel-free.

Furnish loose tube fiber-optic cable with required fiber count that complies with RUS CFR 1755.900, single mode with dielectric central member. Use single mode fiber in cable that does not exceed attenuation of 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 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 loose buffer tube. Use 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*. Provide exactly 6 fibers per buffer tube in all cables regardless of the total number of fibers the cables contain. Do not provide cables with any other fiber count per buffer tube. In buffer tubes containing multiple fibers, ensure colors are stable during temperature cycling and not subject to fading, sticking, or smearing into each other or into water-blocking filling material. Use fillers in cable core if necessary to provide a symmetrical cross-section of cable. Fill buffer tubes with super-absorbent, water-blocking material that is non-hygroscopic, non-nutritive to fungus, electrically non-conductive and homogenous.

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 stranded evenly around cable core.

Provide cable jacket of consistent thickness that is free of holes, splits, and blisters, and contains 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 fungus growth.

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

(1) Plenum-Rated SMFO Communications Cable

Where called for in the Plans, provide plenum-rated single-mode fiber-optic (SMFO) cable, provide optical fiber nonconductive plenum (OFNP) SMFO cable that complies with the following:

- UL® fire safety test Plenum/910
- NEC® Article 770
- Telcordia GR-409

Provide a cable with a flame retardant outer jacket or a flame retardant tape inside the outer jacket or. Provide a loose-tube, gel-free cable that is designed for both indoor and outdoor installation. The plenum-rated cable shall meet all other material and operating characteristics of SMFO communications cable called for in these Project Special Provisions, with the exception of the requirement for a maximum 0.35 dB/km loss at 1310 nm. Plenum-rated cables shall have a maximum 0.65 dB/km loss at 1310 nm.

(B) Drop Cable

Furnish drop cable to provide communications links between splice enclosures and the Ethernet edge switches through interconnect centers mounted in controller cabinets and in CCTV cabinets. Furnish drop cables containing a minimum of six individual fibers. Furnish factory-assembled SMFO pigtails with ST-PC connector for splicing to all drop cable fibers in a cabinet-mounted interconnect center and terminating the fibers on the patch panel of the interconnect center.

Furnish drop cables that comply with RUS-CRF 1755.900 and have a minimum bend radius of 5 inches for a 6-fiber cable. Ensure drop cable has the same operating characteristics as the SMFO cable it is to be coupled with.

Ensure attenuation drop at 1310 nm does not exceed 0.5 dB/km. Ensure attenuation loss for complete drop cable 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 character height of markings is approximately 0.10".

(C) Communications Cable Identification Markers

Furnish 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 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. Provide communications cable wraps that permit writing with an indelible marking pen.

Furnish cable identification markers with the following text for signal system communications cables:

WARNING
CITY OF ROCKY MOUNT
SIGNAL SYSTEM FIBER-OPTIC CABLE
CONTACT TELEPHONE NUMBER:
(252) 972-1121

WARNING
CITY OF ROCKY MOUNT SIGNAL
SYSTEM FIBER-OPTIC CABLE

Overall Marker Dimensions:	*7(l) x 4 (w) inches*
Lettering Height:	*3/8 inch for "WARNING"; 1/4" for all other lettering*
Colors:	*Black text on yellow background*

Submit a sample of proposed communications cable identification marker to the Engineer for approval before installation.

(D) Fiber-Optic Cable Storage Racks

Furnish fiber-optic cable storage racks that are pre-approved on the Department's QPL.

Furnish fiber-optic storage racks (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 the 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 snowshoes are stackable so that multiple cable configurations are possible.

14.3. CONSTRUCTION METHODS

(A) General

Provide cable manufacturer's attenuation and Optical Time Domain Reflectometer (OTDR) testing data for each reel of cable.

Install 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 cable is not damaged during storage, handling, and installation. Do not violate minimum bending radius of 20 times the radius of cable diameter or

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 communications hub cabinet door. No splicing is permitted at any field cabinets other than communications hub cabinets.

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 cable manufacturer's recommended and maximum pulling tension. Do not exceed 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 risers with heat shrink tubing (1-inch or 2-inch as shown on the Plans) or separate conduits. Do not share risers or conduits containing fiber-optic cable with other non-fiber-optic cable unless the Plans specify otherwise or the Engineer directs or approves otherwise.

Within the City Hall and Signal Shop buildings transition to plenum-rated cable at the building entry point as shown in the Plans. Use plenum-rated fiber-optic cable for all indoor runs of fiber-optic cable. Through splice all fiber strands in each cable.

Seal all conduits containing fiber-optic communications cable in junction boxes and cabinet bases with mechanical sealing devices or moldable sealing putty. Comply with the requirements for mechanical sealing devices and moldable sealing putty in the "Underground Conduit" section of these Project Special Provisions.

(B) Aerial Installation

Install one communications cable identification marker on the signal system cable within 36 inches of pole attachment points and at locations where more than one cable originates or terminates. At splice enclosures, install a communications cable marker on one of the cables where it enters or exits the splice enclosure and ensure that the marker is installed so that it visible (but not necessarily readable) from the ground below. At fiber-optic cable storage racks (i.e., snow shoes), install a communications cable marker at each end, 6 inches or less from the inner edge of each snow shoe, to identify the cable being stored.

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

Machine lashing of any cable is not permitted along any messenger cable span to which a traffic signal or overhead sign is or will be attached. Either reuse existing 0.05" x 0.30" aluminum wrapping tape or furnish and install new aluminum wrapping tape.

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

Use a breakaway swivel so as not to exceed 80% of the maximum allowable pulling tension specified by the cable's manufacturer if cable is pulled by mechanical means. Do not allow cable to contact the ground or other obstructions between poles during installation.

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 each fiber-optic cable on all cable runs that are continuous without splices as shown in the Plans.

Locate spare cable storage in the middle of spans between termination points. Do not store spare fiber-optic cable over the roadway or driveways.

(C) Underground Installation

Install fiber-optic cable underground in conduit using cable pulling lubricants recommended by the fiber-optic cable manufacturer. Where more than one fiber-optic cable is being installed in a multiple conduit underground run, ensure that at least one conduit remains empty for future use by installing more than one cable in a conduit as needed, unless directed otherwise by the Engineer.

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

Use a breakaway swivel so as not to exceed 80% of the maximum allowable pulling tension specified by the cable's manufacturer if cable is pulled by mechanical means.

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

Inside all junction boxes, install communications cable identification markers on each communications cable entering the junction box.

In a junction box where no splice enclosure is required, store 30 feet of each fiber-optic cable on all cable runs as shown in the Plans.

In a junction box where a splice enclosure is required but not immediately installed, store 60 feet of fiber-optic cable intended for the splice.

(D) Indoor Installation

Transition the fiber-optic cables from outdoor cables to indoor, plenum-rated cables immediately at the point of entry at the City Hall and Signal Shop buildings by fusion splicing the cables inside wall-mounted splice cabinets as shown in the Plans. Install the plenum-rated fiber-optic cable in risers and conduit between the building entrance and the enclosed communications racks being installed inside the TMC and the Signal Shop using cable pulling lubricants recommended by the fiber-optic cable manufacturer. Obtain approval of cable pulling lubricant and method of pulling before installing the fiber-optic cable.

Use a breakaway swivel so as not to exceed 80% of the maximum allowable pulling tension specified by the cable's manufacturer if cable is pulled by mechanical means. Keep tension on cable reel and pulling line at start of each pull. Do not release tension if pulling operation is halted. Restart pulling operation by gradually increasing tension until cable is in motion.

For pulling cable through junction boxes and cabinets, feed cable by manually rotating the reel. Do not pull cable through cabinets, junction boxes, handholds, or openings in conduit unless otherwise approved. Inside all junction boxes and cabinets, install communications cable identification markers on each communications cable entering the junction box.

Store 30 feet of each fiber-optic cable inside the enclosed communications racks inside the TMC and the Signal Shop after terminating the cables in the rack-mounted splice centers housed therein.

(E) Installation of Drop Cable

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

Splice the free end of the drop cable into the fiber-optic trunk cable in a splice enclosure external to the cabinet.

For existing riser locations, remove the existing weatherhead. Install fiber-optic drop cable and then install heat shrink tubing retrofit kit.

At aerial splice enclosures, install the aerial splice enclosure and corresponding cable storage rack at least 50 feet apart and store at least 50 feet of slack cable for each cable entering and exiting the splice enclosure between the splice enclosure and corresponding cable storage rack. Coil and store any drop cable in excess of what is needed for overhead storage in the base of the equipment cabinet.

At below ground splice enclosures, coil at least 30 feet of slack cable for each cable entering and exiting the splice enclosure in the manhole or junction box where enclosure is located. Coil and store any drop cable in excess of what is needed for storage in the manhole or junction box in the base of the equipment cabinet. Where fiber-optic cables are installed but not immediately spliced, store a minimum of 30 feet of drop cable and 60 feet of fiber-optic trunk cable inside the manhole or junction box to facilitate subsequent splicing in the splice enclosure. Cap and seal ends of cables that have yet to be spliced or terminated with a waterproof heat-shrink cap/seal as approved by the Engineer.

At equipment cabinet end of drop cable, terminate <u>all</u> fibers by splicing them to factory-assembled SMFO pigtails with ST-PC connectors and connecting the pigtails to the connector panel. Label all connectors, pigtails and the connector panel. At the aerial or underground splice location, cap off all unused fibers and label to correspond with the connector panel.

Where the Plans call for a fiber-optic drop cable to be installed in an existing riser, remove all existing cables from the riser and remove the existing weatherhead, sealing bushing or heat shrink tubing. Install the new fiber-optic drop cable in the existing riser and install new heat shrink tubing at the top of the existing riser using a heat shrink tubing retrofit kit. If the riser contains existing fiber-optic communications cable, carefully remove the fiber-optic cable from the riser so as not violate its minimum bending radius or otherwise damage the cable. Temporarily coil and store the existing fiber-optic cable overhead in a manner approved by the Engineer until the new drop cable can be spliced into the existing cable in an aerial splice enclosure. Once splicing has been completed, furnish and install fiber-optic cable storage racks and permanently store all remaining spare cable.

Using an OTDR, test the end-to-end connectivity of the drop cable from patch panel installed inside the signal or CCTV cabinet to the TMC. Comply with the OTDR testing and reporting requirements of the "Fiber-Optic Splice Centers" section of these Project Special Provisions when testing drop cable.

14.4. 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 according to the following conditions: 80% of the payment will be made upon acceptance of the installed cable and the remaining 20% of the payment will be made following splicing, testing and final acceptance (including completion of the 60-day Observation Period). 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.

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 according to the following conditions: 80% of the payment will be made upon acceptance of the installed cable and the remaining 20% of the payment will be made following splicing, testing and final acceptance (including completion of the 60-day Observation Period). 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 (6-fiber) will be measured and paid as the actual linear feet of fiber-optic drop cable of each fiber count furnished, installed, and accepted according to the following conditions: 80% of the payment will be made upon acceptance of the installed and spliced drop cable, and the remaining 20% of the payment will be made following final acceptance (including completion of the 60-day Observation Period).

No measurement will be made for terminating, splicing, and testing fiber-optic cable, communications cable identification markers, fiber-optic cable storage racks, SMFO jumpers and pigtails, mechanical sealing devices and conduit seals/sealing putty, as these will be considered incidental to the installation of fiber-optic cable and drop cables.

No measurement will be made of removing existing cables from existing risers as such removals will be considered incidental to furnishing and installing the fiber-optic cables and drop cables.

No measurement will be made of removing existing weatherheads, sealing bushings, heat shrink tubing and riser caps to install new fiber-optic drop cables in existing risers as such removals will be considered incidental to furnishing and installing heat shrink tubing retrofit kits. Heat shrink tubing retrofit kits will be measured and paid for in accordance with the "Riser Assemblies" section of these Project Special Provisions.

Payment will be made under:

Pay Item	Pay Unit
Communications Cable (24-Fiber)	Linear Foot
Communications Cable (36-Fiber)	Linear Foot
Communications Cable (48-Fiber)	Linear Foot
Plenum-rated Communications Cable (48-fiber)	Linear Foot
Drop Cable (6-Fiber)	Linear Foot

15. FIBER-OPTIC SPLICE CENTERS

15.1. DESCRIPTION

Furnish and install fiber-optic interconnect centers, fiber-optic splice enclosures, and all necessary hardware.

15.2. MATERIALS

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

(A) Interconnect Center

Furnish compact, modular interconnect centers designed to mount inside equipment cabinets. Design and size interconnect centers to accommodate all fibers entering cabinets. Provide interconnect centers for equipment cabinets that are 1 rack unit (RU) high.

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

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

For connecting Ethernet edge switches to the interconnect center patch panel, furnish SMFO jumpers that are a minimum of 3 feet in length with factory-assembled PC-ST connectors one end (i.e., the interconnect center end) and, on the other end, factory-assembled connectors of the same type provided on the Ethernet edge switch. Ensure SMFO jumpers meet the operating characteristics of the SMFO cable with which it is to be coupled.

(B) Splice Enclosure

Furnish 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 oversized oval port that will accept two cables and 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 (i.e., uncut and unspliced) through the enclosure. Ensure enclosures allow sufficient space to prevent microbending of buffer tubes when coiled.

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

(C) Existing Splice Centers

When adding a new fiber-optic cable to an existing splice enclosure or otherwise modifying an existing splice inside an existing splice enclosure, furnish heat shrink cable shields that are compatible with the enclosure to ensure weather-tight seal where each new cable enters the existing enclosure and to replace any existing seals that are broken or removed while modifying the splice.

Provide splice trays that hold, protect, organize optical fibers, and secure fibers inside splice tray for new or modified splices inside existing splice enclosures and interconnect centers. Provide splice trays that are dielectric and that are compatible with the existing splice enclosure or interconnect center. Provide splice trays that are sized to accommodate all fibers entering the splice tray and to provide sufficient space to prevent microbending of optical fibers.

Furnish SMFO pigtails for terminating new fibers on the connector panel of an existing interconnect center. Provide pigtails containing connector panels that are a maximum of 6 feet in length with a factory-assembled PC-ST connector on one end. Ensure SMFO pigtails meet the operating characteristics of the SMFO cable with which it is to be coupled. Provide connector panels with ST-type connectors that are compatible with the existing interconnect center.

For connecting Ethernet edge switches to the interconnect center patch panel, furnish SMFO jumpers that are a minimum of 3 feet in length with factory-assembled PC-ST connectors one end (i.e., the interconnect center end) and, on the other end, factory-assembled connectors of the same type provided on the Ethernet edge switch. Ensure SMFO jumpers meet the operating characteristics of the SMFO cable with which it is to be coupled.

15.3. CONSTRUCTION METHODS

(A) General (Workmanship Identification Information)

Include on the cover of each splice tray in a legible format the following information:

- Splice location reference # or identification information (e.g., 04-xxxx tray 1 of 3, 04-xxxx tray 2 of 3, etc.);
- Date the splice was made;
- Name of company name that performed the splicing;
- Name of person who performed the splicing.

(B) Workmanship

Upon cutting the cable and removing the outer jacketing material down to the individual buffer tubes, secure the central strength member to the enclosure so that no tensile force is applied to the fibers. Secure the individual buffer tubes to the splice trays by a method recommended by the manufacturer. Determine the length of each buffer tube needed to ensure that the buffer tube can be looped a minimum of two times around the inside of the splice tray. Upon determining the length of buffer tube needed, remove the buffer tube to expose the individual fibers for fusion splicing. Adjust individual fiber lengths as necessary to ensure that once the fusion splicing process in completed the finished splices will align with the "splice block organizer" supplied within the splice tray. Ensure the splice block organizer has individual fusion splice space holders for each fiber splice.

While prepping the individual fibers for splicing, install the heat shrink protective tube over the fiber and then perform the splicing operations, following the manufacturer's instructions. Verify that the newly formed splice does not exceed 0.05 dB of attenuation. If the attenuation is more than 0.05 dB, then remake the splice until it meets the 0.05 dB or less requirement. Finish the splicing operation by sliding the heat shrink tube over the splice and applying heat to active the heat shrink tubing. Secure the finished splice in the splice block organizer. Ensure each splice is properly secured in a space holder in the splice block organizer. Multiple splices secured to the same space holder are unacceptable.

Ensure all buffer tubes are contained within splice trays so that no bare fibers are outside of the tray. Do not damage the fibers are damaged or violate the minimum bend radius of the fiber.

Prior to installing the cover over the splice tray and placing it in its final resting location, take a MANDATORY digital photograph of the splice tray that shows the final workmanship. Ensure that the photograph shows the "Workmanship Identification Information" as well as the workmanship associated with installing and terminating the fiber. Include digital copies of each photograph on a compact disc as part of the OTDR Test Results submittal.

(C) Interconnect Center

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

Terminate and fusion splice all fibers as shown in the Plans.

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

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

For all fibers designated to pass through interconnect center, neatly coil and express the fibers without cutting.

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

Install SMFO jumpers between the appropriate connectors on the interconnect center and the edge switch.

(D) Splice Enclosure

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

Do not install aerial splice enclosures and storage racks over roadways or driveways.

Fusion splice all fibers including fibers designated to be coupled with fibers from a drop cable. For all fibers designated to pass through splice enclosure, coil and express the fibers without cutting.

For all buffer tubes designated to pass through splice enclosure, neatly coil 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 enclosure in accordance with manufacturer's recommended procedures at the conclusion of splicing procedure and before final placement of enclosure.

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

Install enclosures with enough slack cable to allow enclosure to be lowered to ground level and extended into a splicing vehicle.

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.

(E) Modify Existing Splice

Terminate and splice new fibers and re-splice existing fibers within existing interconnect centers and splice enclosures as shown on the Plans. Use existing splice trays inside the splice center and install new splice trays as needed. Connect new pigtails and re-connect existing pigtails to connector panels in existing interconnect centers as shown on the Plans, installing new connector panels in the existing interconnect centers as required. Comply with all requirements of "Interconnect Center" and "Splice Enclosure" subsections above.

Relocate existing aerial splice enclosure and corresponding existing fiber-optic cable storage rack(s) as shown on the Plans. Unlash existing, reroute and relash existing fiber-optic cable as required to relocate the existing aerial splice enclosure.

(F) Testing

Provide written notification to the Engineer a minimum of 10 working days before beginning the OTDR tests.

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

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-optic properties of the cable have been impaired, take appropriate actions up to and including replacement of the fiber-optic 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 along with digital photographs showing workmanship for each splice on a compact disc. Furnish the manufacturer's make, model number and software version of the OTDR used for testing.

15.4. MEASUREMENT AND PAYMENT

Interconnect center will be measured and paid as the actual number of fiber-optic interconnect centers furnished, installed, and accepted according to following conditions: 80% of the payment will be made upon acceptance of the installed interconnect centers and the

remaining 20% of the payment will be made following final acceptance (including completion of the 60-day observation period).

Splice enclosure will be measured and paid as the actual number of fiber-optic splice enclosures that are furnished, installed, and accepted, regardless of installation location (i.e., aerial, underground, manhole, or junction box), according to following conditions: 80% of the payment will be made upon acceptance of the installed splice enclosures and the remaining 20% of the payment will be made following final acceptance (including completion of the 60-day Observation Period).

Modify existing splice will be measured and paid as the actual number of existing fiber-optic splice enclosures and interconnect centers where existing splices are reconfigured, new fibers are spliced to existing fibers and new fibers are terminated in the existing splice center. Measurement will be made per existing splice center without regard to type and location of splice center and without regard to the number of splices and terminations required at each location. Payment for modify existing splice will be full compensation for all materials and work required to modify the existing splices in accordance with the plans. No measurement will be made of relocating an existing aerial splice enclosure and associated fiber-optic cable storage rack(s) as such work will be considered incident to modifying the existing splice.

No measurement will be made of fusion splices, splice trays, splice protectors, pigtails, jumpers, connector panels, labeling, testing and photographs as these will be considered incidental to installing interconnect centers, furnishing and installing splice enclosures, and modifying existing splices.

Payment will be made under:

Pay Item	Pay Unit
Interconnect Center	Each
Splice Enclosure	Each
Modify Existing Splice	Each

16. UNDERGROUND CABLE MARKERS

16.1. DESCRIPTION

Furnish and install delineator markers (tubular marker posts), joint-use utility pole tags/decals, equipment cabinet decals, and curb/sidewalk markers/medallions with all necessary hardware and adhesives to warn of buried fiber-optic communications cable.

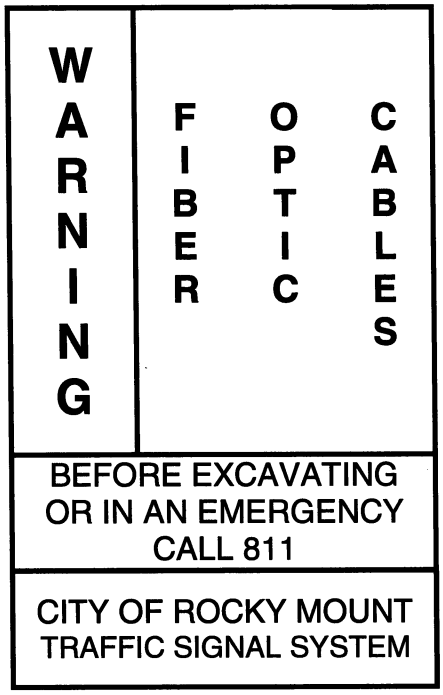
16.2. MATERIALS

(A) Delineator Markers

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

Furnish delineator markers, also referred to as tubular marker posts, that are approximately 6 feet long and constructed of 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 delineator posts.

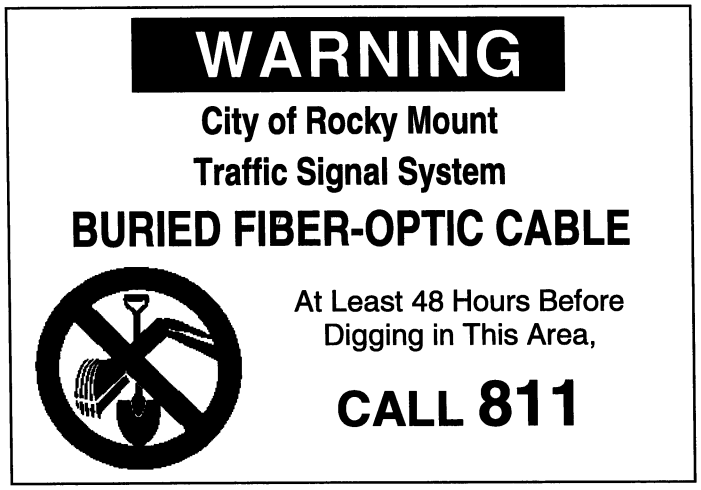
Provide text, including City contact number, hot stamped in black on a yellow reflective background material that will not fade or deteriorate over time. Provide delineator markers with nominal message height of 15" that contain the following text visible from all directions approaching the assembly:



(B) Cabinet Decals

Furnish pressure-sensitive, waterproof decals to apply to the exterior surface of field equipment cabinets. Construct decals of durable vinyl or plastic that is chemical resistant and resists tearing and shrinking. Screen print text and symbols on decal using UV-stable, fade-resistant, waterproof ink. Ensure that decal will adhere permanently to a milled aluminum surface under a variety of weather conditions and a wide range of air temperatures (0° F to 150° F minimum). Provide a decal that can be applied without special surface preparation.

Provide cabinet decals that contain the text and symbols, text emphasis and text proportions depicted in the following examples format:



Overall Decal Dimensions:
6"(w) x 4"(h) minimum,
7"(w) x 5"(h) maximum

Text Height (min.):
1/2" for *WARNING*
3/8" for *BURIED FIBER-OPTIC CABLE* and *CALL,* 1/2" for *811*
1/4" for all other

Background Color: Yellow
Text Color: Black
Symbol Color: Black
Symbol Size: 1.5"- 2" DIA

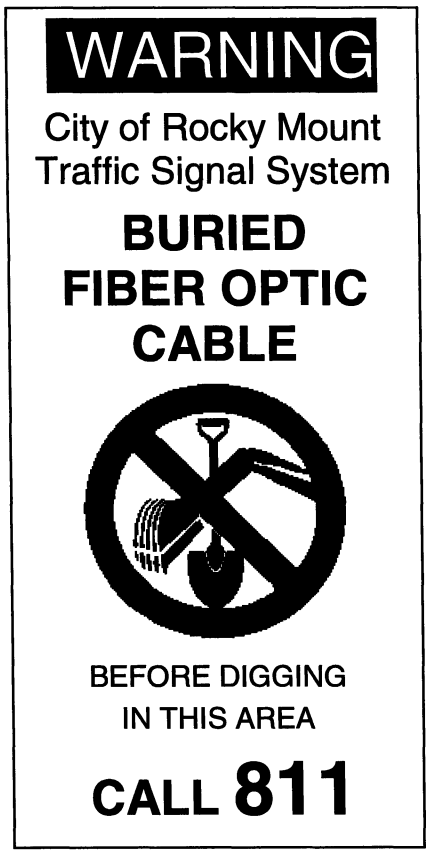
Submit sample of proposed cabinet decals to the Engineer for approval before installation. In lieu of designing a custom decal, the contractor may submit for the Engineer's approval a stock/standard decal format (i.e., off-the-shelf format) from the decal manufacturer that differs from the example format proposed above but that still embodies the content and intent conveyed by the example format.

(C) Utility Pole Signs

Furnish signs for installation on wood utility poles that are constructed of 40 mil aluminum or high-impact, UV-resistant plastic such as high impact polyolefin. Provide signs with rounded corners (0.25" max. radius) and that have pre-drilled/pre-punched fastener holes at the top and bottom edge of the sign and centered horizontally on the sign. Provide hot-dipped, galvanized wood screws or ring-shanked nails for attaching the sign to wood utility poles.

Ensure that background of sign is fade resistant. Screen print text and symbols on decal using UV-stable, fade-resistant, waterproof ink.

Provide utility pole signs that contain the text and symbols, text emphasis and text proportions depicted in the following examples format:



Overall Tag Dimensions: 3.5"(w) x 7"-12"(h)

Text Height (min.):

1/2" for *WARNING;*
3/8" for B*URIED FIBER-OPTIC CABLE*;
3/8" for *CALL;*
1/2" for *811*;
1/4" for all other

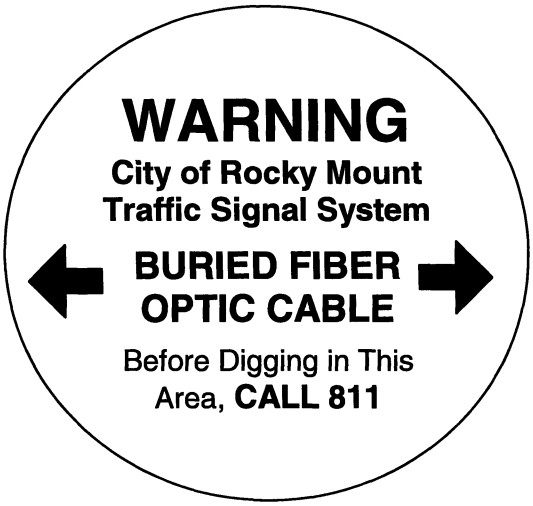
Text Color: Black
Background Color: Yellow
Symbol Color: Black

Submit sample of proposed pole sign to the Engineer for approval before installation. In lieu of designing a custom sign, the contractor may submit for the Engineer's approval a stock/standard sign format (i.e., off-the-shelf format) from the sign manufacturer that differs from the example format proposed above but that still embodies the content and intent conveyed by the example format.

(D) Curb Markers

Furnish durable, non-reflective curb markers fabricated from UV-resistant, non-metallic materials other than ceramic material, such as polyurethane or high impact polypropylene or other high impact plastic. Provide curb markers that are designed for outdoor use, that are waterproof, that resist fading, that are temperature stable and that resist chemical and mechanical abrasion. Furnish curb markers with a quick-setting adhesive to permanently adhere curb markers to Portland cement concrete and granite as well as other non-porous hard surfaces. Do not provide markers that require intrusive fasteners to secure the marker to the surface. Provide curb markers that do not require special tools such as torches, tamping machines or drills or hardware or special surface preparation for installation. Furnish curb markers from a manufacturer that has been producing such curb markers for a minimum of 10 consecutive years. Provide curb markers with a manufacturer's warranty of 10 years or more.

For general marking of underground cable routes in accordance with this Project Special Provision, provide curb markers that contain the text and symbols, text emphasis and text proportions depicted in the following example format:



Overall Curb Marker Dimensions: 2.5" diameter
Text: Black
Background: Orange

Submit samples of proposed curb marker to the Engineer for approval before installation. In lieu of designing a custom curb marker, the Contractor may submit for the Engineer's approval a stock/standard curb marker format (i.e., off-the-shelf format) from the curb marker manufacturer that differs from the example format proposed above but that still embodies the content and intent conveyed by the example format.

Have the curb marker manufacturer provide a list of references along with contract information for at least five different municipal government agencies and/or state departments of transportation that have installed the proposed manufacturer's curb marker and can attest to the performance of the manufacturer's curb marker over a continuous period of no less than seven years. Submit these references to the Engineer for review in conjunction with submission of the sample.

16.3. CONSTRUCTION METHODS

(A) Underground Cable Markers in Historic Districts

Obtain the Engineer's approval prior to installing any underground cable markers (i.e., cabinet decals, utility pole signs/decals, and curb markers) within historic districts. The Engineer may modify the application criteria described herein or delete the requirement for some or all underground cable markers based upon the requirements of the particular historic district.

(B) Delineator Markers

Submit sample of proposed delineator markers for approval before installation.

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

Install delineator markers at locations specified on the plans. Do not install delineator markers at locations other than those specified in the Plans without the prior approval of the Engineer.

(C) Cabinet Decals

Clean the surface to which the decal will be applied using a mild cleaner that will not damage, deface or discolor the milled aluminum finish of the equipment cabinet. Ensure surface is thoroughly dry before applying decal. Observe any application temperature restrictions specified by the manufacturer when applying the decals.

Apply decal to the two sides of the cabinet and not to the front or rear of the cabinets. Do not apply to cabinet doors or over any cabinet vents/louvers. Place the decals in the top right corner.

Do not apply decals to cabinets where cable is fed to the cabinet from aerial drop on a nearby pole unless the Engineer directs otherwise. Apply decals to cabinet where fiber-optic cable is routed to and/or from the cabinet in an underground conduit run other than the stub-out from a nearby riser that conveys and aerial drop cable.

(D) Pole Signs

Using the hot-dipped, galvanized ring-shanked nails or wood screws, mount the pole sign on the side of pole facing the adjacent street at a height of approximately 5 feet above the ground below. Secure the sign to the pole with at least one fastener at the top of the sign and one at the bottom through the pre-drilled/pre-punched fastener holes provided. Do not field-drill or field-punch signs. Do not install over cables, ground wires, other pole signs, pole tags or pole birthmark (embossed class and length). Mount sign to wood poles only; do not attach sign to metal poles.

Install signs on pole line that is parallel to and adjacent to the underground cable route. Install on each pole in the line along the route, unless otherwise approved by the Engineer. When two or more poles are located in close proximity to one another, install the sign on only one of the poles as approved by the Engineer.

(E) Curb Markers

Install curb markers along curbed streets where the presence of underground fiber-optic communications cable cannot be marked otherwise by placing signs or decals on utility poles. Examples could include but are not limited to: streetscaped areas, residential neighborhoods, areas without utility poles and downtown areas.

Install the curb markers at the beginning and end of the underground run, at the beginning, and end of each street block along the underground run, at the midpoint of each street block that is approximately 200-500 feet long, and at intervals of approximately 200 feet elsewhere along the underground run. Premark the proposed locations of the curb markers with 2" x 3" wire flags and obtain the Engineer's approval of the proposed locations prior to installing the curb markers. Remove wire flags immediately following installation and acceptance of curb markers. Do not mark fiber-optic drop cable that originates at an aerial splice enclosure and travels a short distance underground between the riser pole and the equipment cabinet, unless otherwise directed by the Engineer. Do not install any curb markers without the Engineer's prior approval.

Clean surface to which the curb marker will be applied. Make sure application surface is flat, dry, and free of any loose debris or cracks. Apply adhesive to back side of curb marker in accordance with manufacturer's instructions. When installing on curb, position marker on top of curb, not on the face of the curb, and center the marker on the top of the curb. Align the curb marker so that arrows (if any) are parallel to underground cable run and so that text can be read

from the adjacent street. Apply the curb marker to the application surface and press firmly. Ensure that entire edge around perimeter of marker is sealed to the application surface.

Where underground conduit runs and associated junction boxes are within 10 feet of the adjacent curb and junction boxes are visible from the curb (e.g., in sidewalk, between curb and sidewalk, at back of sidewalk, etc.), install the curb markers on the lids of each oversized and special-sized junction box in lieu of installing them on the curb unless directed otherwise by the Engineer. Where the junction boxes are greater than 10 feet from the curb, install curb markers on the lids of each oversized and special-sized junction box in addition to installing them on the curb unless directed otherwise by the Engineer.

Where there is no curb and there are no poles on which to install pole tags or decals to mark the underground run, install curb markers on the lids of each oversized and special-sized junction box.

16.4. MEASUREMENT AND PAYMENT

Delineator marker will be measured and paid for as the actual number of delineator markers (tubular marker posts) furnished, installed, and accepted.

No measurement will be made of utility pole signs, cabinet decals and curb markers as they will be considered incidental to furnishing and installing underground conduit.

Payment will be made under:

Pay Item	Pay Unit
Delineator Marker	Each

17. REMOVE EXISTING COMMUNICATIONS CABLE

17.1. DESCRIPTION

Remove existing fiber-optic communications cable. Remove fiber-optic communications cable splice cabinets, hub cabinets, cabinet foundations, associated risers and in-ground junction boxes as designated in the Plans.

17.2. CONSTRUCTION METHODS

Removal of existing aerial communications cable also includes removal and proper disposal of aerial splice enclosures, messenger cable and mounting hardware, associated guy assemblies, as well as abandoned risers, splice boxes and splice cabinets. Removal of guy assemblies includes the removal of guy anchors if not used by any other guy assembly.

Removal of existing underground communications cable includes proper disposal of junction boxes, if required. Where junction boxes have been removed, backfill hole to 95% of surrounding density and finish level with surrounding ground.

When removing existing communications cable from an underground conduit that will be retained for future use, install a pull tape in the vacated underground conduit in conjunction with or immediately following removal of the existing cable. Seal the ends of the vacated conduit with an approved duct plug or moldable sealing putty following installation of the pull tape.

When the Contractor has made reasonable attempts to remove an existing communications cable but is unable to do so as confirmed by the Engineer, carefully cut the existing cable flush with the end of the conduit/duct and abandon the cable in the existing conduit/duct. Remove and dispose of the severed cable remnant.

Do not reuse any removed communications cable, messenger cable, junction boxes, pole attachment hardware or abandoned risers on the project, unless otherwise specified. In the event that any of the removed communications cable, junction boxes or pole attachment hardware is to be returned to the Department or the City, it will be so noted on the Plans.

Unless otherwise directed by the Engineer, remove and properly dispose of existing wood poles that are vacated upon removal of the existing communications cable (i.e., where the communications cable was the only attachment to the pole).

Remove existing splice/hub cabinet and, where cabinet is base-mounted, remove existing cabinet foundation. Where the existing conduits entering the base-mounted cabinet will be retained to convey the new fiber-optic communications cable, install an oversize heavy-duty junction box over the existing conduit stubouts that remain upon removal of existing splice/hub cabinet foundation. Where the existing conduits entering the base-mounted cabinet will be abandoned, cut the conduits off a minimum of 12 inches below ground and backfill the hole even with the surrounding ground immediately following removal of the existing splice/hub cabinet foundation. Restore the ground surface to the condition of the surrounding area. If the removed foundation is in a concrete sidewalk, replace the entire concrete slab from joint-to-joint with new concrete 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. Comply with the requirements for the removal of existing material

in Section 1 of these Project Special Provisions. Comply with the "Signal Cabinet Foundations" section of these Project Special Provisions concerning replacement of existing sidewalks.

17.3. MEASUREMENT AND PAYMENT

Remove existing communications cable (fiber-optic) will be measured in horizontal linear feet of existing communications cable removed and accepted. Payment will be in linear feet. Where multiple adjacent underground conduits exist (each containing fiber-optic cables), each conduit will be considered separately for purposes of payment. Sag, vertical segments, and spare segments of communications cable will not be paid for, as these distances will be considered incidental to the removal of existing fiber-optic communications cable.

No additional measurement will be made for multiple fiber-optic cables being removed from the same underground conduit or same pole. No payment will be made for fiber-optic cable that cannot be removed and is abandoned in place.

No measurement will be made of the removal of messenger cable, pole attachment hardware, guy assemblies, aerial splice enclosures, wood poles, stub poles, risers and in-ground junction boxes vacated upon removal of the existing fiber-optic communications cable, as these will be considered incidental to the removal of the existing fiber-optic communication cable.

No measurement will be for installing a pull tape inside of and sealing the ends of an existing conduit that will be retained for future use after removing an existing communications cable from that conduit as such work will be considered incidental to installation of new fiber-optic communications cable.

Remove splice/hub cabinet will be measured as the actual existing communications cable splice cabinets and hub cabinets successfully removed, disposed of and accepted without regard to the size or type of cabinet, mounting location or mounting method. Such payment includes removal and disposal of existing splice centers housed inside the cabinet, cabinet base adapters and base extenders for base-mounted cabinets and mounting brackets and hardware for pole-mounted cabinets.

No measurement will be made of the removal of risers vacated upon removal of existing splice/hub cabinets and associate fiber-optic cable, as these will be considered incidental to the removal of the existing splice/hub cabinet.

Remove splice/hub cabinet foundation will be measured as the actual existing communications cable splice/hub cabinet foundations successfully removed, disposed of and accepted without regard to the size of the foundation. Such payment will include all labor and materials required to cutoff existing conduits below ground and backfill the area even with the surrounding ground upon removal of the cabinet foundation. Where called for in the plans, junction boxes installed over existing conduit stubouts remaining after removal of the cabinet foundation will be measured and paid for in accordance with the "Junction Boxes" section of these Project Special Provisions. Repair and replacement of existing sidewalk following removal of a splice/hub cabinet foundation located in an existing sidewalk will be measured and paid for in accordance with the "Signal Cabinet Foundations" section of these Project Special Provisions.

Payment will be made under:

Pay Item	Pay Unit
Remove Existing Communications Cable (Fiber-Optic)	Linear Foot
Remove Splice/Hub Cabinet	Each
Remove Splice/Hub Cabinet Foundation	Each

18. CABLE TRANSFERS

18.1. DESCRIPTION

Remove and reinstall existing communications cable for pole relocations.

18.2. CONSTRUCTION METHODS

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

Payment will be made under:

Pay Item	Pay Unit
Cable Transfer	Each

19. SIGNAL PEDESTALS

19.1. DESCRIPTION

Furnish and install signal pedestal assemblies with foundations, grounding systems, and all necessary hardware.

19.2. MATERIALS

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

Provide aluminum pedestals with foundations that conform to AASHTO. Furnish Class B minimum concrete that conforms to the applicable parts of Section 1000 Portland Cement Concrete Production and Delivery.

Provide reinforcing steel that conforms to the applicable parts of Section 1070 Reinforcing Steel. Provide caps and bases as part of pedestal assemblies. Unless otherwise required, furnish pedestals that provide the following heights:

To support traffic signal equipment cabinets – 30" above foundation.

To support signal heads, see Section 1705 for required signal head height.

Provide pedestal caps fabricated from cast aluminum that meets Aluminum Association Alloy 356.0F. Provide stainless steel set screws as fasteners.

Provide either shoe-type or transformer-type pedestal bases made of aluminum that meets Aluminum Association Alloy 356.0 or equivalent, and designed to break upon impact in accordance with AASHTO requirements. For shoe-type bases, provide aluminum flange plate with four anchor bolt holes, a hole to match the shaft, and a 4 x 8" hand hole with a reinforced frame located 8" above base. For transformer-type bases, provide overall dimensions of 15"(l) x 13"(w) x 13"(d) and an 8" x 8" hand hole with removable cover.

Ensure bases are continuously welded to shafts or threaded to receive shafts. For use in grounding, provide a 1/2" minimum diameter, coarse thread stud located inside base at the handhold and oriented for easy access.

For each pedestal, provide four anchor bolts in accordance with ASTM F 1554 Grade 55 with outside diameter of 3/4" and length of 18" each having two heavy hex nuts with two washers at the top and two heavy hex nuts with one washer at the bottom. Provide anchor bolts with coarse threads at 10 threads per inch for a minimum length of 4 inches from each end of the bolt. Ensure anchor bolts are hot-dipped galvanized in accordance with ASTM A 153 with completely galvanized nuts and washers. Provide hex nuts with coarse threads. Ensure hex nuts are in accordance with ASTM A 563 Grade DH, ASTM A 194 Grade 2H, or equivalent. Ensure washers are in accordance with ASTM F 436 or equivalent. As a minimum, provide standard size washers.

19.3. CONSTRUCTION METHODS

Locate foundations, determine elevation, and submit findings. Obtain the Engineer's approval of foundation locations and elevations before constructing foundations.

Excavate in accordance with Section 410, Foundation Excavation, of the *Standard Specifications*. If encountered, remove rock or boulders to a depth sufficient to obtain stability

necessary to support the structure for design loads. Ensure ground is level before installing foundations.

Construct foundations in accordance with Section 825, Incidental Concrete Construction, of the *Standard Specifications*. Cast concrete for pole foundations against undisturbed soil unless otherwise permitted. Provide forms with chamfer strips that measure one inch along diagonal face at all corners above ground level. Do not install foundations over uncompacted fill or muck. Install conduit in foundations.

Securely place, position, and align anchor bolts symmetrically about the center of foundation.

Give exposed vertical concrete surfaces an ordinary surface finish. Give exposed horizontal surfaces a float finish.

Level tops of concrete foundations. Do not allow tops to exceed 6 inches above adjacent ground surface. Pour and finish foundation to a level flush with surrounding sidewalk when possible.

Do not erect pedestals until concrete has attained a minimum compressive strength of 2500 psi as determined by cylinder breaks.

19.4. MEASUREMENT AND PAYMENT

Signal pedestal with foundation will be measured and paid as the actual number of signal pedestals with foundations furnished, installed, and accepted.

Payment will be made under:

Pay Item	Pay Unit
Signal Pedestal with Foundation	Each

20. SIGNS INSTALLED FOR SIGNALS

20.1. DESCRIPTION

Furnish and install signs for signals with cable hangers, rigid sign mounting brackets, U-channel posts, and all necessary hardware.

20.2. MATERIALS

Comply with Section 901, Sign Fabrication, Article 901-2, of the *Standard Specifications*.

Use High Intensity Prismatic retroreflective sheeting or better (ASTM Type IV or greater) for all reflective legends and borders on all signs. Refer to the FHWA Retroreflective Sheeting Identification Guide, dated September 2005, located at the following Web address for additional information:

http://safety.fhwa.dot.gov/roadway_dept/night_visib/sign_visib/sheetguide_sept05/

Use an approved opaque black overlay film or ink for black, non-reflective black legends and borders.

Conform to the message layout, size, and color as required in the *MUTCD*.

For messenger cable mounting, furnish either messenger cable hangers with free-swinging, 360 degree adjustable sign brackets or three bolt clamps as directed. Furnish aluminum, galvanized steel, or stainless steel sign supporting hardware.

For ground mounting, furnish steel, 3 lb., U-channel posts with hardware for ground mounting. Comply with Section 903, Ground Mounted Sign Supports, Article 903-2, of the *Standard Specifications*.

For mast-arm mounting, furnish rigid aluminum, galvanized steel or stainless steel sign mounting brackets.

20.3. CONSTRUCTION METHODS

Install signs with applicable mounting hardware. Comply with sign offsets and mounting heights as shown in the *MUTCD* and NCDOT Roadway Standard Drawing No. 904.50.

For messenger cable mounting, install signs 6 inches minimum from signal heads.

For ground mounting, comply with Section 903, Ground Mounted Supports, Article 903-3(D), and Section 904, Sign Erection, Articles 904-3(A) and 904-3(C) of the *Standard Specifications*.

For mast arm mounting, install attachment brackets to allow adjustment so signs:

- Are aimed in required direction,
- Are plumb as viewed from respective approaches,
- May be tilted forward or backward as required, and
- May be raised or lowered on mast arm throughout full length of sign.

20.4. MEASUREMENT AND PAYMENT

Sign for signals will be measured and paid as the actual number of signs for signals, regardless of mounting method, furnished, installed, and accepted.

Payment will be made under:

Pay Item	Pay Unit
Sign for Signals	Each

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.

21.2. MATERIALS

Preformed cabinet pad foundation material, equipment, and hardware furnished under this section for standard signal cabinet foundation shall be pre-approved on the Department's QPL. 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" holes are cast or drilled in each pad.

Refer to Article 1000-4, Portland Cement Concrete, of the *Standard Specifications.*

Provide standard cabinet foundations in unpaved areas with a minimum pad area that extends 24" from front and back of cabinet base extenders, adapters and special adapters, and 3" from sides of cabinet base extenders, adapters and special adapters.

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

Furnish Portland cement concrete, in accordance with Article 848-2 of the *Standard Specifications*, to replace removed or damaged sections of existing sidewalk and restore locations to preconstruction condition.

Furnish replacement sidewalk pavers where required to restore locations to preconstruction condition that are of the same color, texture, shape, dimensions and materials as the damaged or modified items.

Provide replacement materials for other special pavement treatments or landscaping that are the same materials as the damaged or modified items to restore locations to preconstruction condition.

21.3. CONSTRUCTION METHODS

Comply with Section 825, Incidental Concrete Construction – General, of the *Standard Specifications.*

Obtain approval for final cabinet foundation locations before pouring 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 concrete. Maintain 12 inches minimum from service pole to closest point on foundation unless otherwise approved.
- Use a minimum of four 1/2-inch diameter expanding type anchor bolts to secure cabinet to foundation.

- In unpaved areas, install cabinet foundations a minimum 4 inches above and 4 inches below finished grade. In paved areas, install foundations 1 inch above the paved surface at its highest point and 4 inches below the paved surface at its lowest point.
- Locate external stubbed out conduit at 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 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. Use loop sealant to seal the conduit stub-outs within the knock-out.

Restore the disturbed ground surrounding the new cabinet foundation to its original, preconstruction condition as determined and approved by the Engineer.

- For paved areas, replace removed or damaged pavement with in kind materials, matching the elevation, color, texture/finish and general appearance of the surrounding pavement. Refer to Section 1 of these Project Special Provisions for additional requirements concerning sidewalks and curbs in historic districts. Replace concrete sidewalk in whole slabs from joint to joint and comply with Section 848 of the *Standard Specifications*. Replace sidewalk pavers using pavers of the same color, texture, shape, dimensions and materials as the damaged or modified items. Place graded stone material to temporarily maintain pedestrian traffic where repairs cannot be performed immediately. Comply with Article 545-4 of the *Standard Specifications.*
- For unpaved areas, backfill excavations with removed material, tamp the backfilled material and rake smooth the top 1½ inches. Finish unpaved areas flush with surrounding natural ground and to match the original contour of the ground. Seed with same type of grass as surrounding area and mulch the newly seeded area. If unpaved area was not grassed, replace the original ground cover in kind as directed by the Engineer.

Complete repairs to and restoration of all ground (paved and unpaved) disturbed for construction within five consecutive calendar days following initial removal. If the Contractor fails to repair and restore the ground in accordance with these Project Special Provisions within the time frame specified, the Department reserves the right to make the necessary repairs, and all expenses incurred by the Department in making the repairs and restoring the ground will be deducted from payment due the Contractor, plus $500 liquidated damages per occasion, per day, or any portion thereof, until corrected.

21.4. MEASUREMENT AND PAYMENT

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

4" concrete sidewalk will be measured and paid as the actual square yards of concrete furnished, installed and accepted.

Brick pavers will be measured and paid as the actual square feet of pavers furnished, installed and accepted.

No measurement or payment will be made for restoration of the surrounding unpaved ground surfaces in accordance with these Project Special Provisions as such work will be considered incidental to furnishing and installing signal cabinet foundations.

No measurement or payment will be made for furnishing and installing and subsequently removing graded stone material for temporary maintenance pedestrian traffic where a portion of an existing sidewalk has been removed as such work will be considered incidental to furnishing and installing signal cabinet foundations.

Payment will be made under:

Pay Item	Pay Unit
Signal Cabinet Foundation	Each
4" Concrete Sidewalk	Square Yard
Brick Pavers	Square Foot

22. MODIFY CABINET FOUNDATIONS

22.1. DESCRIPTION

Where approved by the Engineer, install conduit entrances into existing foundations in accordance with the Plans and Project Special Provisions.

Modify existing foundations in accordance with the Plans and Project Special Provisions.

22.2. MATERIALS

Comply with the provisions of Signal Cabinet Foundations section of these Project Special Provisions.

22.3. CONSTRUCTION METHODS

(A) Install Conduit Entrance into Existing Foundation

Install conduit entrances into existing cabinet foundations by core drilling foundations to install additional conduit. Ensure that an IMSA certified, or equivalent, Level II traffic qualified signal technician is standing by to provide emergency maintenance services whenever work is being performed on traffic signal controller cabinets and traffic signal controller cabinet foundations. Standby status is defined as being able to arrive, fully equipped, at the work site within 30 minutes ready to provide maintenance services.

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

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 6 inches deep on 12-inch centers into the existing foundation. Clean holes with compressed air only prior to applying epoxy and installing dowels. Do not clean holes with water or any other liquid. Install #4 dowels and epoxy into place. Provide dowels of the following lengths:

Foundation Extension	Length of Dowel
>16"	18"
>6" and ≤16"	11"
=6"	8"

Use concrete to install the maintenance technician pad.

Form the sides of the modified foundation to a minimum depth of 4 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.

As a minimum, enlarge the foundation to the distance specified for new cabinet foundations. 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, unless otherwise directed by the Engineer. Increase the pad enlargement beyond these minimum dimensions to match the width of the existing foundation along the side to which concrete is being added to maintain the rectangular shape of the pad.

Provide a 1-inch chamfer on all new outside edges.

(C) Ground Surface Restoration

Restore the disturbed ground surrounding the modified cabinet foundation to its original condition as determined and approved by the Engineer. For paved areas, replace removed or damaged pavement with in kind materials, matching the elevation, color, texture/finish and general appearance of the surrounding pavement. Refer to Section 1 of these Project Special Provisions for additional requirements concerning sidewalks and curbs in historic districts. For unpaved areas, backfill excavations with removed material, tamp the backfilled material and rake smooth the top 1½ inches. Finish unpaved areas flush with surrounding natural ground and to match the original contour of the ground. Seed with same type of grass as surrounding area and mulch the newly seeded area. If unpaved area was not grassed, replace the original ground cover in kind as directed by the Engineer.

Complete repairs to and restoration of all ground (paved and unpaved) disturbed for construction within five consecutive calendar days following initial removal. If the Contractor fails to repair and restore the ground in accordance with these Project Special Provisions within the time frame specified, the Department reserves the right to make the necessary repairs, and all expenses incurred by the Department in making the repairs and restoring the ground will be deducted from payment due the Contractor, plus $500 liquidated damages per occasion, per day, or any portion thereof, until corrected.

22.4. MEASUREMENT AND PAYMENT

Conduit entrance into existing foundation will be measured as the actual number of conduit entrances drilled into existing cabinet foundations furnished, installed and accepted.

Modify foundation for controller cabinet will be measured as the actual number of existing cabinet foundations modified and accepted.

No measurement or payment will be made for restoration of the surrounding unpaved ground surfaces in accordance with these Project Special Provisions as such work will be considered incidental to the pay items above.

Payment will be made under:

Pay Item	Pay Unit
Conduit Entrance into Existing Foundation	Each
Modify Foundation for Controller Cabinet	Each

23. ELECTRICAL SERVICE AND CABINET FOUNDATIONS FOR DOWNTOWN TRAFFIC SIGNALS

23.1. DESCRIPTION

Install new electrical service equipment, electrical service conduit, integrated base adapters, preformed foundations and other items as shown in the Plans for traffic signal cabinets located in downtown Rocky Mount. Provide traffic control for extended periods of time while the traffic signal electrical service and foundation are being modified.

Comply with the National Electrical Code (NEC), the National Electrical Safety Code (NESC), the NCDOT 2006 Standard Specifications, the Project Special Provisions and all local ordinances. All work involving the electrical service shall be coordinated with the Rocky Mount Electric Division.

The Contractor shall be responsible for applying and paying for all fees associated with any electrical permits and inspections if required by the local utility or Municipality.

NORTH CAROLINA PROFESSIONAL SEAL 023919 ENGINEER GREGORY A. FULLER

Gregory A. Fuller 6-15-11

Prepared by:
N.C. Department of Transportation
Intelligent Transportation Systems Section
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Provide _5_ day's notification to the Rocky Mount Electric Division, City of Rocky Mount, Rocky Mount Police Department and Engineer as to when the traffic signal is to be turned off.

Do not replace more than one downtown cabinet and foundation at a time. Complete all work at each location and have power restored to the traffic signal before beginning work at any other downtown location.

Modify existing foundations in accordance with the Plans and Project Special Provisions. At locations 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. Contractor shall take a digital photograph of each location to document pre-construction conditions. Avoid damaging existing conduit and conductors. Take precaution to protect conduit and conductors while removing the existing foundation. Remove and dispose of the existing cabinet foundation.

23.2. INTEGRATED BASE ADAPTER

(A) Description

Install base adapter with integrated electrical service meter and disconnect at the following locations in downtown Rocky Mount.

04-0044 Church @ Hammond	04-0034 Franklin @ Hammond
04-0045 Church @ Nash	04-0035 Franklin @ Nash
04-0046 Church @ Western	04-0036 Franklin @ Western
04-0047 Church @ Sunset	04-0037 Franklin @ Sunset
04-0048 Church @ Thomas	04-0038 Franklin @ Thomas

The adapter and electrical service equipment shall be a single, integrated piece with separation between the electrical service equipment and traffic signal cabinet.

(B) Materials

Fabricate integrated base adapters from the same materials and with the same finish as cabinet housing. Fabricate integrated base adapters in the same manner as controller cabinets, meeting all applicable specifications called for in Section 7.5 of CALTRANS TEES (11/19/99). Provide integrated base adapters a minimum height of **18** inches. Provide meter column sized to house one (1) 1.25 inch Liquidtight Flexible Nonmetallic Conduit with connectors and one (1) 1 inch Liquidtight Flexible Nonmetallic Conduit with connectors.

(C) Construction Methods

Ensure that a new Model 336 base mounted cabinet will mount directly to the integrated base adapter. Install conduits, feeder conductors and service conductors as show on the plans. Ensure that cabinet doors open fully.

Use permanent, flexible waterproof sealing material to:

- Seal between cabinet base and integrated base adapter,
- Seal space between integrated base adapter and foundation.

23.3. Electrical Service

(A) Description

Install new electrical service where required by the plans. Coordinate all work involving electrical service with the City Electrical Inspector and Rocky Mount Electric Division.

(B) Materials

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

Provide, reuse, revise and/or upgrade all materials necessary to form a complete electrical service assembly as shown in the plans. Furnish new external electrical service disconnects, meter bases, feeder conductors, electrical service conductors and conduits between the disconnects and the controller cabinets as required.

Provide new external electrical service disconnects at all traffic signal cabinets located in downtown Rocky Mount. Furnish external electrical service disconnects with one 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 listed as meeting UL Standard UL-489 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. Provide ground bus and neutral bus with a minimum of four (4) terminals with minimum wire capacity range of # 14 through # 4.

Furnish NEMA Type 3R meter base rated 100 ampere minimum that meets the requirements of the local utility. Provide meter base with socket's ampere rating based on sockets being wired with minimum of 167 degrees F insulated wire. Furnish 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
- With or without horn bypass
- Made of galvanized steel
- Listed as meeting UL Standard UL-414
- Overhead or underground service entrance as specified

Ensure meter bases have electrostatically applied dry powder paint finish, light gray in color, with minimum thickness of 2.4 mils.

If meter base and electrical service disconnect are supplied in the same enclosure (i.e., combination panel), ensure assembly is marked as being suitable for use as service equipment. Ensure combination meter and disconnect mounted in a pedestal for underground service is listed as meeting UL Standard UL-231. Otherwise, ensure combination meter and disconnect is listed as meeting UL Standard UL-67.

Provide a new grounding system at each traffic signal cabinet. In addition to NEC requirements, test grounding electrode resistance for a maximum of 20 ohms. Follow test equipment's procedures for measuring grounding electrode resistance. 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 at:

http://www.ncdot.gov/doh/preconstruct/traffic/ITSS/ws/signal_data.xls

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

(C) Construction Methods

At locations where new electrical service is to be installed, make an application for a new electrical service with the Rocky Mount Electric Division (252-467-4808). Furnish and install a new electrical service as required by the Plans. At locations where the electrical service is being modified, make an application for electrical service change to allow for a transfer or replacement of the existing meter. Coordinate with the Rocky Mount Electric Division for service disconnection and re-connection to limit the time the traffic signal will be out of service.

Furnish and install new external service disconnect (breaker box). Route the electrical service conductors through the meter base and service disconnect to the controller cabinet to form a complete electrical service assembly as shown in the plans.

Provide Engineer with a copy of all permits and final inspections if required.

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, where required to restore locations to preconstruction condition, shall be the same materials of the damaged or modified items.

23.4. Signal Cabinet Foundations

(A) Description

Furnish and install signal cabinet foundations and all necessary hardware.

Furnish preformed cabinet pad foundations and all necessary hardware and openings (window) for new and existing conduits. **Ensure that each preformed cabinet foundation has the correct sized opening (window) to accommodate the new and existing conduit spread with the correct width and length**. Measure and obtain the conduit spread, width and length for each location. Obtain approval for each preformed foundation type.

Remove existing cabinet foundation leaving all conduits in place. Extend existing conduit(s) as needed. Protect existing conduits and conductors from damage.

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.

(B) Materials

Preformed cabinet pad foundation material, equipment, and hardware furnished under this section shall be submitted for approval.

Comply with Article 1000-4 Portland Cement Concrete.

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

Provide preformed cabinet pad foundations with opening not to exceed the maximum conduit spread for the cabinet mounting configuration on that foundation. Ensure that no more than four 3/4 inch holes are cast or drilled in each pad.

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, where required to restore locations to preconstruction condition, shall be the same materials of the damaged or modified items

(C) 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.

Provide foundations with a minimum pad area of 2 inches from all sides of the integrated base adapter. Technician pads will not be required.

Do not install foundations over uncompacted fill or muck.

Use procedures, equipment, and hardware as follows:

- Hand tamp soil before placing the concrete.

- Use a minimum of four 1/2 inch diameter expanding type anchor bolts to secure the cabinet to foundation.
- Install flush with finished grade.
- Seal space between cabinet base and foundation with permanent, flexible, waterproof sealing material.
- Ensure ground is level before installation.

23.5. OVERVIEW OF WORK BY LOCATION

Listed is a summary of the work to be completed at each location. Other items and material may be needed.

04-0044 Church @ Hammond

- Make an application for a **new electrical service** with the Rocky Mount Electric Division. Request access to the existing Rocky Mount Electric Division pedestal. Remove existing cabinet foundation leaving all conduits in place.
- Protect existing conduit and conductors.
- Add a new 2 inch conduit entrance for the existing signal cable running to steel pole.
- Add a new 2 inch conduit entrance for spare cable. Stub out conduit to the south in the direction of the nearby train station and mark location of stub outs.
- Install new preformed foundation over new and existing conduits and conductors.
- Install new 336 base mounted cabinet with integrated base adapter.
- Route the new 1.25 inch PVC electrical service conduit as show in the plans. Extend new electrical service conduit up into meter/disconnect column. Extend the other end of the 1.25 PVC electrical service conduit into the existing Rocky Mount Electric Division pedestal. Secure conduit to meter/disconnect column. Attach new electrical service conduit to new meter base using electrical fittings as needed. Install three (3) # 6 AWG aluminum Type URD service entrance conductors. Identify the grounded conductor in accordance with NEC.
- Install 1 inch Liquidtight Flexible Nonmetallic Conduit (LFNC) from new disconnect through the meter/disconnect column to the cabinet. Secure 1 inch LFNC to meter/disconnect column, base adapter and cabinet. Install three (3) # 8 AWG copper Type THWN feeder conductors into 1" LFNC. Identify the grounded conductor in accordance with NEC. Install connectors and bushings as required. Seal all conduits using moldable duct seal.

04-0045 Church @ Nash

- Make an application for a **new electrical service** with the Rocky Mount Electric Division. Request Transformer covers be removed to allow installation of the new electrical service. Remove existing cabinet foundation leaving all conduits in place.
- Protect existing conduit and conductors.
- Install new preformed foundation over existing conduits and conductors.
- Install new 336 base mounted cabinet with integrated base adapter.
- Route the new 1.25 inch PVC electrical service conduit as show in the plans. Extend new 1.25 PVC inch electrical service conduit up into transformer pad. Extend the other end of the 1.25 PVC electrical service conduit up into meter/disconnect column. Secure conduit

to meter/disconnect column. Attach new electrical service conduit to new meter base using electrical fittings as needed. Install three (3) # 6 AWG aluminum Type URD service entrance conductors. Identify the grounded conductor in accordance with NEC.

- Install 1 inch Liquidtight Flexible Nonmetallic Conduit (LFNC) from new disconnect through the meter/disconnect column to the cabinet. Secure 1 inch LFNC to meter/disconnect column, base adapter and cabinet. Install three (3) # 8 AWG copper Type THWN feeder conductors into 1" LFNC. Identify the grounded conductor in accordance with NEC. Install connectors and bushings as required. Seal all conduits using moldable duct seal.

04-0046 Church @ Western

- Make an application for a **service change** with the Rocky Mount Electric Division.
- Remove existing cabinet foundation leaving all conduits in place.
- Protect existing conduit and conductors.
- Install new 336 base mounted cabinet with integrated base adapter.
- Insert existing service conductors into a new 1.25 inch Liquidtight Flexible Nonmetallic Conduit (LFNC). Slide new 1.25 inch LFNC into the existing service conduit a minimum of 12 inches. Run new 1.25 inch LFNC up into meter column. Secure new 1.25 inch LFNC to meter/disconnect column, base adapter and cabinet. Identify the grounded conductor in accordance with NEC. Install connectors and bushings as required.
- Install 1 inch Liquidtight Flexible Nonmetallic Conduit (LFNC) from new disconnect through the meter/disconnect column to the cabinet. Secure 1 inch LFNC to meter/disconnect column, base adapter and cabinet. Install three (3) # 8 AWG copper Type THWN feeder conductors into 1" LFNC. Identify the grounded conductor in accordance with NEC. Install connectors and bushings as required. Seal all conduits using moldable duct seal.

04-0047 Church @ Sunset

- Make an application for a **service change** with the Rocky Mount Electric Division.
- Remove existing cabinet foundation leaving all conduits in place.
- Protect existing conduit and conductors.
- Install new 336 base mounted cabinet with integrated base adapter.
- Insert existing service conductors into a new 1.25 inch Liquidtight Flexible Nonmetallic Conduit (LFNC). Slide new 1.25 inch LFNC into the existing service conduit a minimum of 12 inches. Run new 1.25 inch LFNC up into meter column. Secure new 1.25 inch LFNC to meter/disconnect column, base adapter and cabinet. Identify the grounded conductor in accordance with NEC. Install connectors and bushings as required.
- Install 1 inch Liquidtight Flexible Nonmetallic Conduit (LFNC) from new disconnect through the meter/disconnect column to the cabinet. Secure 1 inch LFNC to meter/disconnect column, base adapter and cabinet. Install three (3) # 8 AWG copper Type THWN feeder conductors into 1" LFNC. Identify the grounded conductor in accordance with NEC. Install connectors and bushings as required. Seal all conduits using moldable duct seal.

04-0048 Church @ Thomas

- Make an application for a **service change** with the Rocky Mount Electric Division.
- Remove existing cabinet foundation leaving all conduits in place.
- Protect existing conduit and conductors.
- Install new 336 base mounted cabinet with integrated base adapter.
- Insert existing service conductors into a new 1.25 inch Liquidtight Flexible Nonmetallic Conduit (LFNC). Slide new 1.25 inch LFNC into the existing service conduit a minimum of 12 inches. Run new 1.25 inch LFNC up into meter column. Secure new 1.25 inch LFNC to meter/disconnect column, base adapter and cabinet. Identify the grounded conductor in accordance with NEC. Install connectors and bushings as required.
- Install 1 inch Liquidtight Flexible Nonmetallic Conduit (LFNC) from new disconnect through the meter/disconnect column to the cabinet. Secure 1 inch LFNC to meter/disconnect column, base adapter and cabinet. Install three (3) # 8 AWG copper Type THWN feeder conductors into 1" LFNC. Identify the grounded conductor in accordance with NEC. Install connectors and bushings as required. Seal all conduits using moldable duct seal.
- Add a new 2 inch conduit entrance stubbed out to a new oversize junction box located immediate north of the cabinet and cabinet base for routing the new fiber-optic communications cable to and from the north along the east side of Church Street.

04-0034 Franklin @ Hammond

- Make an application for a **service change** with the Rocky Mount Electric Division.
- Remove existing cabinet foundation leaving all conduits in place.
- Protect existing conduit and conductors.
- Only saw cut sidewalk if necessary to install integrated base adapter.
- Install new 336 base mounted cabinet with integrated base adapter.
- Insert existing service conductors into a new 1.25 inch Liquidtight Flexible Nonmetallic Conduit (LFNC). Slide new 1.25 inch LFNC into the existing service conduit a minimum of 12 inches. Run new 1.25 inch LFNC up into meter column. Secure new 1.25 inch LFNC to meter/disconnect column, base adapter and cabinet. Identify the grounded conductor in accordance with NEC. Install connectors and bushings as required.
- Install 1 inch Liquidtight Flexible Nonmetallic Conduit (LFNC) from new disconnect through the meter/disconnect column to the cabinet. Secure 1 inch LFNC to meter/disconnect column, base adapter and cabinet. Install three (3) # 8 AWG copper Type THWN feeder conductors into 1" LFNC. Identify the grounded conductor in accordance with NEC. Install connectors and bushings as required. Seal all conduits using moldable duct seal.

04-0035 Franklin @ Nash

- Make an application for a **service change** with the Rocky Mount Electric Division.
- Remove existing cabinet foundation leaving all conduits in place.
- Protect existing conduit and conductors.
- Only saw cut sidewalk if necessary to install integrated base adapter.

- Install new 336 base mounted cabinet with integrated base adapter.
- Insert existing service conductors into a new 1.25 inch Liquidtight Flexible Nonmetallic Conduit (LFNC). Slide new 1.25 inch LFNC into the existing service conduit a minimum of 12 inches. Run new 1.25 inch LFNC up into meter column. Secure new 1.25 inch LFNC to meter/disconnect column, base adapter and cabinet. Identify the grounded conductor in accordance with NEC. Install connectors and bushings as required.
- Install 1 inch Liquidtight Flexible Nonmetallic Conduit (LFNC) from new disconnect through the meter/disconnect column to the cabinet. Secure 1 inch LFNC to meter/disconnect column, base adapter and cabinet. Install three (3) # 8 AWG copper Type THWN feeder conductors into 1" LFNC. Identify the grounded conductor in accordance with NEC. Install connectors and bushings as required. Seal all conduits using moldable duct seal.

04-0036 Franklin @ Western

- Make an application for a **service change** with the Rocky Mount Electric Division.
- Remove existing cabinet foundation leaving all conduits in place.
- Protect existing conduit and conductors.
- Remove first course of brick pavers (if necessary). Do not damage brick pavers.
- Install new 336 base mounted cabinet with integrated base adapter.
- Insert existing service conductors into a new 1.25 inch Liquidtight Flexible Nonmetallic Conduit (LFNC). Slide new 1.25 inch LFNC into the existing service conduit a minimum of 12 inches. Run new 1.25 inch LFNC up into meter column. Secure new 1.25 inch LFNC to meter/disconnect column, base adapter and cabinet. Identify the grounded conductor in accordance with NEC. Install connectors and bushings as required.
- Install 1 inch Liquidtight Flexible Nonmetallic Conduit (LFNC) from new disconnect through the meter/disconnect column to the cabinet. Secure 1 inch LFNC to meter/disconnect column, base adapter and cabinet. Install three (3) # 8 AWG copper Type THWN feeder conductors into 1" LFNC. Identify the grounded conductor in accordance with NEC. Install connectors and bushings as required. Seal all conduits using moldable duct seal.

04-0037 Franklin @ Sunset

- Make an application for a **service change** with the Rocky Mount Electric Division.
- Remove existing cabinet foundation leaving all conduits in place.
- Protect existing conduit and conductors.
- Install new 336 base mounted cabinet with integrated base adapter.
- Insert existing service conductors into a new 1.25 inch Liquidtight Flexible Nonmetallic Conduit (LFNC). Slide new 1.25 inch LFNC into the existing service conduit a minimum of 12 inches. Run new 1.25 inch LFNC up into meter column. Secure new 1.25 inch LFNC to meter/disconnect column, base adapter and cabinet. Identify the grounded conductor in accordance with NEC. Install connectors and bushings as required.

- Install 1 inch Liquidtight Flexible Nonmetallic Conduit (LFNC) from new disconnect through the meter/disconnect column to the cabinet. Secure 1 inch LFNC to meter/disconnect column, base adapter and cabinet. Install three (3) # 8 AWG copper Type THWN feeder conductors into 1" LFNC. Identify the grounded conductor in accordance with NEC. Install connectors and bushings as required. Seal all conduits using moldable duct seal.

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- Make an application for a **service change** with the Rocky Mount Electric Division.
- Remove existing cabinet foundation leaving all conduits in place.
- Protect existing conduit and conductors.
- Install new 336 base mounted cabinet with integrated base adapter.
- Insert existing service conductors into a new 1.25 inch Liquidtight Flexible Nonmetallic Conduit (LFNC). Slide new 1.25 inch LFNC into the existing service conduit a minimum of 12 inches. Run new 1.25 inch LFNC up into meter column. Secure new 1.25 inch LFNC to meter/disconnect column, base adapter and cabinet. Identify the grounded conductor in accordance with NEC. Install connectors and bushings as required.
- Install 1 inch Liquidtight Flexible Nonmetallic Conduit (LFNC) from new disconnect through the meter/disconnect column to the cabinet. Secure 1 inch LFNC to meter/disconnect column, base adapter and cabinet. Install three (3) # 8 AWG copper Type THWN feeder conductors into 1" LFNC. Identify the grounded conductor in accordance with NEC. Install connectors and bushings as required. Seal all conduits using moldable duct seal.

23.6. MEASUREMENT AND PAYMENT

Electrical service and cabinet foundation for downtown signal will be measured and paid for as the actual number of electrical services and cabinet foundations with associated integrated base adapters for downtown signals furnished, installed and accepted. No separate measurement or payment will be made for integrated base adapters, conduits, conduit extensions, foundations, removal and disposal of existing foundation, electrical service meters, disconnects, and associated wiring, service conductors, feeder conductors, grounding, grounding electrodes, ground wire, connectors, acquisition of service fees or permits and any remaining hardware or fittings as this will be considered incidental to the Electrical Service and Cabinet Foundation for Downtown Signal. Concrete for sidewalk replacement and brick pavers shall be paid for elsewhere in the Project Special Provisions.

Payment will be made under:

Pay Item	Pay Unit
Electrical Service and Cabinet Foundation for Downtown Signal	Each

24. CONTROLLERS WITH CABINETS

24.1. DESCRIPTION

Furnish and install controllers with cabinets and all necessary hardware. Furnish all pole or foundation mounting hardware, detector sensor cards, one Corbin Number 2 cabinet key, one police panel key, conflict monitors, surge protection, grounding systems, AC/DC isolator cards, auxiliary files (where required) and all necessary hardware. Furnish and install new conflict monitors in existing cabinets. Install Department-furnished local controller software on existing controllers where required. Install updates of local controller and operating system software. Furnish and install test controller and test controllers with cabinets.

24.2. MATERIALS - GENERAL

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

24.3. MATERIALS – TYPE 2070L CONTROLLERS

Conform to CALTRANS *Transportation Electrical Equipment Specifications* (TEES) (dated August 16, 2002, plus Errata 1 dated October 27, 2003 and Errata 2 dated June 8, 2004) except as required herein.

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

The Department will provide local controller software at the beginning of the burning-in period. Contractor shall give 5 working days notice before needing software. Program software provided by the Department. The Department will provide updates to the local controller software for installation by the Contractor up through final acceptance of the project.

Provide Model 2070L controllers with the latest version of OS9 operating system 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)

Provide all updates to the OS9 operating system software released up through final acceptance of the project at no additional cost to the Department.

Provide Model 2070L controllers that are capable of properly running the Department's OASIS local controller software and that are capable of operating properly within an Ethernet communications system.

24.4. MATERIALS – GENERAL CABINETS

Provide a moisture resistant coating on all circuit boards.

Provide one V150LA20 MOV or equal protection on each load switch field terminal.

Provide a power line surge protector that is a two-stage device that will allow connection of the radio frequency interference filter between the stages of the device. Ensure that a maximum continuous current is 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 200μh. 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

24.5. MATERIALS – TYPE 170E CABINETS

(A) Type 170 E Cabinets General

Conform to CALTRANS *Traffic Signal Control Equipment Specifications* except as required herein.

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

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

Furnish CALTRANS Model 332A base mounted cabinets with PDAs #2 and configured for 8 vehicle phases, 2 pedestrian phases, and 2 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.

Provide a mercury contactor or solid state relay (normally closed) in PDAs #2 that is rated at minimum of 50A, 120VAC.

(B) Special Coatings for Cabinets

For certain locations in downtown Rocky Mount as designated in the Plans, provide cabinets with a special black powder-coated finish and anti-graffiti coating in accordance with the "Special Coating for Cabinets" section of these Project Special Provisions. The locations include:

- Main Street at Nash Street/Marigold Street
- Main Street at Hill Street/Western Avenue
- Main Street at Sunset Avenue/Tarboro Street
- Main Street at Thomas Street
- Tarboro Street at Washington Street

(C) Type 170 E 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 fiber transceivers, 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 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 megohms. 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.

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.

Provide a shorting jack inside cabinet that functions exclusively to call the controller and cabinet assembly into the automatic diagnostics functions. Ensure shorting jack will mate with a Switchcraft Model 190 plug or equivalent. Place jack in a convenient, unobstructed location inside cabinet. When the mating plug is inserted into the jack, ensure controller enters the diagnostic test mode and a controller generated monitor reset signal is placed on Pin C1-102 (monitor external reset) of the Model 2010 enhanced conflict monitor which causes the monitor to automatically reset.

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
10	Channel 11 Red	20	Red Enable

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) Type 170 E 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 controller mounting section of the cabinet. 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 170E 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 170E controller or removal of cards inside the controller when fully extended. Provide a locking mechanism that is easily released when the shelf is to be returned to its non-use position directly under the controller.

(E) Model 2010 Enhanced Conflict Monitor

Furnish Model 2010 Enhanced Conflict Monitors that provide monitoring of 16 channels. Ensure each channel consists of a green, yellow, and red field signal input. Ensure that the conflict monitor meets or exceeds CALTRANS Transportation Electrical Equipment Specifications dated August 16, 2002 with Erratum 1 and 2 (hereafter referred to as CALTRANS's 2002 TEES) for a model 210 monitor unit and other requirements stated in this specification.

Ensure the conflict monitor is provided with a 16 channel conflict programming card. Pin 16 and Pin T of the programming card shall be connected together. Ensure that the absence of the conflict programming card will cause the conflict monitor to trigger (enter into fault mode), and remain in the triggered state until the programming card is properly inserted and the conflict monitor is reset.

Provide a conflict monitor that incorporates LED indicators into the front panel to dynamically display the status of the monitor under normal conditions and to provide a comprehensive review of field inputs with monitor status under fault conditions. Ensure that the monitor indicates the channels that were active during a conflict condition and the channels that experienced a failure for all other per channel fault conditions detected. Ensure that these indications and the status of each channel are retained until the Conflict Monitor is reset. Furnish LED indicators for the following:

- AC Power
- VDC Failed
- WDT Error
- Conflict
- Red Fail
- Dual Indication
- Short Yellow/Sequence Failure
- Program Card/PC Ajar
- Monitor Fail/Diagnostic Failure

- Channel Indicators (One indicator for each green, yellow, and red field signal input for each channel)

In addition to the connectors required by CALTRANS's 2002 TEES, provide the conflict monitor with a red interface connector mounted on the front of the monitor (3M-3428-5302 or equivalent with polarizing keys) which ensures proper mating with a 20 pin ribbon cable connector that conducts the signals from the P20 connector on the cabinet assembly. Keying of the connector shall be between pins 3 and 5, and between 17 and 19. The odd numbered pins are on one side, and the even pins are on the other. Provide connector pins on the monitor with the following functions:

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

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

Provide Special Function 1 and Special Function 2 inputs to the unit which shall disable only Red Fail Monitoring when either input is sensed active. A Special Function input shall be sensed active when the input voltage exceeds 70 Vrms with a minimum duration of 550 ms. A Special Function input shall be sensed not active when the input voltage is less than 50 Vrms or the duration is less than 250 ms. A Special Function input is undefined by these specifications and may or may not be sensed active when the input voltage is between 50 Vrms and 70 Vrms or the duration is between 250 ms and 550 ms.

Ensure the conflict monitor recognizes field signal inputs for each channel that meet the following requirements:

- consider a Red input greater than 70 Vrms and with a duration of at least 500 ms as an "on" condition;
- consider a Red input less than 50 Vrms or with a duration of less than 200 ms as an "off" condition (no valid signal);
- consider a Red input between 50 Vrms and 70 Vrms or with a duration between 200 ms and 500 ms to be undefined by these specifications;
- consider a Green or Yellow input greater than 25 Vrms and with a duration of at least 500 ms as an "on" condition;
- consider a Green or Yellow input less than 15 Vrms or with a duration of less than 200 ms as an "off" condition; and

- consider a Green or Yellow input between 15 Vrms and 25 Vrms or with a duration between 200 ms and 500 ms to be undefined by these specifications.

Provide a conflict monitor that recognizes the faults specified by CALTRANS's 2002 TEES and the following additional faults. Ensure the conflict monitor will trigger upon detection of a fault and will remain in the triggered (in fault mode) state until the unit is reset at the front panel or through the external 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 that 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 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. **Short/Missing Yellow Indication Error (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 for a minimum of 2.7 seconds (± 0.1 second) following the detection of an "on" signal at a Green input for that channel, ensure that the monitor triggers and generates a sequence/short yellow error fault indication. This fault shall not occur when the channel is programmed for Yellow Inhibit or when the Red Enable signal is inactive.

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 200 ms, ensure that the monitor does not trigger. G-Y-R dual indication monitoring shall be enabled on a per channel basis by use of switches located on the conflict monitor. G-Y dual indication monitoring shall be enabled for all channels by use of a switch located on the conflict monitor.

4. **Configuration Settings Change:** The configuration settings are comprised of (as a minimum) the permissive diode matrix, dual indication switches, yellow disable jumpers, any option switches, any option jumpers, and the Watchdog Enable switch. Ensure the conflict monitor compares the current configuration settings with the previous stored configuration settings on power-up, on reset, and periodically during operation. If any of the configuration settings are changed, ensure that the conflict monitor triggers and causes the program card indicator to flash. Ensure that configuration change faults are only reset by depressing and holding the front panel reset button for five seconds. Ensure the external remote reset input does not reset configuration change faults.

Ensure the conflict monitor will trigger and the AC Power indicator will flash at a rate of 2 Hz ± 20% with a 50% duty cycle when the AC Line voltage falls below the "drop-out" level.

Ensure the conflict monitor will resume normal operation when the AC Line voltage returns above the "restore" level. Ensure the AC Power indicator will remain illuminated when the AC voltage returns above the "restore" level. The "drop-out" level is at 98 Vrms and the "restore" level is at 103 Vrms with timing at 400 ms. Should an AC Line power interruption occur while the monitor is in the fault mode, then upon restoration of AC Line power, the monitor will remain in the fault mode and the correct fault and channel indicators will be displayed.

Provide a flash interval of at least 6 seconds and at most 10 seconds in duration following a power-up, an AC Line interruption, or a brownout restore. Ensure the conflict monitor will suspend all fault monitoring functions, close the Output relay contacts, and flash the AC indicator at a rate of 4 Hz ± 20% with a 50% duty cycle during this interval. Ensure the termination of the flash interval after at least 6 seconds if the Watchdog input has made 5 transitions between the True and False state and the AC Line voltage is greater than the "restore" level. If the watchdog input has not made 5 transitions between the True and False state within 10 ± 0.5 seconds, the monitor shall enter a WDT error fault condition.

Ensure to monitor an intersection with up to four approaches using the four-section Flashing Yellow Arrow (FYA) vehicle traffic signal as outlined by the NCHRP 3-54 research project for protected-permissive left turn signal displays. Ensure the conflict monitor will operate in the FYA mode and FYAc (Compact) mode as specified below to monitor each channel for the following fault conditions: Conflict, Red Fail, Dual Indication, and Clearance. Provide a switch to select between the FYA mode and FYAc mode. Provide a switch to select each FYA phase movement for monitoring.

FYA Mode				
FYA Signal Head	Phase 1	Phase 3	Phase 5	Phase 7
Red Arrow	Channel 9 Red	Channel 10 Red	Channel 11 Red	Channel 12 Red
Yellow Arrow	Channel 9 Yellow	Channel 10 Yellow	Channel 11 Yellow	Channel 12 Yellow
Flashing Yellow Arrow	Channel 9 Green	Channel 10 Green	Channel 11 Green	Channel 12 Green
Green Arrow	Channel 1 Green	Channel 3 Green	Channel 5 Green	Channel 7 Green

FYAc Mode				
FYA Signal Head	Phase 1	Phase 3	Phase 5	Phase 7
Red Arrow	Channel 1 Red	Channel 3 Red	Channel 5 Red	Channel 7 Red
Yellow Arrow	Channel 1 Yellow	Channel 3 Yellow	Channel 5 Yellow	Channel 7 Yellow
Flashing Yellow Arrow	Channel 1 Green	Channel 3 Green	Channel 5 Green	Channel 7 Green
Green Arrow	Channel 9 Green	Channel 9 Yellow	Channel 10 Green	Channel 10 Yellow

Ensure that the conflict monitor will log at least nine of the most recent events detected by the monitor in non-volatile EEPROM memory (or equivalent). For each event, record at a minimum the time, date, type of event, status of each field signal indication with RMS voltage, and specific channels involved with the event. Ensure the conflict monitor will log the following events: monitor reset, configuration, previous fault, and AC line. Furnish the signal sequence log that shows all channel states (Greens, Yellows, and Reds) and the Red Enable State for a

minimum of 2 seconds prior to the current fault trigger point. Ensure the display resolution of the inputs for the signal sequence log is not greater than 50 ms.

Provide a 10/100 Ethernet port (RJ45 socket/female connector) on the front panel of the conflict monitor in order to provide communications from the conflict monitor to the 170/2070L controller or to a Department-furnished laptop computer. Electrically isolate the port interface electronics from all monitor electronics, excluding Chassis Ground. Ensure that the controller can receive all event log information through a controller Asynchronous Communications Interface Adapter (Type 170E) or Async Serial Comm Module (2070L). Provide a Windows based graphic user interface software to communicate directly through the same monitor 10/100 Ethernet port to retrieve and view all event log information to a Department-furnished laptop computer. The 10/100 Ethernet port on the monitor shall allow the monitor to function as a DCE device.

24.6. MATERIALS – TYPE 170 DETECTOR SENSOR UNITS

Furnish detector sensor units (i.e., detector cards) that comply with Chapter 5, "General Requirements for Detector Sensor Units," of the CALTRANS Specifications, and the requirements for Model 222 loop detector sensor units.

24.7. CONSTRUCTION METHODS

(A) General

Identify and label all field wiring (e.g., signal conductors, pushbutton wires, loop detector lead-ins, etc.) in existing controller cabinets prior to disconnecting any field wiring.

Remove existing controllers and cabinets where required. Remove maintenance diary from cabinet and deliver to the Engineer. Take existing equipment out of service only at the time directed. Provide a law enforcement officer(s) to direct traffic through the signalized intersection while the signal is inoperable. Complete installation the new controller and cabinet and restore signal operations within three hours of taking the existing controller and cabinet out of service.

Place new City-furnished maintenance diaries inside new cabinets as well as inside existing cabinets with existing 2070L controllers. Make the initial entry in the maintenance diary upon installation of the new controller and cabinet to document the date and time of installation. Make the initial entry in the new maintenance diary in the existing 2070L controller cabinet to document the date and the time that the old diary was removed and returned to the Engineer and the new diary was placed inside the cabinet. Maintain the new maintenance diary and update it upon each subsequent visit to the cabinet until final acceptance of the project.

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 required phasing, color sequence, flash sequence, interconnection, railroad clearance and preemption, and emergency vehicle clearance and preemption.

For all Department-owned signals, stencil the signal inventory number on both the front and rear doors of the cabinet. Use 3-inch black characters. Do not stencil letters or numbers on the cabinets for City-owned signals.

Provide external electrical service disconnect, mounted independent of the cabinet, at all new and existing cabinet locations unless otherwise specified.

Do not program controller for late night flashing operation at railroad preemption installations. For all other installations, do not program 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 installed.

When installing a pole mounted cabinet in a new location or in an existing location where new risers and cabling are replacing existing risers and cabling, mount the cabinet so that the height to cabinet middle is 4 feet from the ground below. Avoid mounting cabinets so that they overhang and encroach upon an adjacent sidewalk or pedestrian path. Where a minor overhang of the sidewalk or pedestrian path cannot be reasonably avoided, ensure that that a minimum of 4 feet of clear sidewalk width will remain once the cabinet is installed. Do not mount cabinets where one of its doors opens into a street, driveway or other area subject to vehicular traffic or where an existing physical feature such as a pole, sign post, down guy, shrub or tree prevents its doors from being opened at least 90 degrees.

When replacing an existing pole-mounted cabinet with a new pole-mounted cabinet and the existing risers and cabling are being retained, mount the new cabinet so that the cabinet bottom rests upon the existing riser connections even though this causes the cabinet middle to be higher or lower than 4 feet above ground, unless the Plans indicate or the Engineer directs otherwise. Except where the "Summary of Work by Intersection" sheet calls for use of the "Reconfigured Pole Mounted 336S Cabinet Detail" to mount the 2070L controller lower in the rack inside such cabinets, comply with the cabinet layout shown in RSD No. 1751.01, Sheet 2 of 2.

Do not construct new conduit entry holes into existing metal poles to attain the 4-foot mounting height.

Program and activate controllers with proposed phasing and timing.

Where an existing 2070L controller that currently uses Department-owned the "standard version" (i.e., "non-IP" version) of OASIS™ local controller software will be retained, install Department-furnished "IP version" of the OASIS™ local controller software (i.e., OASIS™ IP) on the existing 2070L controller.

Install all updates to the local controller software and OS9 operating system software during the life of the project up through final acceptance of the project, including existing 2070L controllers that will be retained and incorporated into the upgraded and expanded Rocky Mount Signal System.

Once all new cables have been installed in and existing cables, where applicable, have been removed from base-mounted cabinets, seal <u>all</u> conduits entering the cabinet base as follows:

- Seal spare conduits with approved duct plugs.
- Seal conduits containing fiber-optic communications cable with mechanical sealing devices or moldable sealing putty.
- Seal conduits containing signal cable, and loop lead-in wire with moldable sealing putty.

Seal existing conduits as well as new conduits, regardless of whether cables are being removed from or installed in them. Comply with the requirements for conduit plugs, mechanical

sealing devices and moldable sealing putty in the "Underground Conduit" section of these Project Special Provisions.

(B) Conflict Monitors in Existing Cabinets

At locations indicated in the Plans where an existing 2070L controller housed in a 332 or 336 cabinet is being incorporated into the expanded Rocky Mount Signal System, remove the existing conflict monitor and install in its place a new conflict monitor with a 10/100 Ethernet port.

(C) Church Street and Franklin Street Cabinet Change-outs

For the following 10 intersections in downtown Rocky Mount, the underground electrical power service must be reworked and cabinet foundation must removed and replaced simultaneously with the controller and cabinet change-outs:

- Franklin Street at Hammond Street
- Franklin Street at Nash Street
- Franklin Street at Western Avenue
- Franklin Street at Sunset Avenue
- Franklin Street at Thomas Street
- Church Street at Hammond Street
- Church Street at Nash Street
- Church Street at Western Avenue
- Church Street at Sunset Avenue
- Church Street at Thomas Street

Perform the controller and cabinet change-outs, concurrent electrical power service, cabinet foundation and cabinet special base adapter work at only one intersection at a time. Complete the work at one intersection before moving to the next. Provide law enforcement to direct traffic the entire time that the signal is on flash or powered down; use of flaggers and temporary stop signs in lieu of law enforcement is not permitted. Perform work on only one intersection per day. **Complete all work at a given location and return the traffic signal to normal operations within eight (8) consecutive hours of beginning the work at a the given intersection**. Failure to complete the work at a given location within eight (8) consecutive hours will result in the Contractor being assessed **liquidated damages of $500 per hour** until the work is completed and signalized operations of the intersection have been restored. The Contractor is prohibited from beginning work at the next intersection until the work at the previous intersection has been completed and accepted.

(D) Electrical Service and Grounding

Where electrical services do not include an external electrical service disconnect, modify service to include electrical service disconnect and a new grounding electrode system.

Provide a grounding electrode system at all new electrical services. In addition to NEC requirements, test grounding electrode resistance for a maximum of 20 ohms. Furnish and install additional ground rods to grounding electrode system as necessary to meet test requirements.

Modify existing electrical services, as necessary, to meet the grounding requirements of the NEC, these Project Special Provisions and the Plans. Remove any ground rods in the cabinet foundation and install a new grounding electrode system. Cut off abandoned ground rods in the cabinet foundation flush with the foundation surface. Where a grounding electrode system is connected to the electrical service in accordance with the NEC, test grounding electrode resistance for a maximum of 20 ohms. Grounding electrode resistance test must be verified or

witnessed by the Engineer or the Engineer's designated representative. Furnish and install additional ground rods to grounding electrode system as necessary to meet the requirements of these Project Special Provisions and test requirements.

Follow test equipment's procedures for measuring grounding electrode resistance. When using clamp-type ground resistance meters, readings of less than 1 ohm typically indicate a ground loop. Rework bonding and grounding circuits as necessary to remove ground loop circuits and retest. If a ground loop cannot be identified and removed to allow the proper use of a clamp-type ground resistance meter, use the three-point test method.

Submit a completed Inductive Loop & Grounding Test Form available on the Department's website. The form is located on the Department's website at:

www.ncdot.gov/doh/preconstruct/traffic/ITSS/ws/signal_data.xls

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

(E) Edge Switch

Install and program the Ethernet edge switches in accordance with the "Communications Hardware" section of these Project Special Provisions.

(F) Emergency Vehicle Preemption

For intersections that have existing Opticom™ infrared emergency vehicle preemption detectors, transfer the existing Opticom™ Phase Selector cards to the appropriate card slot inside the new 2070L controller. The City will provide a spare Opticom™ Phase Selector card for the Contractor's use during the controller burn-in period. Test the operation of the Opticom™ Phase Selector card in the presence of the City's Traffic Signal Supervisor or his designated representative during the controller burn-in period. Upon the successful completion of the burn-in period and prior to transporting the controller and cabinet to the field for installation, remove the Opticom™ Phase Selector card and retain it for use during the burn-in of subsequent controllers and cabinets. Once all new controllers and cabinets have been successfully burned-in, return the Opticom™ Phase Selector card to the City's Traffic Signal Supervisor or his designated representative.

Once the existing controller and cabinet have been removed and the new controller and cabinet installed at an intersection, remove the existing Opticom™ Phase Selector card from the Opticom™ card cage inside the existing controller cabinet and install the existing Phase Selector Card in the appropriate card slot inside the 2070L conroller.

(G) Workshop

Provide enclosed workshop to store, set up and test new controllers and cabinets before installation. Locate workshop within the City Limits of Rocky Mount. Ensure workshop provides protection from weather and sufficient space to house two test observers, all necessary test equipment and material, controllers and cabinets. Provide the workshop until final acceptance of the project.

Configure and test each controller and cabinet to match the proposed signal design. Ensure all equipment furnished and installed or modified by the Contractor at each location operates in full compliance with the Plans and Project Special Provisions. Test each controller and cabinet for proper color sequence, flashing operation, phase timings, preemption, coordination, and

conflict monitor programming. Ensure that simultaneous conflicting phase outputs will cause the cabinet to revert to flashing operation. For intersections with any type of preemption, submit a completed Preemption Test Procedure Checklist. The checklist is located on the Department's Web site.

Test the cabinet and controller for eight hours minimum. Following this test, and before installation, the Engineer will inspect the equipment in operation. The Engineer may require other tests to ensure proper operation. These tests shall be at no additional cost to the Department.

(H) GPS Coordinates

Provide real world coordinates for all junction boxes and equipment cabinets installed or utilized under this project. Provide the coordinates in feet units using the North Carolina State Plane coordinate system (1983 North American Datum also known as NAD '83). Furnish coordinates that do not deviate more than 1.7 feet in the horizontal plane and 3.3 feet in the vertical plane. Global positioning system (GPS) equipment able to obtain the coordinate data within these tolerances may be used. Submit cut sheets on the GPS unit proposed to collect the data for approval by the Engineer.

Provide both a digital copy and hard copy of all information regarding the location (including to but not limited to manufacturer, model number, City system ID number and NCDOT inventory number) in the Microsoft Excel® spreadsheet using the format shown in example below.

City System ID#	NCDOT Inv #	Name	Location	Latitude	Longitude	Manufacturer	Model #
	05-0134	Equipment Cabinet	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5500	35.6873	McCain	Type-332
	05-0134	Junction Box # 1 (Phase 2 Side)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5516	35.6879	Quazite	PG1118BA12(Box) PG118HA00(Cover)
	05-0134	Junction Box # 2 (Phase 2 Side)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5506	35.6876	Quazite	PG1118BA12(Box) PG118HA00(Cover)
	05-0134	Junction Box # 3 (Near Cabinet)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5501	35.6873	Quazite	PG1118BA12(Box) PG118HA00(Cover)
	05-0134	Junction Box # 4 (Phase 6 Side)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5486	35.6873	Quazite	PG1118BA12(Box) PG118HA00(Cover)
	05-0134	Junction Box # 5 (Phase 6 Side)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5493	35.6876	Quazite	PG1118BA12(Box) PG118HA00(Cover)
	05-0134	Junction Box # 6 (Phase 4 Side)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5503	35.6879	Quazite	PG1118BA12(Box) PG118HA00(Cover)

24.8. MEASUREMENT AND PAYMENT

Controllers with cabinets (____) will be measured and paid as the actual number of each type of controllers with cabinets of each type and mounting method that are furnished, installed, and accepted, subject to the following conditions: 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 60-day observation period).

No measurement will be made of conflict monitors (except where being installed in an existing 332 or 336 cabinet), grounding systems, modems and workshop as these will be considered incidental to furnishing and installing controllers with cabinets.

Detector cards (Model 222) will be measured and paid as the actual number of Model 222 detector cards furnished, installed, and accepted.

Auxiliary output files will be measured and paid as the actual number of auxiliary output files furnished, installed, and accepted.

Install conflict monitor in existing cabinet will be measured and paid as the actual number of 2010 enhanced conflict monitors furnished, installed in existing 332 or 336 cabinets, and accepted. No measurement will be made removing the existing conflict monitor from the existing cabinet as such work will be considered incidental to installing the new conflict monitor in the existing cabinet.

Ethernet edge switches will be measured and paid for in accordance with the "Communications Hardware" section of these Project Special Provisions.

No measurement or payment will be made of any hardware and fasteners required for mounting controller cabinets to poles and foundations as these items will be considered incidental to installing controllers with cabinets.

No measurement or payment will be made of conduit nipples, fittings, signal cable, service wire, locknuts and bushings or other materials necessary to mount a new pole-mounted cabinet in the same location as an existing pole-mounted cabinet that is being replaced.

No measurement or payment will be made of sealing conduits with duct plugs, mechanical sealing devices and moldable sealing putty as such work will be considered incidental to furnishing and installing controllers with cabinets.

No measurement will be made of collecting and recording GPS coordinates for controller cabinets and junction boxes and compiling this data in the prescribed Microsoft Excel® spreadsheet as such work will be considered incidental installing controllers with cabinets and installing controllers.

No measurement will be made of removing an existing Opticom™ Phase Selector card from the existing Opticom™ card cage inside the existing controller cabinet and reinstalling it inside the new 2070L controller as such work will be considered incidental to furnishing and installing controllers with cabinets.

No measurement will be made for installing Department-furnished software on existing controllers as such work will be considered incidental to furnishing and installing Ethernet edge switches and new conflict monitors in existing controller cabinets.

The special anti-graffiti, black power-coated finish for controller cabinet where called for in the Plans will be measured and paid for in accordance with the "Special Coating for Cabinets" section of these Project Special Provisions.

Furnish detector card (Model 222) will be measured and paid as the actual number of Type 222 detector cards furnished and accepted.

Furnish 2070L controller will be measured and paid as the actual number of 2070L controllers furnished and accepted.

Furnish _____ cabinet will be measured and paid as the actual number of each type of controller cabinet furnished and accepted.

Furnish 2010 enhanced conflict monitor will be measured and paid as the actual number of Model 2010 enhanced conflict monitors furnished and accepted.

Payment will be made under:

Pay Item	Pay Unit
Controller with Cabinet (2070L, 336, Pole Mounted)	Each
Controller with Cabinet (2070L, 332, Base Mounted)	Each
Controller with Cabinet (2070L, 336, Base Mounted)	Each
Detector Card (Model 222)	Each
Auxiliary Output File	Each
Install Conflict Monitor in Existing Cabinet	Each
Furnish Detector Card (Model 222)	Each
Furnish 2070L Controller	Each
Furnish 336S Cabinet	Each
Furnish 332 Cabinet	Each
Furnish 2010 Enhanced Conflict Monitor	Each

25. CABINET BASE ADAPTER AND BASE EXTENDER

25.1. DESCRIPTION

Furnish and install cabinet base adapters and base extenders with all necessary hardware for 170E-family cabinets.

25.2. 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 that have a minimum height of 12". Provide cabinet base adapters that comply with the details shown in the Plans.

For certain locations in within the limits of the City's Downtown Streetscape Improvements Project as designated in the Plans, provide base extenders and base adapters with a special black powder-coated finish and anti-graffiti coating in accordance with the "Special Coating for Cabinets" section of these Project Special Provisions. The locations include:

- Main Street at Nash Street/Marigold Street
- Main Street at Hill Street/Western Avenue
- Main Street at Sunset Avenue/Tarboro Street
- Main Street at Thomas Street
- Tarboro Street at Washington Street

For certain locations in along Church Street and Franklin Street in downtown Rocky Mount as designated in the Plans, provide integrated base adapters in accordance with the "Electrical Service and Cabinet Foundations for Downtown Traffic Signals" section of these Project Special Provisions. These locations include:

- Church Street at Hammond Street
- Church Street at Nash Street
- Church Street at Western Avenue
- Church Street at Sunset Avenue
- Church Street at Thomas Street
- Franklin Street at Hammond Street
- Franklin Street at Nash Street
- Franklin Street at Western Avenue
- Franklin Street at Sunset Avenue
- Franklin Street at Thomas Street

25.3. CONSTRUCTION METHODS

(A) General

Unless otherwise shown in the Plans, install a cabinet base extender at locations requiring a new Model 332 cabinet on an existing/modified or new foundation and where an existing base-mounted Model 332 cabinet that is being retained does not have a cabinet base extender.

Install a cabinet base adapter at locations requiring a new Model 332 cabinet to be installed on an existing/modified foundation where the opening in the bottom of a cabinet base extender will not fit over the existing conduit spread. Unless otherwise directed by the Engineer, install cabinet base adapters only at locations indicated in the Plans. Do not install cabinet base adapters where the plans call for use of a cabinet base extender without the prior approval of the Engineer.

Where the plans require a Model 336S cabinet to be base mounted, 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.

25.4. MEASUREMENT AND PAYMENT

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

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

The special anti-graffiti, black power-coated finish for cabinet base extenders and bases adapters where called for in the Plans will be measured and paid for in accordance with the "Special Coating for Cabinets" section of these Project Special Provisions.

The integrated base adapters where called for in the Plans will be measured and paid for in accordance with the "Electrical Service and Cabinet Foundations for Downtown Traffic Signals" section of these Project Special Provisions.

Payment will be made under:

Pay Item	Pay Unit
Cabinet Base Extender	Each
Cabinet Base Adapter	Each

26. SPECIAL COATING FOR CABINETS

26.1. DESCRIPTION

Furnish and apply a special black powder-coated finish with anti-graffiti coating to controller cabinets, CCTV cabinets and cabinet base extenders and adapters for locations in downtown Rocky Mount as shown in the Plans.

26.2. MATERIALS

Provide a powder-coated finish that is black in color with an additional anti-graffiti top coating. Match the black color used for the new metal traffic signal poles with mast arms and signal pedestals being installed in downtown Rocky Mount under the City's Downtown Streetscape Project. Contact the City of Rocky Mount Engineering Department to confirm the color used for the Downtown Streetscape Project.

Prior to applying the special coating to the equipment, submit sample chips, 2 x 4 inches, of the black powder coating to the Engineer for approval along with catalog cuts/product data sheets from the manufacturer for the coatings proposed. Do not apply the coating to any equipment without the prior approval of the Engineer.

26.3. CONSTRUCTION METHODS

Apply the special coating to new equipment only and in accordance with the instructions of the coating manufacturer. Properly prepare the aluminum surfaces that will receive the special coating in accordance with coating manufacturer's specifications. Factory-apply the coating indoors in a temperature and humidity-controlled controlled environment. Except for special coating applied to new weatherhead, conduit entrance(s) and mounting plate installed on the existing special coated metal pole with mast arms at the intersection of NW Main Street and Thomas Street, field application of the coating is prohibited. Apply the coating only to the exterior of the cabinet, base extender or base adapter; do not apply the coating to interior of the equipment. Field apply the special coating to new weatherhead, conduit entrance(s) and CCTV camera mounting plate installed on existing special coated metal poles with mast arm at the intersection of NW Main Street and Thomas Street.

26.4. MEASUREMENT AND PAYMENT

Special coating (332 cabinet) will be measured and paid as the actual number of Model 332 cabinets to which a special coating is a applied and accepted.

Special coating (336 cabinet) will be measured and paid as the actual number of Model 336 cabinets to which a special coating is a applied and accepted. Measurement and payment will be without regard to cabinet mounting (i.e., pole or base) and Model 336 cabinet subtype (i.e., 336A vs. 336S).

Special coating (base adapter/extender) will be measured and paid as the actual number of cabinet base adapters and cabinet base extenders to which a special coating is a applied and accepted.

No measurement will be made of special coating applied to new weatherheads, conduit entrances and mounting plates installed on existing special-coated metal poles with mast arms

as such work will be considered incidental to the special coating for cabinets and base adapters at the same location.

Payment will be made under:

Pay Item	Pay Unit
Special Coating (332 Cabinet)	Each
Special Coating (336 Cabinet)	Each
Special Coating (Base Extender/Adapter)	Each

27. ELECTRICAL SERVICE

27.1. DESCRIPTION

At locations called out in the Plans, install a new electrical service, including an external disconnect and meter base.

27.2. MATERIALS

(A) Electrical Service

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

Provide, revise and/or upgrade all materials necessary to form a complete electrical service assembly as shown in the Plans on the special details entitled "Electrical Service Grounding" and "Electrical Service Options". Furnish new external electrical service disconnects, meter bases, and required grounding and extend or replace electrical service conductors and conduits between the disconnects and the controller cabinets as required.

Provide external electrical service disconnects at all new and existing cabinet locations unless otherwise specified in the Plans. Where electrical services do not include an external electrical service disconnect, modify service to include electrical service disconnect and a new grounding electrode system.

For locations where electrical service is being provided to a single traffic signal controller cabinet only, furnish external electrical service disconnects with one 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. For locations where electrical service is being provided to both a traffic signal controller cabinet and a CCTV cabinet (i.e., two separate circuits from single electrical service), furnish external electrical service disconnects with two single-pole circuit breakers, one 50 ampere plus one 15 ampere, each with a minimum of 10,000 RMS symmetrical amperes short circuit current in a lockable NEMA 3R enclosure. Furnish service conductors (3 number 12 THWN conductors) and 1" rigid conduit between the disconnect and the equipment cabinets as required.

Ensure service disconnects are listed as meeting UL Standard UL-489 and marked as being suitable for use as service equipment. Fabricate enclosure from galvanized steel and electrostatically apply dry powder paint finish to yield a minimum thickness of 2.4 mils that is light gray in color, except for the following locations in downtown Rocky Mount which shall be black in color for consistency with the Downtown Streetscape Project:

- Main Street at Nash Street/Marigold Street
- Main Street at Hill Street/Western Avenue
- Main Street at Sunset Avenue/Tarboro Street
- Main Street at Thomas Street (2, one for signal and one for CCTV)
- Tarboro Street at Washington Street

Provide ground bus and neutral bus with a minimum of four terminals with minimum wire capacity range of number 14 through number 4.

Furnish NEMA Type 3R meter base rated 100 Ampere minimum that meets the requirements of the local utility. Provide meter base with socket's ampere rating based on sockets being wired with minimum of 167 degrees F insulated wire. Furnish 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;
- With or without horn bypass;
- Made of galvanized steel;
- Listed as meeting UL Standard UL-414; and
- Overhead or underground service entrance as specified.

Ensure meter bases have electrostatically applied dry powder paint finish with minimum thickness of 2.4 mils and that is light gray in color, except for the following locations in downtown Rocky Mount which shall be black in color for consistency with the Downtown Streetscape Project:

- Main Street at Nash Street/Marigold Street
- Main Street at Hill Street/Western Avenue
- Main Street at Sunset Avenue/Tarboro Street
- Main Street at Thomas Street (2, one for signal and one for CCTV)
- Tarboro Street at Washington Street

Furnish 1" watertight hub for threaded rigid conduit with meter base.

If meter base and electrical service disconnect are supplied in the same enclosure (i.e., combination panel), ensure assembly is marked as being suitable for use as service equipment. Ensure combination meter and disconnect mounted in a pedestal for underground service is listed as meeting UL Standard UL-231. Otherwise, ensure combination meter and disconnect is listed as meeting UL Standard UL-67.

Except where the Plans require installation of an integrated base adapter, provide a combination panel with pedestal extension as shown in the Plans for all new ground-mounted electrical service assemblies for underground electrical service. Do not provide wood posts, steel U-channel posts, square tube sign posts (i.e., Telespar, etc.), Unistrut metal framing or any method other than an underground service pedestal to mount meter bases and disconnects for new underground electrical service. Provide a combination panel for mounting on the power pedestal of integrated base adapters.

Provide a grounding electrode system at all new electrical services. In addition to NEC requirements, test grounding electrode resistance for a maximum of 20 ohms. Furnish and install additional ground rods to grounding electrode system as necessary to meet test requirements.

Modify existing electrical services, as necessary, to meet the grounding requirements of the NEC, these Project Special Provisions and the Plans. Remove any ground rods in the cabinet foundation and install a new grounding electrode system. Cut off abandoned ground rods in the cabinet foundation flush with the foundation surface. Where a grounding electrode system is connected to the electrical service in accordance with the NEC, test grounding electrode resistance for a maximum of 20 ohms. Grounding electrode resistance test must be verified or witnessed by the Engineer or the Engineer's designated representative. Furnish and install

additional ground rods to grounding electrode system as necessary to meet the requirements of these Project Special Provisions and test requirements.

Follow test equipment's procedures for measuring grounding electrode resistance. When using clamp-type ground resistance meters, readings of less than 1 ohm typically indicate a ground loop. Rework bonding and grounding circuits as necessary to remove ground loop circuits and retest. If a ground loop cannot be identified and removed to allow the proper use of a clamp-type ground resistance meter, use the three-point test method.

Submit a completed Inductive Loop & Grounding Test Form available on the Department's website. The form is located on the Department's website at:

www.ncdot.gov/doh/preconstruct/traffic/ITSS/ws/signal_data.xls

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

27.3. CONSTRUCTION METHODS

(A) General

All work involving electrical service shall be coordinated with the appropriate electric utility company. Coordinate with the utility company to ascertain the feasibility of installing electrical service at each location before performing any work. Obtain all required local permits before beginning work.

Run service conductors separately from all other conductors in a 1-inch rigid galvanized conduit. Do not allow service conductors to share conduits with any other conductors or cables. Do not route unfused electrical service conductors inside of metal poles.

Upon completion of electrical service installation and backfilling of all excavations, restore the disturbed ground to its original condition as determined and approved by the Engineer. For paved areas, replace removed or damaged pavement with in kind materials, matching the elevation, color, texture/finish and general appearance of the surrounding pavement. Refer to Section 1 of these Project Special Provisions for additional requirements concerning sidewalks and curbs in historic districts. For unpaved areas, backfill excavations with removed material, tamp the backfilled material and rake smooth the top 1½ inches. Finish unpaved areas flush with surrounding natural ground and to match the original contour of the ground. Seed with same type of grass as surrounding area and mulch the newly seeded area. If unpaved area was not grassed, replace the original ground cover in kind as directed by the Engineer.

Complete repairs to and restoration of all ground (paved and unpaved) disturbed for construction within five consecutive calendar days following initial removal. If the Contractor fails to repair and restore the ground in accordance with these Project Special Provisions within the time frame specified, the City reserves the right to make the necessary repairs, and all expenses incurred by the City in making the repairs and restoring the ground will be deducted from payment due the Contractor, plus $500 liquidated damages per occasion, per day, or any portion thereof, until corrected.

(B) New Electrical Service for Traffic Signal

At locations identified in the Plans, install new electrical service as shown in the Plans on the special details entitled "Electrical Service Grounding" and "Electrical Service Options". Install a new electrical service comprised of an external service disconnect as well as a meter base, even

if the new service is replacing an existing non-metered electrical service. After installation of the meter base, the local power company will transfer the existing meter or install a new meter and make any necessary connections to the power lines.

For locations that have existing PVC service risers, replace the existing electrical service with a new electrical service that has a rigid galvanized riser, as described above.

(C) New Electrical Service for CCTV

At locations identified in the Plans, install new electrical service for a CCTV cabinet in accordance with the details shown in the Plans. Install a new electrical service comprised of an external service disconnect and a meter base housed in a combination panel. Mount the combination panel on the CCTV pole. If the CCTV camera and cabinet are being mounted on an existing signal pole, the combination panel may be ground-mounted on a pedestal adjacent to the pole subject to the approval of the Engineer. After installation of the meter base, the local power company will transfer the existing meter or install a new meter and make any necessary connections to the power lines.

Unless the Plans indicate otherwise, have the power company route the service drop underground to free-standing, combination panel with pedestal extension, even where source power lines are overhead.

(D) New Shared Electrical Service for Traffic Signal and CCTV

For locations where a single new electrical service is being provided to both a traffic signal controller cabinet and a CCTV cabinet (i.e., two separate circuits from single electrical service), install the new electrical service with two circuit breakers in the disconnect adjacent to the signal controller cabinet in accordance with the "New Electrical Service for Traffic Signal" subsection above. Install new 1" rigid galvanized underground conduits and short risers between the new disconnect and the CCTV cabinet. Route new conductors (3 number 12 THWN conductors) from the 15 amp circuit breaker to the CCTV cabinet through the new underground conduit and short risers. Permanently label the circuit breakers to identify which circuit serves the signal controller cabinet and which circuit serves the CCTV cabinet.

27.4. MEASUREMENT AND PAYMENT

New electrical service will be measured and paid for as the actual number of complete, functional electrical service locations furnished, installed and tested.

No measurement will be made of short risers (i.e., from disconnect to underground conduit and from underground conduit to bottom of cabinet), meter bases, service disconnects, additional circuit breakers in service disconnects where required, underground conduit runs for service conductors between the service disconnect and the signal controller and CCTV cabinets, or signal cabinets, acquisition of service fees, electrical service conductors, grounding electrode, ground wire and any remaining hardware and conduit to connect the electrical service to the cabinet as they will be considered incidental to furnishing and installing new electrical service.

No measurement will be made of risers with weatherheads for electrical service as they will be considered incidental to furnishing and installing a new electrical service.

No measurement will be made of restoration of paved roadways/driveways and unpaved ground surfaces with like materials, including but not limited to backfill, graded stone, paved materials, seeding and mulching, as this work will be considered incidental to installation of a

new electrical service. The Department will make no payment for a given new electrical service until all repairs to paved and unpaved surfaces damaged/disturbed during the installation the electrical service have been completed and accepted.

Repair and replacement of existing sidewalk will be measured and paid for in accordance with the "Signal Cabinet Foundations" section of these Project Special Provisions.

Payment will be made under:

Pay Item	Pay Unit
New Electrical Service	Each

28. ETHERNET RADIO

28.1. DESCRIPTION

Furnish and install an Ethernet radio system with all necessary hardware and signage in accordance with the Plans and this Project Special Provision to provide a data link between traffic signal controllers. Provide a 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.

Furnish material and workmanship conforming to the *National Electrical Code* (NEC), the *National Electrical Safety Code* (NESC), Underwriters 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.

28.2. MATERIALS

(A) General

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

(B) 900 MHz Ethernet Radio Transceivers

Furnish license free 902 – 928 MHz Ethernet radio transceivers with antennas, coaxial cable and mounting hardware, and configuration software. Design radio transceivers to work in "point-to-point", "store and forward repeater", "point-to-multipoint" and "peer to peer" configurations. Provide radios that can operate as repeaters. Ensure the 900 MHz Ethernet radio transceivers meet 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 1mW, 10mW, 100mW, or 1 Watt,
- A minimum of 139 user-selectable radio frequency channels, with 62 available hopping sequences (2 non-overlapping),
- Ethernet interface capable of operating at 1.1 Mbs with a data rate of 345 Kbps,
- DB9-F connector for RS-232/422/485 serial port,
- 32 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),
- Data encryption 128 bit WEP, 128 bit WPA, 256 Bit AES,
- Receiver sensitivity of –110dBm @ 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, and
  - Signal strength.
- 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 600 mA when powered with 12 VDC input, and transmitting 1 Watt of RF output power. and
- Shelf mounted design not to exceed 5" long x 2" wide x 7" high.

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

Furnish an Ethernet data interface cable to be installed between the Ethernet radio transceivers and either a traffic signal controller or Ethernet edge switch. Ensure cable is a minimum of 6 feet long.

Ensure that installing the Ethernet radio transceivers with a fully functional traffic signal controller does not require any field device modifications with regards to hardware or software.

(C) Software

Furnish units with a Windows® XP compatible software program that uses a GUI (Graphical User Interface) to provide "remote programming, radio configuration, remote maintenance, diagnostics and spectrum analyzer" features. Provide software approved by the Engineer that is designed to function with the approved radio. Provide configuration software that can be upgraded in the future at no additional charge.

Ensure the radio transceiver is configurable from a single location (i.e. master radio location) via supplied software (no extra cost). Furnish software supplied with drivers to allow easy set-up with all industry standard traffic signal controllers, including 2070 controllers containing custom software written specifically for the North Carolina Department of Transportation. Ensure the supplied software contains pre-written drivers for industry standard radar and video detection packages.

(D) 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:

Attenuation (dB per 100 feet) @ 900 MHz	3.9 dB
Power rating @ 900 MHz	0.58 kW
Center conductor	0.108" Copper Clad Aluminum
Dielectric: Cellular PE	0.285"
Shield	Aluminum Tape – 0.291" Tinned Copper Braid – 0.320"
Jacket	Black UV protected polyethylene
Bend radius	1" with less than 1 ohm impedance change at bend
Impedance	50 ohms
Capacitance per foot	23.9 pf/ft
End connectors	Standard N-Type Male Connectors on both ends

(E) 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 – 940 MHz
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 sq ft
Number elements	6
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	

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"
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 sq ft
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 recommended by the manufacturer of the antenna and as approved by the Engineer.

(F) Signal Splitter

Furnish a coaxial antenna splitter at a repeater site to provide for connection of two antennae. The splitter shall be compatible with the antenna cable and antenna.

(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 requirements:

- 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,
- Waterproofing sleeve: Adhesive lined polyolefin – heat shrink, and
- Attachment Size: Crimp Size 0.429" (minimum) hex.

Electrical Properties:

- Impedance: 50 ohms,
- Working voltage: 1000 vrms (max),
- Insertion loss: 0.1 x √ Fghz, and
- 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 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, and
- 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), and
- Instructions on properly installing the weatherproofing system.

(I) Surge Protector

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 200μh. Ensure that the voltage does not exceed 280V. Provide devices that comply with the following:

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

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

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.

(J) 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 2.0GHz ≤ 1.1 : 1 VSWR,
  8kA, 800MHz to 2.3GHz ≤ 1.1 : 1 VSWR,
  700MHz to 2.7GHz ≤ 1.2 : 1 VSWR,
- Insertion loss: ≤0.1 dB over frequency range,
- Max power: 500 w @ 920MHz (750 W @ at 122° F),
- RF power: 300 Watts,
- Let through voltage: ≤+/- 3 Volts for 3kA @ 8/20 µs Waveform,
- Throughput energy: ≤ 0.5 µJ for 3kA @ 8/20 µs Waveform,
- Temperature: -40 to 185° F Storage/Operating 122° F,
- Vibration: 1G at 5 Hz up to 100Hz,
- Unit impedance: 50Ω,
- VSWR: 1.1:1,
- Frequency range: 800 MHz to 2200 MHz,
- Multistrike capability,
- Low strike throughput energy,
- Flange mount and bulkhead mount options, and
- Standard N-Type female connector on both the surge side and protected side connectors.

(K) Disconnect Switch

Where an antenna is mounted on a joint-use pole, furnish a double pole, single throw snap switch in a weatherproof outlet box with cover, suitable for use in wet locations. Ensure outlet box and cover supports a lockout tag device. Ensure outlet box includes one ½-inch hole in back of box. Furnish mounting hardware, sealing gaskets and lockout tag. (NOTE: On NCDOT or City-owned poles, the disconnect switch can be omitted).

(L) Warning Signs(s) and Decal(s)

Where an antenna is mounted on a joint-use pole, 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. (NOTE: On NCDOT or City-owned poles, the warning sign and decal can be omitted).

28.3. CONSTRUCTION METHODS

(A) Site Survey

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 antennas in accordance with the following table:

Location	Radio Configuration	Antenna	
		Direction Pointing	Type/Gain
Church Street at Airport Road	Receiver	East	1- Yagi (13 dB)
Airport Road at Atlantic Avenue	Transmitter	West	1- Yagi (13 dB)

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

(B) Antenna

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

(C) Cabling

Install the coaxial cable shield grounding system by carefully removing the outer jacket of the coaxial cable without damaging the cable shield. Install the shield grounding system following the cable manufacturer's recommendations. Install and weatherproof the connection using the appropriate weatherproofing materials and following the manufacturer's recommendations. On wood poles, secure the #6 AWG grounding lead cable to the pole ground

using split bolt or compression type fitting or an Engineer approved method. On metal poles, secure the #6 AWG grounding lead cable to the pole using an Engineer approved method.

Do not exceed the 1-inch bend radius of the coaxial cable as it traverses from the cabinet to the antenna assembly. Connect the lightning arrestor to the coaxial cable in the equipment cabinet. Properly ground and secure the arrestor in the cabinet.

(D) Cabinet and Electrical Power Wiring

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 VAC terminals on the power panel.

Permanently label all cables entering the cabinet. Ensure the power supply for the radio system is **NOT** connected to the GFCI receptacle circuit located in the cabinet. Place a copy of all manufacturer equipment specifications and instruction and maintenance manuals in the equipment cabinet.

(E) Disconnect Switch

At locations where the antenna is mounted on a joint-use pole, install a double pole, snap switch to remove power from the Ethernet radio transceiver 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 the 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 the power supply for the radio in a GFCI protected outlet.

(F) Warning Sign(s) and Decal(s)

At locations where the antenna is mounted on a joint use pole, 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. If the antenna is mounted on an NCDOT or City-owned pole, the disconnect and corresponding decal may be omitted.

28.4. MEASURMENT AND PAYMENT

900MHz Ethernet Radio will be measured and paid as the actual number of Ethernet radios furnished, installed and accepted according to following conditions: 75% of the payment will be made upon acceptance of the installed radio system and the remaining 25% of the payment will be made following final acceptance (including completion of the 60-day Observation Period). This item includes the appropriate antenna(e), coaxial cable, splitter cable, coaxial cable shield grounding system with weatherproofing, lightning arrestor, installation materials, configuration software, labeling, any integration between the radio system and a fiber-optic network (if necessary) and warranties.

Furnish 900MHz Ethernet Radio will be measured and paid as the actual number of Ethernet radios furnished and accepted. This item includes one spare antenna, coaxial cable shield grounding system with weatherproofing, lightning arrestor, power supply and power cord per radio.

No measurement will be made of power supplies, power cords, adapters, antenna mounting hardware, connectors, serial cables, signs, decals, disconnect switches, and installation materials necessary to complete this work, including the radio path site survey test and warranties, as these will be considered incidental to furnishing and installing Ethernet radios.

Riser assemblies will be measured and paid for separately in accordance with the "Riser Assemblies" section of these Project Special Provisions.

Payment will be made under:

Pay Item	Pay Unit
900MHz Ethernet Radio	Each
Furnish 900MHz Ethernet Radio	Each

29. ETHERNET COMMUNICATIONS CABLE

29.1. DESCRIPTION

Furnish and install copper Ethernet cable, as shown in the Plans, for interconnecting various hardware in an Ethernet network located between the traffic signal cabinets, CCTV cabinets, the TMC, the Signal Shop and the Headquarters Fire Station.

29.2. MATERIALS

(A) Ethernet Cable

Provide Category 5 Enhanced (5e) Ethernet cable that complies with ANSI/TIA-568-A-5 standards for four-pair unshielded twisted copper for Ethernet communications. The cable shall meet all of the mechanical requirements of ANSI/ICEA S-80-576 applicable to four-pair inside wiring cable for plenum or general cabling.

Furnish Ethernet cable meeting the following minimum performance requirements:

- Specified frequency range: 1-100 MHz
- Attenuation: 24 dB
- NEXT: 37.1 dB
- ACR: 3.1 dB
- ELFEXT: 17 dB
- Power-sum ELFEXT: 14.4 dB
- Return loss: 8 dB
- Propagation delay: 548 nsec
- Delay skew: 50 nsec

(B) Connectors

Provide RJ-45 connectors with gold wire conductors terminated according EIA/TIA-568-A/568-B standards. Provide connectors with eight contacts. Furnish connectors appropriately rated for the cable being installed. Provide cables with factory-installed connectors for interior cables as much as possible.

(C) Environmental Requirements

(1) Outdoor Cable

Provide 4-pair twisted copper Ethernet cable and connectors rated for an ambient operating temperature range of -30° to 165° F. The cable shall be shielded, outdoor-rated and have a UV-resistant jacket. The void between the insulated copper pairs and the polyethylene outer jacket shall be injected with a water resistant flooding compound.

(2) Interior Cable

Provide 4-pair twisted copper Ethernet cable and connectors rated for an ambient operating temperature range of -30° to 165° F. Furnish factory pre-terminated/pre-connectorized Ethernet cables whenever possible. Provide factory pre-connectorized Ethernet cables for all cables that are less than or equal to 12 feet in length.

29.3. CONSTRUCTION METHODS

(A) General

Install Category 5e cable for all network cabling in the TMC, the Signal Shop, and the Headquarters Fire Station.

Install Category 5e Ethernet cable for all other locations, including traffic signal controller cabinets, traffic signal and utility poles, and in conduits or on messenger cable to bring the cable between traffic signal controller and CCTV cabinets.

Furnish all tools, equipment, materials, supplies, and hardware necessary to install a fully operational Ethernet cable system as depicted in the Plans. Install the Ethernet cable according to the latest version of the manufacturer's cable installation procedures and the industry-accepted installation standards, codes, and practices, or as directed by the Engineer.

Take all precautions necessary to ensure the Ethernet cable is not damaged during storage and installation. Do not step on the cable nor run over the cable with vehicles or equipment. Do not pull the cable over or around obstructions or along the ground.

Immediately cease work and notify the Engineer and the affected owner should damage to existing cables or equipment occur. Make the required repairs at no additional cost to the Department.

Provide the Engineer with three copies of the Ethernet cable manufacturer's recommended and maximum pulling tensions for each Ethernet cable size before the installation of Ethernet cable.

Install Ethernet cable in continuous lengths with no splices outside cabinets.

Cut cables to length to minimize coils of spare cable. Cut outer jacket and trim conductors per manufacturer's recommendations. Ensure all conductors extend to the end of the channel and make solid electrical contact with the gold connectors. Crimp the RJ-45 connector body to lock conductors in channels.

(B) Aerial Installation

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

Maintain tension during the pulling process for aerial run Ethernet cable by using a mechanical clutch (dynamometer) device approved by the Engineer. Do not exceed 80 percent of the manufacturer's maximum allowable pulling tension. Do not allow the Ethernet cable to contact the ground or other obstructions between the poles during installation. Do not use a motorized vehicle to generate cable-pulling forces.

(C) Messenger Cable Installation

Double lash the Ethernet cable to the messenger cable where the messenger cable is used solely to support the communications cable.

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

(D) Underground Installation

Install underground Ethernet cable as shown in the Plans using cable-pulling lubricants approved by the Ethernet cable manufacturer and the Engineer. Obtain the Engineer's approval of the cable lubricant and method of pulling before the installation of underground Ethernet cable.

Do not exceed 80 percent of the manufacturer's maximum pulling tension when installing underground Ethernet 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.

29.4. MEASUREMENT AND PAYMENT

Ethernet cable will be measured and paid as the actual linear feet of Ethernet 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. No measurement will be made of connectors as such work is considered incidental to installing the Ethernet cable.

No measurement will be made for Ethernet patch cables that connect adjacent devices/equipment (e.g., between an edge switch and a controller housed in the same cabinet; between equipment housed in the same or adjacent equipment racks in the TMC; between a computer or server and a wall receptacle; between equipment housed in the same room such as in the TMC and the Signal Shop) as they will be considered incidental to furnishing and installing the equipment that they connect.

Payment will be made under:

Pay Item	Pay Unit
Ethernet Cable	Linear Foot

30. SYSTEM SUPPORT AND TEST EQUIPMENT

30.1. DESCRIPTION

Furnish fiber-optic system support and test equipment and signal system support and test equipment with all necessary hardware in accordance with the Plans and Project Special Provisions.

30.2. 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.

Before starting any system testing or training, furnish all fiber-optic communications system support and test equipment as well as signal system support and test equipment.

(B) Fiber-Optic Restoration Kit

Furnish a fully functional fiber-optic restoration kit consisting of the following items (minimum):

- Pliers-type strippers,
- Non-nicking fiber stripper tool with procedures,
- Buffer tube stripper tool with procedures,
- Fiber-optic cleaver with diamond blade and average cut less than 0.5 degrees from perpendicular,
- Screw driver set,
- Fiber-optic cable for cleaning alignment sleeves, ST, SC, and LC connectors and jumper ends,
- Fifty 2.5 mm swabs,
- Twenty-four 2.5 mm cleaning tips for cleaning ST, SC and LC connectors, ferrules, and termini faces,
- Two rolls of electrical tape, ¾-inch width,
- Laboratory type cleaning wipes,
- Metal ruler,
- Tweezers,
- Crimping pliers,
- CamSplice™ assembly manual,
- CamSplice™ assembly fixture,
- 12 non-adhesive, mechanical CamSplice™ splices,
- Scissors,
- Hard-sided, padded storage case.
- Jensen Tools, 497-043 Paladin Service KitPlier-type strippers
- 2 Mechanical Splice Trays, 12 CamSplice™ Capacity, compatible with the interconnect centers being installed in the traffic signal controller cabinets and CCTV cabinets.

(C) Spare Cable and Connectors Kit

Furnish a minimum of 10 of each type of fiber-optic jumper of each length and each type of connector combination used on the project. In addition, furnish the following:

- 500 feet of outdoor-rated, UV-resistant CAT 5e cable,
- 10 BNC crimp-on male connectors,
- 5 CAT 5e patch cords, 5 feet long with molded strain relief cables, and
- 5 CAT 6 patch cords, 5 feet long with molded strain relief cables.

(D) Fiber-Optic Power Meter

Furnish one fiber-optic power meter 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,
- Fiber-optic connector: LC, SC and ST,
- 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° F,
  - Storage: 0° to 150° F,
- Relative humidity: 5 to 95 percent, non-condensing,
- Battery power: Alkaline: 28 hours; NiCad: 8 hours (recharger and NiCad batteries provided)
- Carrying case

(E) Optical Light Generator

Furnish optical light generators for testing link losses and trouble-shooting single-mode fiber-optic cables and networks. Provide a lightweight, compact, handheld unit constructed of rugged, durable materials. Provide a unit with automatic wavelength detection mode and the following additional features:

- Emitter type: Class I laser
- Spectral width: 5 nm or less,
- Nominal wavelengths: 1310 and 1550 nm,
- Warm-up period: 15 minutes or less
- Display: Backlit LCD,
- Fiber-optic connector: ST or Universal
- Power/signal stability: ±0.10 dB,
- Modulation: 270, 1k, 2k Hz,

- Weight with batteries: 1.2 lb. max.
- Temperature (minimum range):
  Operating: 14° to 122° F,
- Relative humidity: 0% to 95% non-condensing,
- Batteries: No more than two AA or two AAA (alkaline)
- Battery Life: Minimum of 120 hours in auto mode
- Carrying case.

(F) Visual Fault Locator

Furnish a lightweight, compact, handheld, battery-powered visual fault locater (VFL) designed for visually locating faults in single-mode fiber-optic cables, jumpers, pigtails and patch panels, such microbends, breaks, bare fibers, poor connectorization and poor splicing. Provide a unit with a red laser light source that when coupled with an optical fiber will identify a fault in the optical path by emitting light (e.g., producing a glow) at the point of the fault. Provide a unit constructed of rugged, durable materials and which has a dust cap tethered to the unit to protect the optic interface when not in use. Provide batteries of the required size and quantity and a carrying case or protective belt holster with each visual fault locator. Provide the following additional features:

- Emitter Type: Class II Visible Red Laser
- Wavelength: 635 - 670 nm
- Peak Output Power: 1mW
- Selectable Output Modes: Continuous (steady; constant-on) and pulsed (flashing; blinking) at 2-3 Hz frequency
- Batteries: No more than two AA or two AAA (alkaline)
- Battery Life: Minimum of 30 hours of continuous operation in continuous mode
- Connector Interface: 2.5mm ferrule connector, Type ST
- Weight with Batteries: 5.7 oz. (180 g) maximum
- Operating Temperature (min. range): 14°F to 113°F (-10°C to +45°C)
- Storage Temperature (min. range): -4°F to 140°F (-20°C to +60°C)

(G) Video Monitor

Furnish one portable color CCTV monitor for field testing of CCTV installations with the following features.

- Display: 4" liquid crystal display (LCD) active matrix,
- Input Signal: 2 NTSC inputs,
- Color: Full color or back and white,
- Video Resolution: 480 x 234,
- Dot Pitch: 171 x .264,
- Lighting: Back lit and built in,
- Controls: Color, brightness, power on/off, tint, red and blue drive,
- Power: 12 VDC, 500 mA,
- Cables: 6" power and video cables each,
- Connectors: Video – BNC, Power – DC jack, and
- Operating Temperature: 32° F to 104° F.

(H) Conflict Monitor Tester with Notebook Computer

Furnish a standalone, portable conflict monitor test unit with notebook computer intended for use on workbench. The tester shall use/control an Intel-based notebook computer of equal requirements to other notebook computers furnished under this project for input/output. The tester shall test conflict 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 or DVD 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 electronically to a disc file. A "No Faults Detected" indication shall be displayed as appropriate.

(I) Test Controller

Furnish and install a 2070L controller in the enclosed communications half-rack inside the TMC as shown in the Plans. Provide controller that complies with the material requirements of the "Controllers with Cabinets" section of these Project Special Provisions. Plug the power cord from the controller into the UPS mounted in the half-rack. Furnish and install an Ethernet patch cable to connect the test controller with the managed Ethernet switch also housed in the half-rack.

(J) Test Controllers with Cabinets

Furnish and install a 2070L controller with a 332 test cabinet and a 2070L controller with 336 test cabinet in the Traffic Signal Supervisor's Office at the Signal Shop as shown in the Plans. Each test cabinet shall include a full complement of detector cards, switch packs, a conflict monitor, two (2) AC isolators, two (2) DC isolators and a railroad preemption test panel. Provide a railroad preemption panel that is identical to those installed at railroad preemption locations in the field under this contract. Fully label the test cabinet and panels. Equip the 332 test cabinet with an auxiliary output file to simulate flashing yellow arrow phasing. Provide controllers and cabinets that comply with the material requirements for controllers and cabinets in the preceding subsections of this Project Special Provision. Fully label each test cabinet. Plug the power cord from the test cabinet into an existing wall receptacle adjacent to the cabinet.

(1) Construction

Furnish each test cabinet with a heavy-duty aluminum dolly base with heavy-duty, locking casters. The base shall accommodate a fully equipped, base-mounted cabinet. Attach a pole or pedestal to each base to support a display panel, which shall be located beside the cabinet for convenient use by maintenance personnel. The display panel shall have all indicators and switches on the front and shall have a suitable aluminum enclosure. The panel shall be fully labeled.

(2) Indicators

The panel shall contain indictors to display the outputs of all the cabinet's traffic signal load switched. Red, yellow and green indicators shall be use to display the outputs of the traffic signal load switches. In addition, indicators shall be provided for four (4) pedestrian signal displays and 4 special functions. The indicators shall use LED's that are user replaceable.

(3) Controls

Equip the display panel with controls that are connected to simulate all the inputs, for test purposed, to the controller which are not already accommodated by switches in the controller cabinet.

(4) Harnesses

Connect the display panel to the controller cabinet by means of harnesses. Conceal the harnesses inside the pedestal or pipe supporting the panel and route the harnesses into the test cabinet through the bottom of the cabinet.

(5) Connection to the System

Furnish and install Ethernet cables to connect the test controllers and their corresponding conflict monitors to the managed Ethernet switch housed in the wall-mounted communications rack inside the Traffic Signal Supervisor's office.

(K) CCTV Test Cabinet

Furnish and install one (1) CCTV test cabinet inside the Traffic Signal Supervisor's office 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 a CCTV test panel, a digital video encoder unit, and all cabling necessary to integrate all cabinet equipment. The test cabinet and panel shall be fully labeled.

Integrate the CCTV test cabinet with a CCTV assembly furnished under the "CCTV Field Equipment" section of these Project Special Provisions.

(1) Construction

Mount the CCTV test cabinet on a heavy-duty aluminum dolly base with four (4) heavy duty locking casters. The base shall accommodate a fully equipped base-mounted CCTV 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.

(2) Connection to System

Furnish and install Ethernet cables to connect the CCTV test cabinet to the managed Ethernet switch housed in the wall-mounted communications rack inside the Traffic Signal Supervisor's office.

30.3. MEASUREMENT AND PAYMENT

Furnish fiber-optic restoration kit will be measured and paid as the actual number of fiber-optic restoration kits furnished and accepted.

Furnish spare cable and connectors kit will be measured and paid as the actual number of spare cable and connectors kits furnished and accepted.

Furnish fiber-optic power meter will be measured and paid as the actual number of fiber-optic power meters furnished and accepted.

Furnish optical light generator will be measured and paid as the actual number of optical light generators furnished and accepted.

Furnish visual fault locator will be measured and paid as the actual number of visual fault locators furnished and accepted.

Furnish video monitor will be measured and paid as the actual number of video test monitors furnished and accepted.

Furnish conflict monitor tester will be measured and paid as the actual number of conflict monitor testers with notebook computers furnished and accepted. There will be no separate measurement and payment for the notebook computer as it will be considered incidental to furnishing the conflict monitor tester.

Test controller (2070L) will be measured and paid as the actual number of 2070L controllers furnished, installed in the half-rack inside the TMC, and accepted. No measurement will be made of Ethernet cable required to connect the test controller to the managed Ethernet switch and the power cord required to plug the test controller into the rack-mounted UPS as they will be considered incidental to furnishing and installing the test controller.

Test controller with cabinet (2070L, 332) will be measured and paid as the actual number of 2070L controllers with a 332 test cabinet furnished, installed in the Signal Shop and accepted.

Test controller with cabinet (2070L, 336) will be measured and paid as the actual number of 2070L controllers with a 336 test cabinet furnished, installed in the Signal Shop and accepted.

No measurement will be made of load switches, AC isolator cards, DC isolator cards, detector cards, preemption panels, and auxiliary output files provide with the test controllers and test cabinets as they will be considered incidental to furnishing and installing the test controllers with cabinets. No measurement will be made of Ethernet cables required to connect the test controller and conflict monitor to the managed Ethernet switch and the power cord required to plug the test cabinet into the existing wall receptacle as they will be considered incidental to furnishing and installing the test controllers with cabinets.

CCTV test cabinet will be measured and paid as the actual number of CCTV test cabinets furnished, installed in the Signal Shop and accepted. No measurement will be made of Ethernet cables required to connect the CCTV test cabinet to the managed Ethernet switch and the power cord required to plug the test cabinet into the existing wall receptacle as they will be considered incidental to furnishing and installing the CCTV test cabinet.

Payment will be made under:

Pay Item	**Pay Unit**
Furnish Fiber-Optic Restoration Kit	Each
Furnish Spare Cable and Connectors Kit	Each
Furnish Fiber-Optic Power Meter	Each
Furnish Optical Light Generator	Each
Furnish Visual Fault Locator	Each
Furnish Video Monitor	Each
Furnish Conflict Monitor Tester	Each

Pay Item	Pay Unit
Test Controller (2070L)	Each
Test Controller with Cabinet (2070L, 332)	Each
Test Controller with Cabinet (2070L, 336)	Each
CCTV Test Cabinet	Each

31. CCTV FIELD EQUIPMENT

31.1. DESCRIPTION

Furnish and install CCTV field equipment, cabinets and local camera control software described in this Section. Remove and deliver existing CCTV field equipment and cabinets that will not be used per Section 1 of these Project Special Provisions and as shown in the Plans.

Furnish and install new electrical service for CCTV as shown in the Plans.

Provide a system to protect field devices and electronic equipment from lightning and surge protection using UL listed surge protection devices.

31.2. MATERIALS

(A) General

Provide new CCTV camera assemblies with composite cable and CCTV cabinets.

Each CCTV camera assembly shall consist of the following:

- NEMA environmental dome enclosure,
- CCTV color digital signal processing camera unit with zoom lens, filter, control circuit, and accessories,
- Control receiver/driver that complies with the NTCIP specifications listed below,
- Motorized pan, tilt, and zoom,
- Power supplies,
- Pole-mount camera attachment hardware,
- All necessary cable, connectors and incidental hardware to make a complete and operable system,
- NEMA Type 4, IP 66 enclosure constructed of aluminum with a clear acrylic dome or approved equal camera unit housing,
- 60-foot composite cable for power supply and video and data transmission, and
- Surge protection devices.

Each CCTV cabinet assembly shall consist of the following:

- Type 336A cabinet (both base-mounted and pole-mounted versions)
- Local interface panel,
- Power supplies/transformers,
- Transient voltage surge suppressors, and
- All necessary cable, connectors and incidental hardware to make a complete and operable system.

Provide camera software as described herein.

(B) Standards

- ANSI,
- ASTM,
- CE, Class B,
- EIA Standards 170, 232, 422, 250C and 485,

- FCC Rules Part 15, Sub-part J,
- FCC Class A,
- FCC, Class B,
- IEEE,
- ICEA,
- IMSA,
- ISO 9001,
- NEC,
- NEMA 4X, IP 66,
- NEMA Type 1,
- NTSC, and
- UL Listed.

Provide UL listed surge protection devices according to the UL 1449, 2nd edition standard that comply with the NEMA requirements as detailed in the NEMA LS 1 (1992) standard.

Provide a means to ground all equipment as called for in the Standard Specifications, these Project Special Provisions, and the Plans.

(C) Camera Assembly

(1) Cameras

Provide new ¼-inch charged-coupled device (CCD) color day/night cameras. Provide cameras with automatic gain control (AGC) for clear images in varying light levels. The camera must meet the following minimum requirements:

• Video signal format:	NTSC composite color video output, 1 volt peak to peak,
• Horizontal resolution:	540 TV Lines,
• Image sensor resolution:	768 horizontal pixels by 752 vertical pixels,
• Automatic gain control (AGC):	0-20 dB, peak-average adjustable,
• White balance:	Automatic through the lens with manual override,
• Electronic-shutter:	Dip-switch selectable NTSC electronic shutter with speed range from 1/2 of a second (off) to 1/30,000 of a second (NTSC),
• Overexposure protection:	Built-in circuitry or a protection device to prevent any damage to the camera when pointed at strong light sources, including the sun,
• Gain control:	Automatic and manual,
• Sensitivity:	1.5 lux at 90% scene reflectance,
• Sync system:	Internal AC line lock, phase adjustable using remote control, V-sync,
• Signal to noise ratio:	Greater than 50 dB,
• Video output connection:	1-volt peak to peak, 75 ohms terminated, BNC connector, and
• Primary voltage:	120 VAC,
• Camera voltage:	24 VAC or 24 VDC, and

- Camera power: 73 VA with heater at 24 VAC or 3 amps at 24 VDC.

(2) Lens

Provide each camera with a motorized zoom lens with automatic iris control with manual override and neutral density spot filter. Provide lenses that meet the following optical specifications:

- Automatic focus: Automatic with manual override,
- Horizontal angle of view: 54 degrees at 3.6 mm wide zoom and 2.5 degrees at 82 mm telephoto zoom,
- Focal length: 3.6 mm to 82 mm, 23X optical zoom, 12X electronic zoom,
- Zoom Speed: 2.9, 4.2 and 5.8 seconds,
- Lens aperture: Minimum of f/1.6,
- Maximum Sensitivity at 35 IRE: .025 lux at ½ second color, .1 lux at 1/60 second black and white, .004 lux at ½ second black and white,
- Preset positioning: Minimum of 128 presets.

The lens must be capable of both automatic and remote manual control iris and focus override operation. The lens must be equipped for remote control of zoom and focus, including automatic movement to any of the preset zoom and focus positions. Provide mechanical or electrical means to protect the motors from overrunning in extreme positions. The operating voltages of the lens must be compatible with the outputs of the camera control.

(3) Pan and Tilt Unit

Equip each new dome style assembly with a pan and tilt unit. The pan and tilt unit must be integral to dome system. The pan and tilt unit must be rated for outdoor operation, provide dynamic braking for instantaneous stopping, prevent drift, and have minimum backlash. The dome must have an auto flip dome rotation to rotate and reposition camera for viewing objects passing below camera. Provide electronic image stabilization. The pan and tilt units must meet or exceed the following specifications:

- Pan: Continuous 360 degrees,
- Tilt: +2 to -92 degrees minimum,
- Presets: Minimum of 128 presets,
- Preset accuracy: .1 degree,
- Preset pan speed: .1 degrees/second to 200 degrees/second,
- Preset tilt speed: .1 degrees/second to 400 degrees/second,
- Privacy zones: Minimum of eight user configurable shapes,
- Input voltage: 24 VDC or 24 VAC, and
- Motors: Two-phase induction type, continuous duty, instantaneous reversing.

(4) Power Supplies

Provide all power supplies necessary for the camera and its pan tilt unit. Mount power supplies in the camera cabinet and utilize composite cable to supply power the camera and pan tilt unit.

(5) Control Receiver/Driver

Each new camera unit must contain a control receiver/driver that is integral to the CCTV dome assembly. The control receiver/driver must 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 must provide the following functions:

- Zoom in/out,
- Automatic focus with manual override,
- Tilt up/down,
- Automatic iris with manual override,
- Pan right/left, and
- Minimum of 128 preset positions for pan, tilt, and zoom.

In addition, each control receiver/driver must accept status information from pan/tilt unit and motorized lens for preset positioning of those components. The control receiver/driver must relay pan, tilt, zoom, and focus positions from the field to remote camera control units. The control receiver/driver must 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.

(6) Camera Housing

Provide new dome style enclosure for assemblies with a high performance integrated dome system or approved equal. Provide the dome housing with a 1½" NPT threaded cable entry. Equip each camera housing with a mounting assembly for attachment to the CCTV camera pole. The enclosures must be equipped with a strip heater. Provide a sunshield fabricated from corrosion resistant aluminum and finished in a neutral color of weather resistant enamel. The viewing area of the enclosure must be tempered glass. \

For CCTV-9 at the intersection of Main Street and Thomas Street in downtown Rocky Mount only, provide a dome enclosure and sunshield that is black in color for consistency with the Downtown Streetscape Project.

Provide surge protectors for all ungrounded conductors that will enter the CCTV enclosure as described below. House the surge protectors within the CCTV housing in a manner approved by the Engineer.

A dome-type environmental housing shall have a sustained ambient operating temperature of -50 degrees F to 122 degrees F, with 100 percent non-condensing relative humidity as defined within the NEMA TS-2 (1998) standard.

The enclosure shall have a NEMA 4X/IP-66 rating.

(D) Composite Cable

Provide a composite cable for carrying the CCTV power, analog video and serial data between the camera and CCTV cabinet. The composite cable shall consist of:

- Outer jacket composed of UV resistant PVC,
- RG-59U coaxial cable
  - Maximum outer diameter .75 in.,
  - PVC jacket
  - 75 ohm rating
  - Nominal capacitance of 17.5 pF/ft.,
  - 22 AWG stranded copper center conductor,
  - Bare copper stranded shield,
- Data cable
  - 22 AWG stranded cable,
  - Two twisted pairs,
  - Nominal capacitance of 26 pF/ft.,
  - Nominal impedance of 55 ohms,
  - Common shield/drain wire,
- Power Cable,
  - 16 AWG,
  - Four wire, and
  - THHN stranded.

(E) Camera Mounting Bracket

Provide a pole attachment assembly for the CCTV camera unit to mount on wood poles, metal poles, and metal mast arms. The attachment assembly shall use stainless steel banding around the pole approved by the Engineer.

For CCTV-9 at the intersection of Main Street and Thomas Street in downtown Rocky Mount only, provide a pole attachment assembly that is black in color for consistency with the Downtown Streetscape Project. Submit shop drawings for review and approval by the Engineer prior to delivery.

Provide the CCTV attachment assembly 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.

Provide CCTV camera attachment assembly that is able to withstand wind loading at the maximum wind speed and gust factor called for in the interim revision of the 2002 ASHTO Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals and can support a minimum camera unit dead load of 45 pounds.

For CCTV-8 at the intersection of Sunset Avenue and Grace Street, provide a galvanized steel luminaire (i.e., street light) mast arm that is approximately 6 feet in length for mouting the CCTV camera unit to the CCTV wood pole. Provide all brackets, hardware and fasteners required to mount the camera enclosure to the luminaire mast arm.

(F) Camera Cabinet

(1) General

Provide cabinets to house CCTV related and communications equipment described herein. Provide the cabinets with a 19-inch communications rack for all equipment.

Provide Type 336A CCTV cabinets that provide for and meet the following minimum requirements:

- Ethernet edge switch (paid for separately),
- Digital video encoder (paid for separately),
- Termination of the composite cable to the camera,
- Local interface panel with maintenance access points for data and video connections to observe camera images and program/monitor camera status,
- Fiber-optic interconnect center (paid for separately),
- Grounding bus bar,
- 19-inch rack system for mounting of all devices in the cabinet,
- Pull-out shelf for laptop and maintenance use,
- Stationary shelf for shelf-mounting the digital video encoder and Ethernet edge switch,
- Fluorescent lighting,
- Ventilation fan,
- Thermostats,
- 120 VAC power supply,
- 120 VAC GFCI-protected duplex outlets for tools,
- 120 VAC surge protected duplex outlets for equipment,
- Surge protection on incoming and outgoing electrical lines (power and data),
- Transformers/power supplies, and
- Power strip along vertical rail.

Provide cabinets complete with a prefabricated cabinet shell, and all internal components and equipment, back and side panels, front and back doors, terminal strips, cabling and harnesses, surge protection for power and communication circuits, power distribution blocks or assemblies, shelves, connectors and all mounting hardware necessary for installation of equipment.

Provide the cabinets using unpainted (except for the CCTV-9 cabinet) sheet aluminum with a minimum thickness of 0.125 inch. For the CCTV-9 cabinet at the intersection of Main Street at Thomas Street, provide a cabinet and cabinet base extender with a special black powder-coated finish and anti-graffiti coating in accordance with the "Special Coating for Cabinets" section of these Project Special Provisions.

Provide the rack assembly with a removable, standard 19-inch EIA compliant rack. Equip each cabinet with an aluminum storage compartment mounted in the rack assembly with the following dimensions (±0.5 inch): 16 inches wide, 14 inches long and 1.75 inches deep. Provide the compartment with a ball bearing telescoping drawer guides to allow full extension from the rack assembly. The storage compartment shall open to provide a full-depth storage space for cabinet documentation and other miscellaneous items. The storage compartment shall be of adequate construction to support a weight of 20 pounds without sagging when extended. The top

of the storage compartment shall be hinged aluminum. Provide at least one removable metal a full-depth shelf with each cabinet.

Provide all cabinets and exterior door seams with continuously welded seams and with smooth exterior welds. Provide all cabinets with two (2) full-size doors (one front, one back). Provide the doors with three hinges, or a full-length stainless steel piano hinge, with stainless steel pins spot-welded at the top. The hinges shall utilize stainless steel hinge pins. Mount the hinges so that they cannot be removed from the door or cabinet without first opening the door. Brace the door and hinges to withstand a 100-pound per vertical foot of door height load applied vertically to the outer edge of the door when standing open. There shall be no permanent deformation or impairment of any part of the door or cabinet body when the load is removed. Provide the cabinet door with a #2 Corbin lock. Provide two keys for each cabinet. Provide the cabinet doors so they can be padlocked. Provide door openings with double flanges on all four sides.

Doorstops shall be included at 90 and 180-degree positions. Provide both the door and the doorstop mechanism of sufficient strength to withstand a simulated wind load of five pounds per square foot of door area applied to the both inside and outside surfaces without failure, permanent deformation, or compromising of door position and normal operation. Provide the cabinets without auxiliary police doors.

Ensure that cabinet doors include a gasket to provide a dust and weather-resistant seal when closed. Provide the gasket material with closed-cell neoprene and shall maintain its resiliency after exposure to the outdoor environment. The gasket shall show no sign of rolling or sagging, and shall ensure a uniform dust and weather-resistant seal around the entire door facing.

Provide both pole-mounted and base-mounted (i.e., open bottom) versions of the 336A CCTV cabinet as required by the Plans. Provide base adapters for the base-mounted 336A CCTV cabinets that comply with the "Cabinet Base Adapters and Base Extenders" section of these Project Special Provisions.

(2) Ventilation

Provide a cooling fan in all cabinets with a minimum capacity of 100 CFM. Provide a thermostat to control the ventilation system.

Provide the cabinets with vent openings in the door to allow convection cooling of electronic components. Locate the vent opening on the lower portion of the cabinet door and cover fully on the inside with a commercially available disposable three layer graded type filter.

Provide cabinets with a serial number unique to the manufacturer. Engrave the entire identification code on a metallic plate that is epoxied to the cabinet on the upper right hand sidewall.

(3) Electrical

Provide a power distribution assembly that consists of power filters, transient voltage suppression, equipment grounding, main and branch circuit breakers for equipment, electrical outlets, lighting and ventilation.

Provide AC isolation within the cabinet. Configure all cabinets to accept 120 VAC from the utility company.

Provide UL listed circuit breakers with an interrupt capacity of 5,000 amperes and insulation resistance of 100 MΩ at 500 VDC. Provide power distributions blocks for use as power feed and junction points for two and three wire circuits. The line side of each shall be capable of handling up to 2/0 AWG conductors. Isolate the AC neutral and equipment ground wiring and terminal blocks from the line wiring by an insulation resistance of at least 10 MΩ when measured at the AC neutral.

For components that are furnished by the Contractor that are mounted on cabinet side panels, fasten with hex-head or Phillips-head machine screws. Install the screws into tapped and threaded holes in the panels. The components include, but are not limited to, terminal blocks; bus bars, and DC power supply chassis.

Tag and identify all cabinet wiring installed by the Contractor by the use of insulated pre-printed sleeves. The wire markers shall identify in plain words with sufficient details without abbreviations or codes.

Neatly arrange all wiring in the cabinet, firmly lace or bundle it, and mechanically secure the wiring without the use of adhesive fasteners. Route and secure all wiring and cabling so as to avoid sharp edges and to avoid conflicts with other equipment or cabling. Terminate all wiring on a terminal block, strip, bus bar, device clamp, lug; or connector, do not splice any wiring. Label all wiring, cables, terminal strips, and distribution blocks provided by the Contractor. Provide strain relief for all cabling with connectors, all cabling entering knockouts or ports at the equipment, and where appropriate.

(4) Video Cable Terminations

Provide terminal strips in the cabinets for the composite coaxial video, 4-wire EIA 422 data communications, and 24 VAC power cable.

Provide an interface panel to permit a technician to connect a laptop and video monitor to the front side to control the camera locally and view live CCTV video without disconnecting the field wiring. All field wiring shall be routed through the surge protection units before the interface panel. Clearly label all connections on the interface panel.

Provide three adaptor cables to convert USB data to RS-422/RS-232.

Provide a video splitter on the video cable to simultaneous provide video to the video monitor port and to the encoder. Provide a switch for selecting and local camera PTZ control.

(5) Surge Suppression

Provide surge protection both ahead of and behind the ITS device electronics for the cameras. All surge protection devices shall have an ambient operating temperature of -40 degrees F to 165 degrees F with 95 percent non-condensing relative humidity. All surge protection devices shall comply with the following standards:

- UL 1449 version 3 for electrical power,
- UL 1449A for paired data communications, and
- UL 1449C for coaxial communications..

Grounding

Provide a cabinet grounding system as shown in the Plans. Incorporate a means to bond (i.e., connected) all metal components of the camera and cabinets to the grounding system with a grounding cable that uses a mechanical connection on the equipment side and an exothermic welded connection at the down cable.

Line Side CCTV Power

Each cabinet must be provided with a hybrid-type, power line surge protection device mounted inside the power distribution assembly. The protector must be installed between the applied line voltage and earth ground. The surge protector must be capable of reducing the effect of lighting transient voltages applied to the AC line. The protector must be mounted inside the power distribution assembly housing facing the rear of the cabinet. The protector must include the following features and functions:

- Maximum AC line voltage: 140 VAC,
- Twenty pulses of peak current, each of which must rise in 8 microseconds and fall in 20 microseconds to ½ the peak: 20,000 Amperes,
- The protector must be provided with the following terminals:
  - Main line (AC line first stage terminal),
  - Main neutral (AC neutral input terminal),
  - Equipment line out (AC line second state output terminal, 19 amps),
  - Equipment neutral out (neutral terminal to protected equipment),
  - Ground (earth connection),
- The main AC line in and the equipment line out terminals must be separated by a 200 Microhenry (minimum) inductor rated to handle the 10 Amp AC service,
- The first stage clamp must be between main line and ground terminals,
- The second stage clamp must be between equipment line out and equipment neutral,
- The protector for the first and second stage clamp must have an MOV or similar solid-state device rated at 20 KA and must be of a completely solid-state design (i.e., no gas discharge tubes allowed),
- The main neutral and equipment neutral out must be connected together internally and must have an MOV similar solid-state device or gas discharge tube rated at 20 KA between main neutral and ground terminals,
- Peak clamp voltage: 350 volts at 20 KA (voltage measured between equipment line out and equipment neutral out terminals. Current applied between main line and ground terminals with ground and main neutral terminals externally tied together),
- Voltage must never exceed 350 volts, and
- The protector must be epoxy-encapsulated in a flame-retardant material.
- Continuous service current: 10 Amps at 120 VAC RMS.
- The equipment line out must provide power to cabinet CCTV and communications equipment and to the 24V power supply.

Load Side CCTV Power

Load side protection is designed to restrict surge current transients from entering the power source from the CCTV device and/or site. The surge protection for the CCTV power source shall have an operating voltage of 120 volts single phase and a maximum continuous operating voltage of 150 volts single phase.

The device's surge protection shall be rated at a minimum of 90,000 amps per phase and have maximum clamping voltage ratings of 330 volts at 500 amps, 395 volts at 3,000 amps, and 533 volts at 10,000 amps. The surge protection shall also be UL listed for a minimum suppressed voltage of 330 volts per line to the neutral/ground. The suppression device shall be of the metal oxide varistor (MOV) type.

Load Side CCTV Data/Video

Provide specialized surge protection devices at the supply and load sides of all low voltage connections to the CCTV device and its operating subsystems. These connections include, but are not limited to, coaxial video cables and low voltage control serial data cables that comply with EIA requirements as detailed in the EIA-232/422/485 standards.

The surge protection shall have an operating voltage to match the characteristics of the CCTV, such as 24 volts of direct current (VDC) or 24 volts of alternating current and less than 5 VDC for data and video functions. These specialized surge protection units shall be UL listed according to the UL 497A standard. The minimum surge current rating for the surge protection shall be 2,000 amps for data and telecommunications, 2,000 amps for twisted pair video, and 4,000 amps for binary network connectors (BNC).

(G) Grounding

Provide grounding electrodes (i.e., multiple electrodes as required to achieve 20 Ω or less) with a minimum length of 20 feet and listed according to UL requirements as detailed in the *UL 467J* standard. Provide copper clad or solid copper electrodes.

(H) Software

Provide a vendor-supplied GUI-based software to setup, configure and operate the cameras in the field. This software shall include features to set communications addresses and protocols, define camera ID lens control, digital signal processing (DSP) settings, azimuth configuration, presets, tours, and privacy zones. The software shall allow the user to control all functions of the camera locally from the CCTV cabinet at the base of the pole with a serial or USB cable.

31.3. CONSTRUCTION METHODS

(A) 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 as described below. 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 must not pass through this cabinet.

(B) CCTV Camera Assembly

Mount CCTV camera units at a height sufficient to adequately see traffic in all direction and as approved by the Engineer. Mount cameras on poles at the attachment heights shown on Special Details in the Plans.

Mount CCTV camera on the side of pole that is nearest to the intended field of view, to avoid occlusion of the view by the pole or utility lines. Obtain approval of camera orientation from the Engineer. Comply with the "Wood Poles" section of these Project Special Provisions.

(C) CCTV Camera Attachment to Pole

Have the Engineer approve the pole location prior to installing the camera on an existing pole and prior to setting a new pole. At locations shown in the Plans, assemble the camera attachment hardware for the CCTV camera unit and attach to the pole using stainless steel banding approved by the Engineer. Submit shop drawings for review and approval by the Engineer prior to installation.

Install the camera attachment assembly to the pole in a manner 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.

Install CCTV camera attachment assembly that is able to withstand wind loading at the maximum wind speed and gust factor called for in the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*, 4th Edition, 2006 Interim, and can support a minimum camera unit dead load of 45 pounds.

(D) CCTV Cabinet

Mount the CCTV cabinet on the pole supporting the CCTV camera it controls using approved hardware and attachment brackets. Avoid mounting cabinets where they will overhang and encroach upon an adjacent sidewalk or pedestrian path. Where a minor overhang of the sidewalk or pedestrian path cannot be reasonably avoided, ensure that that a minimum of 4 feet of clear sidewalk width will remain once the cabinet is installed. Do not mount cabinets above pedestrian pushbuttons or where they will hinder access to pedestrian pushbuttons. Have the Engineer approve the proposed mounting position prior to attaching the CCTV cabinet to the pole.

Where the new CCTV cabinet is replacing an existing base-mounted CCTV cabinet, remove the existing cabinet from its existing foundation, install a new cabinet base adapter over the existing conduit spread on the existing foundation and mount the new CCTV cabinet on the base adapter.

Ground all cabinets in accordance with the requirements of these Project Special Provisions. Keep the ground wire from the cabinet ground bus bar to the ground rod assembly or array as short as possible. Ensure the ground wire is not in contact with any other part of the cabinet.

Tag and identify all cabinet wiring installed by the Contractor by the use of insulated pre-printed sleeves. The wire markers shall identify in plain words with sufficient details without abbreviations or codes.

Neatly arrange all wiring, firmly lace or bundle it, and mechanically secure the wiring without the use of adhesive fasteners. Route and secure all wiring and cabling to avoid sharp edges and to avoid conflicts with other equipment or cabling. Terminate all wiring on a terminal block, strip, bus bar, device clamp, lug, or connector, do not splice any wiring. Label all wiring, cables, terminal strips, and distribution blocks installed by the Contractor. Provide strain relief for all cabling with connectors, all cabling entering knockouts or ports at the equipment, and where appropriate.

Fasten all components installed by the Contractor to be mounted on cabinet side panels with hex-head or Phillips-head machine screws. Install the screws into tapped and threaded holes in the panels. The components include, but are not limited to, terminal blocks; bus bars, and DC power supply chassis.

Connect the CCTV camera cabinet to the CCTV camera assembly using a composite cable carrying the video, serial data and power. Terminal strips shall be provided with the cabinets to support 4-wire EIA 422 communications and the 24 VAC power as will be required for power and data.

Mount the digital video encoder on a shelf in the 19" equipment rack inside the cabinet in accordance with the "Digital Video Encoder" section of these Project Special Provisions. Mount the fiber-optic interconnect center in accordance with the "Fiber-Optic Communications Cable" section of these Project Special Provisions.

Install the Ethernet edge switch inside the cabinet in accordance with the "Communications Hardware" section of these Project Special Provisions. Mount the edge switch on the same shelf in the CCTV cabinet as the video encoder. Connect the appropriate connectors on the interconnect center with those on the Ethernet edge switch using SMFO jumpers.

(1) Power Service

Provide 120 VAC power from the existing electrical service for an existing traffic signal controller cabinets as shown on the Plans. For locations where traffic signal cabinet power service is not available, install new power service under separate pay item as shown in the Plans. Comply with the "Electrical Service" section of these Project Special Provisions and the details shown in the Plans.

(E) Grounding

Connect all grounding points related to CCTV pole and its subsystems to a single point main grounding electrode, sometimes referred to as the ground window, which shall be driven a minimum of 12 inches from the CCTV pole. Each grounding electrode requires an interfacing hemisphere, an imaginary cylinder with a diameter and depth equal to the length of the electrode. Therefore, a grounding electrode that is a minimum of 10 feet long shall be installed 10-20 feet away from any additional grounding electrodes and/or ground-mounted devices.

Install a minimum of one grounding radiant, plus additional radiants as required to achieve a resistance to ground of 20 Ω or less, at each CCTV pole. This grounding radiant shall consist of one main grounding rod that is a minimum of 10 feet long located at the structural base of the CCTV pole and attached to one additional 20-foot radiant grounding rod placed a minimum of 20 feet away from the main grounding rod. Attach the main grounding rod to the CCTV pole by a solid #4 ground cable that shall be exothermically welded. Attach the radiant grounding rod to the main grounding rod with a minimum #4 solid bare copper wire that is exothermically welded at both the main grounding rod and the radiant grounding rod.

(1) Device Line Side

Connect the surge protection devices on the CCTV power source on the line side. This device shall provide protection between line-to-neutral, line-to-ground, line-to-line and neutral-to-ground.

(2) Device Load Side

Connect the surge protection devices in the power line side ahead of all CCTV electronic equipment. This installation technique is designed to restrict earth current transients induced within the ground or directly from the power source from entering the ITS device through the

incoming 120/240-volt power circuit. This device shall provide protection between line-to-neutral, line-to-ground, line-to-line and neutral to ground.

(3) Device Data/Video Supply

Connect the specialized surge protection devices at the supply and line sides of all low voltage connections to the CCTV device and its operating subsystems. These connections include, but are not limited to, Category 5E data cables, coaxial video cables, twisted pair video cables, and low voltage control cables that comply with EIA requirements as detailed in the EIA-232/422/485 standards.

(F) Software

Install the vendor-supplied GUI-based software to setup, configure and operate the cameras on each laptop supplied with the project.

(G) GPS Coordinates

Provide real world coordinates for all junction boxes and equipment cabinets installed or utilized under this project. Provide the coordinates in feet units using the North Carolina State Plane coordinate system (1983 North American Datum also known as NAD '83). Furnish coordinates that do not deviate more than 1.7 feet in the horizontal plane and 3.3 feet in the vertical plane. Global positioning system (GPS) equipment able to obtain the coordinate data within these tolerances may be used. Submit cut sheets on the GPS unit proposed to collect the data for approval by the Engineer.

Provide both a digital copy and hard copy of all information regarding the location (including to but not limited to manufacturer, model number, City system ID number and NCDOT inventory number) in the Microsoft Excel spreadsheet using the format shown in example below.

City System ID#	NCDOT Inv #	Name	Location	Latitude	Longitude	Manufacturer	Model #
	05-0134	Equipment Cabinet	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5500	35.6873	McCain	Type-332
	05-0134	Junction Box # 1 (Phase 2 Side)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5516	35.6879	Quazite	PG1118BA12(Box) PG118HA00(Cover)
	05-0134	Junction Box # 2 (Phase 2 Side)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5506	35.6876	Quazite	PG1118BA12(Box) PG118HA00(Cover)
	05-0134	Junction Box # 3 (Near Cabinet)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5501	35.6873	Quazite	PG1118BA12(Box) PG118HA00(Cover)
	05-0134	Junction Box # 4 (Phase 6 Side)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5486	35.6873	Quazite	PG1118BA12(Box) PG118HA00(Cover)
	05-0134	Junction Box # 5 (Phase 6 Side)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5493	35.6876	Quazite	PG1118BA12(Box) PG118HA00(Cover)
	05-0134	Junction Box # 6 (Phase 4 Side)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5503	35.6879	Quazite	PG1118BA12(Box) PG118HA00(Cover)

31.4. MEASUREMENT AND PAYMENT

CCTV camera assemblies will be measured and paid as the actual number of CCTV camera assemblies furnished, installed, and accepted according to following conditions: 75% of the payment will be made upon acceptance of the installed CCTV camera assembly and the remaining 25% of the payment will be made following final acceptance (including completion of the 60-day observation period).

No separate measurement will be made for composite cabling, connectors, CCTV camera attachment assemblies (including luminaire mast arms), software, grounding equipment, surge protector devices, composite cable, other cabling, and conduit, or any other equipment or labor required to install the CCTV assembly and integrate it with the fiber-optic communications equipment as they are considered incidental to furnishing and installing the CCTV camera assembly and the CCTV cabinet.

Furnish CCTV camera assemblies will be measured and paid as the actual number of CCTV camera assemblies furnished accepted. This item includes composite cabling, connectors, CCTV camera attachment assemblies, software, grounding equipment, surge protector devices and cabling.

CCTV cabinets (_____) will be measured and paid as the actual number of CCTV cabinets of each mounting type furnished, installed, and accepted, according to following conditions: 75% of the payment will be made upon acceptance of the installed CCTV cabinet and the remaining 25% of the payment will be made following final acceptance (including completion of the 60-day observation period).

No separate measurement and payment will be made for hardware, fasteners and brackets required to mount CCTV cabinets to a pole or foundations as shown in the Plans as such work with be considered incidental to furnishing and installing the CCTV cabinets.

Furnish CCTV cabinets (_____) will be measured and paid as the actual number of CCTV cabinets of each mounting type furnished and accepted. This item includes mounting hardware, fasteners and brackets to mount the CCTV cabinet to a pole.

Base adapters required for base-mounted CCTV cabinets will be measured and paid for in accordance with the "Cabinet Base Adapter and Based Extender" section of these Project Special Provisions.

The special anti-graffiti, black power-coated finish for the CCTV-9 cabinet and base extender will be measured and paid for in accordance with the "Special Coating for Cabinets" section of these Project Special Provisions.

Installation of Ethernet edge switches and digital video encoders will be measured and paid for in accordance with the "Communications Hardware" and "Digital Video Encoder" sections of these Project Special Provisions.

No measurement and payment will be made for removing existing CCTV equipment (e.g., cameras and their mounting brackets, cabling, cabinets, fiber-optic transceivers, etc.) that will not be retained and used as part of the new CCTV system, nor for delivery of removed CCTV cameras to City's Signal Shop, delivery of removed CCTV cameras and all equipment housed inside to the Division 4 Traffic Services office, and disposal of all other removed CCTV related hardware, as such work will be considered incidental to furnishing and installing CCTV camera assemblies and CCTV cabinets.

Foundations for base-mounted CCTV cabinets, where called for in the Plans, will be measured and paid for as *signal cabinet foundations* in accordance with the "Signal Cabinet Foundations" section of these Project Special Provisions.

Payment will be made under:

Pay Item	Pay Unit
CCTV Camera Assembly	Each
Furnish CCTV Camera Assembly	Each
CCTV Cabinet (Base Mount)	Each
CCTV Cabinet (Pole Mount)	Each
Furnish CCTV Cabinet (Base Mount)	Each
Furnish CCTV Cabinet (Pole Mount)	Each

32. CCTV SOFTWARE

32.1. DESCRIPTION

Furnish a network-ready, client-server CCTV system software package that operates over the LAN. The software shall be integrated into the signal systems software. . The software shall be configurable and scalable to add and delete devices.

32.2. MATERIALS

(A) CCTV Control Software

Provide the CCTV system software that will allow users to:

- Select and control selected analog and IP-based cameras via software based graphical controls, including PTZ and other advance features of cameras,
- Assign CCTV images to specific output devices (NVR, monitors), workstation video capture cards, and component device inputs,
- Facilitate video sharing,
- Video display control such as individual monitors and monitor walls,
- Video image capture, and
- Video archiving.

The system software shall support TCP/IP and SNMP. Provide a graphical user interface for CCTV control functions.

Software shall be a scalable product that controls both analog and IP video streams.

The software shall provide the capability for up to 16 videos per windows. A window can span one or more display monitors. Provide the following features:

- Drag and drop maps to display video on maps,
- Zoom in and out feature,
- Pan/tilt control of cameras, and
- Presets for setting camera positions.

(1) Access Controlled Privileges

Provide up to 20 unique operator identification passwords. Operator privileges shall be definable by the system administrator. The software shall allow these privileges to be assigned by time of day/week and year. At a minimum, the following privileges shall be definable for each operator:

- Individual workspace definition (content, size, position, and number of windows),
- Device access,
- Camera pan, tilt, zoom camera control,
- Map access,
- Device programming control, and
- NVR control.

Provide the ability to configure the access privileges of individual and groups of users.

(2) Programming Control

Provide user-defined programming scripts 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:

- Windows based user interfaces for client server architecture,
- Simple-to-use Telnet hook commands for incorporation into map based GUI,
- Quad displays for viewing of four (4) individual video signals to be displayed in one full screen view,
- Video server and camera to any monitor (including remote monitors),
- Command pan/tilt unit to a defined pre-set,
- Programming of time-based execution of actions or events,
- Alarms and notifications,
- Defining and initiating video tours, and
- Activate (or deactivate) a relay to turn the NVR on or off.

The software shall allow for up to four (4) events to be initiated per timed event. The software shall permit the manual override of the scheduled events.

(3) Graphical User Interface

The graphical user interface (GUI) shall consist of an interface for configuring all devices and variables of the system, the configuration GUI shall permit those users with access privileges to add, delete or modify devices.

The GUI shall also consist of the users' normal operational interface. The user GUI shall provide a graphic map of the overall project area with icons representing camera locations. At a minimum, include the users' GUI with a map display, available device list, and viewer to see current events.

Map Display

Provide this graphic display with the same map used for the signal system software. Map format shall be jpg, bmp, emf, or wmf file formats. The maps shall be customizable, with access privileges, to add icons, labels, hyperlinks, and alarms. Provide maps that zoomable.

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 icon shall also display current status. At the operator's discretion, the GUI or the camera control panel may be used to control all camera functions.

Device List

Clicking on an icon in the CCTV system software shall produce a scrollable, drop-down list that contains the name of all video outputs (such as monitors, NVR, encoders, etc.) that are connected to the system. A subsequent click on the appropriate video output name shall select the device on which the video is to be displayed or transmitted And provide access to that device's controls available to the user Output devices presently in use shall not be available for use until they have been de-selected.

Programming an alarm on the map shall include the ability to include animation, program scripts.

The same user GUI shall provide access to retrieve archived video.

The Client application shall automatically discover the server upon login. When a user logs into the system the client workstation and server shall automatically synchronize maps, databases and other configuration variables.

Event Viewer

Provide an event viewer to show a log of events that have occurred and are scheduled to occur. Provide a means to search the event log.

(1) Device Drivers

Provide device drivers for each device in the system including cameras, monitors, video recorders provided with this project. Provide the ability to share device drivers. Device drivers may run as an executable program or window service.

(2) FTP Image Capture

Provide a video image capture application to collect and save video images to share with NCDOT. Provide support for unicast, multicast, TCP and HTTP network protocols and program stream and transport stream transport protocols. Provide ability to capture MPEG-2, MPEG-4 Part 10, and H.264 video streams. Provide the user the ability to define the frequency and duration of image captures and the frame rate.

Provide FTP transfer capability and file archiving formats with ability to save to multiple locations.

Provide error checking of the video stream and FTP transfer process.

(B) Regional ITS Graphical Interface Software (GUI)

The Regional ITS Graphical Interface Software includes a zoomable static display map that includes a location of each ITS device. This map can be dynamically sized. Each ITS device is associated with an icon that loads an executable application. All ITS elements, icon and their respective locations are stored in the 1983 North American Datum North Carolina state plane coordinates in English units (feet). Text notes are stored for each device, which includes the dates of the last modification.

The purpose of the regional ITS GUI is to provide a common interface among the various traffic operations and management centers in the region to launch traffic management applications on other servers from local computer workstations in their respective centers. The ITS regional GUI assumes the following:

- When a field device on the GUI is actuated, the client software for the application is present on the workstation from where the application is launched,
- The user on the local workstation has network level rights to log onto the application server where the ITS devices native software resides, and
- The user on the local workstation has application level security rights to use the application software for the devices actuated.

32.3. CONSTRUCTION METHODS

(A) CCTV Control Software

Install the CCTV software on the video server along with the CCTV software decoders.

Install up to six (6) machines of the CCTV system client application in City Hall and the Signal Shop. Verify that the software is fully operable on the applicable workstations and laptops included in the project and designated by the Engineer. . Provide licenses for the CCTV devices described in this project and for up to ten simultaneous users. Provide free software upgrades for three years.

For each camera assign names consistent with the existing system. Configure presets and tours for each camera.

Assign operator rights to City staff provided by the Engineer. Assign a City staff person with administrator rights. Provide NCDOT staff access for those provided by the Engineer.

Coordinate Internet access through the firewall with the City of Rocky Mount IS Department for the image capture software in order to send the image files to NCDOT by FTP transfer.

(B) Regional ITS Graphical Interface Software (GUI)

Reuse the existing EIC server and edit any existing unified device database to add the new CCTV devices with icons and correct coordinates. The unified device database contains the coordinates of each device in individual records and contains a maximum of fifty fields. Collect the location data from all CCTV field devices required to include the new CCTV devices in the database. Ensure the map extents have adequate coverage to show the new CCTV devices. Ensure the existing capability to import data from other file formats is maintained. All additions to the database must be viewable by all users at the NCDOT Division office and the EIC in the NCDOT Transportation Building.

32.4. MEASUREMENT AND PAYMENT

CCTV Software shall be measured and paid as a lump sum. This shall include the furnishing, installation, 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: 50% of the lump sum price upon delivery and installation of the software and 50% of the lump sum price upon successful completion of the Observation Period. No payment will be made for providing software license and source code as required in these Project Special Provisions.

Regional ITS Graphical Interface Software shall be measured and paid as a lump sum. This shall include the furnishing, installation, 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: 50% of the lump sum price upon delivery and installation of the software and 50% of the lump sum price upon successful completion of the Observation Period. No payment will be made for providing software license and source code as required in these Project Special Provisions.

Payment will be made under:

Pay Item	Pay Unit
CCTV Software	Lump Sum
Regional ITS Graphical Interface Software	Lump Sum

33. SIGNAL SYSTEM SOFTWARE

33.1. DESCRIPTION

Furnish and install traffic control system software for the following applications

- Distributed Processing System Software
- System Support Software

Install the following software as furnished by the Engineer.

- Local Controller Software (latest IP version of NCDOT's OASIS® software package)

The Contractor shall be responsible for the development of and integration of all system graphics (and associated system devices) described in the following specifications.

33.2. FUNCTIONAL REQUIREMENTS

(A) General

The overall architecture of the system shall be a client server design based on hybrid centralized/distributed intersection control concepts.

Processing shall be distributed and OASIS® communications protocol shall be used for all intersection controller interfaces. Client workstations shall access networked file servers that perform traffic management, system communications, database management, and system graphics.

The system shall be implemented using standard, commercially available computer hardware required in the "Computer Hardware and Peripherals" section of these Project Special Provisions. Windowing graphical user interfaces (GUI) using object-oriented design and geographically coded database components shall be an integral part of the system design. These elements shall form the basis of all user interactions with the system.

The software shall be portable, as a minimum, across multiple PC hardware platforms and shall be designed to integrate with off-the-shelf PC software. For example, the system shall provide the ability to exchange files with common Geographic Information Systems (GIS), databases, and the Microsoft® Office 2010.

All software and firmware furnished under this project (both for individual field equipment locations and for central software) that maintain internal clocks and utilize those clocks for display of time, reporting of time back to system users, reporting of time on reports and event logs, and/or use of internal time clock to coordinate actions and activities with other software or devices shall be able to adjust to leap-year and current day light savings time dates automatically without user intervention or adjustment.

(1) Local Area Network Requirements

A 10/100/1000 Base-T Ethernet, local area network (LAN) shall support the distributed client/server architecture. The requirements for the LAN are in "Communications Hardware" section of these Project Special Provisions.

The software shall allow for a minimum of sixteen (16) simultaneous users (including remote users) of the traffic signal system applications software. No degradation in system performance shall occur when sixteen operators use the system simultaneously. Each user, subject to his or her security level, shall have full access for system control, database entry/examination, malfunction diagnosis, system operation evaluation and measures of effectiveness analysis. Access by any particular user to any particular command shall be allowed or disallowed based upon that user's assigned security level.

(2) Software License

Provide a perpetual, irrevocable software license to the Department and the City of Rocky Mount that gives them the right to copy and use the distributed processing software furnished with this project at any facility within the signal system limits.

Furnish software modifications necessary for system operation as per this Project Special Provision to the agency at no additional cost during the warranty period.

Furnish software that may be used at TMC/City Hall building, City of Rocky Mount Signal Shop, NCDOT Division 4, 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 of the Rocky Mount signal system.

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 copyrighted commercial off-the-shelf (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 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 Rocky Mount for software that may be used. Example: report-configuring, diagnostic, or monitoring software.

(3) Operating System

The operating system for all software provided under this project shall be Microsoft Windows Server® 2008 and Microsoft Windows® 7 Professional Edition. The release used shall be the latest revision and service packs available as recommended by the supplier of the system software.

The network operating system (NOS) shall be Microsoft Windows Server® 2008 or approved equal and must be compatible with the traffic signal system software.

The NOS shall be compatible and work seamlessly with the traffic signal system software and all other software (video, cellular, productivity, LAN, etc.).

(B) Distributed Processing Signal System Software

(1) General

The signal system software shall not be a prototype or software custom-developed for this project. The software shall have been successfully integrated, tested, and accepted in at least two cities of comparable size (a minimum of 100 intersections). This deployment shall be with 2070 controllers utilizing the local controller software to be deployed under this project.

The system software shall communicate directly with the local intersection 2070 controllers installed under this project. The use of remote communication units (RCUs) is not permitted. The signal system software shall interface with the latest IP version of NCDOT's OASIS® local controller software package. The system shall use a client-server design based on hybrid centralized/distributed intersection control.

The Contractor shall demonstrate to the Department that the system software is capable of communicating with 2070L controllers produced by at least three different manufacturers on at least three channels.

The system shall be designed to operate 24 hours per day, unattended, with operator attention required only periodically. Operator intervention requirements shall be limited to defining system components, modifying system timing, responding to alarms or malfunction indicators, diagnosing component failures, and manually "fine-tuning" new timing plans.

The software shall provide central monitoring of up to 1000 intelligent controllers. The system design shall accommodate future expansion. The addition of new intersections and detectors, in the field, shall not require additional software or central hardware, except for modems or transceivers and shall require only modification of the control database. The software design shall facilitate the easy, future incorporation of additional control strategy, software logic, and additional system features.

All changes to the system, including adding new controllers, configuring communications, modifying maps and intersection displays, etc., shall be performed through the system graphical user interface and by updating files in the system software folders. The use of initialization files and external editors shall not be required.

A laptop utility program shall provide on-street accessibility to off-line controllers.

(2) Start-Up and Shut-Down

The traffic control system shall provide for the initial start-up of the system by initializing all operational and failure arrays within the software. The initialization routines shall be used not only at the true initial start-up of the system, but whenever it is desired to reinitialize the system without prior status information.

The traffic control system shall accommodate a planned shutdown of the monitoring functions of the traffic control software.

(3) Power Failure

Interface system software with the uninterruptible power supply. Upon detection of a loss of power, the system software shall notify the operator.

The traffic control program may suddenly stop execution for various hardware or software reasons. In such event, alarms shall alert the operator as to the problem and circuitry shall ensure against the transmission of erroneous data by the field communications subsystem.

In the event that the operator determines that the operation of the system is improper, he/she shall be able to immediately force all system intersections to an off-line, or a time-based coordination timing plan stored in the local controller (depending on the local day plan) from any system workstation.

(4) Backup Intersection Operation

The system shall provide for backup intersection operation in case of failure of the ITS Application Server, ITS Communications Server, or the communication system. This backup shall be accomplished by means of time-based coordination (TBC) provided by the local controller software.

When operating by centrally controlled scheduled events, the local controllers shall automatically implement local TBC, according to the day plan programmed into the controller whenever communication to central is absent.

When operating by centrally controlled manual commands, the local controllers shall continue to run according to those commands regardless of the state of communications.

(5) Clock Updates

Upon login, each workstation clock shall be automatically updated by the Microsoft Windows operating system to the current time of the distributed system server clock.

(6) Remote Access

The system shall allow full access to the system for a multiple user by means of Ethernet access through a secured firewall, using Microsoft Terminal Services or other means approved by the Department. The remote user shall be allowed to perform any functions, permitted by Terminal Services, and available to any other user with the same level of security regardless to where the user is physically located.

(7) Paging

The system shall be capable of automatically sending alphanumeric messages (SMS – text messaging) to cellular telephones and email addresses upon detecting problems with the system or from any device. Malfunctions notifications shall also appear as a pop-up alarm, or similar notification approved by the department, on each workstation logged into the system. An audible alert shall be associated with a pop-up alarm, and configurable by the user.

The visual pop-ups and audible alerts shall be configurable to stay up for a specified time period or to stay up indefinitely until closed by the user. Malfunction notifications shall consist of at least three (3), user configurable, priority levels, to include low priority, medium priority and high priority alerts. Acknowledgements of incoming malfunction alarms shall be required for all medium and high priority on-screen notifications. Low priority alarm notifications shall not require acknowledgements.

Malfunction alerts shall be sent via text (SMS) or email notifications and shall be configurable by TOD/DOW, allowing recipients to be selected based upon severity or priority of event and to issue text/email messages sent to multiple devices or addresses.

Notifications shall allow a confirmation to assure that the malfunction has been acknowledged. If no acknowledgement is received upon expiration of a user programmable time-out period, subsequent notifications shall be configurable to be sent to alternate devices.

The system shall log all malfunction notifications, retries, and acknowledgements with time and date stamps. The first acknowledgement shall be recorded; all others shall be ignored.

(8) Field Communications

Within the Rocky Mount computerized signal system, traffic signal controllers will be integrated with field Ethernet edge switches that are arranged in a multi-drop communications channels capable of supporting a minimum twenty (20) traffic signal controllers on a dedicated communications channel. The software shall operate with a fully redundant communications network. Each controller is connected to the system via a pair of optical fibers and field Ethernet switch. A channel consists of two fibers: one transmitting and the other receiving.

Each channel with its boundaries and the controllers and CCTV cameras contained within it are depicted on the cable schematic diagram shown in the Plans.

(9) Database Preparation

Complete all data entry necessary to implement the operation of the system software.

The Engineer will furnish intersection timing information and coordination parameters (cycle, split, offset). Any custom intersection displays will also be provided by the Department or City. Otherwise, default intersection timing data and standard intersection maps will be utilized when configuring intersections onto the system. Program all system detectors shown in the plans. Coordinate with the City to provide setup, naming/labeling, logging and any features required for the operation of all system detectors.

TOD/DOW plans, alarms and other information for the operation of the signal system shall be entered by the Contractor.

(10) System Function Monitoring

Verification of on-street system operation shall be incorporated in the new signal system. Operation of all controller equipment shall be monitored, with current displays and malfunctions reported in near real-time. Continuous, polled communication shall occur from the local controller to the communication server.

(11) Database Backup and Restoration

The system shall have a simple means of copying the database files from the hard disk to a removable storage device or archive server. All files required to restore the system to operation without the need to manually re-enter data shall be included on removable storage device.

Files containing records of logged events and detector data shall be saved on a RAID array disk storage as described in the "Computer Hardware and Peripherals" of these Project Special Provisions. The system shall enable an operator to copy all logged events, within a user-specified date range, to the removable storage device or archive server. The system shall enable an operator to copy all selected detector data to the removable storage device.

The software shall provide simple, straightforward means for restoring system operation from the backup database files.

(12) Graphical User Interface

An object-oriented, graphical user interface (GUI) shall be provided to control and access all systems displays, reports, and dialogue boxes. The GUI shall provide access to all signal system monitoring and control options from a single screen.

Graphical icons shall be used on the displays to represent system devices. The icons shall provide easy access to traffic control data (signal timing, geometric, etc.), real-time data (intersection, link status, etc.), the database, and graphical image files.

The GUI shall include an intersection/link base map with windowed table reports and management input windows. The GUI shall provide interactive mechanisms to assist in creating, editing, and modifying editable dynamic graphic screens that are linked to system dynamic elements. As a result, all operator actions shall be immediately visible as a change in the system graphic.

The workspace session window shall display a toolbar near one of the window borders. The toolbar shall contain buttons and other controls specific for actions relating to a selected window. Actions supported by and pertaining to an active window shall be invoked through the toolbar, action bars, menu selection, popup menu or controls internal to the window itself.

Menu and dialogue box options that are not appropriate in a particular context or not available to a given user shall be "grayed-out" and unavailable for selection.

Traffic engineering terminology shall be used throughout the programming displays. Display organization and data entry approach shall allow system operators to operate the distributed signal system software without using reference cards or manuals.

The user interface shall include an object library that contains dynamic icon objects for system control and monitoring devices. The basic system shall include, at a minimum, objects for traffic signals (OASIS®).

The library shall also include an interactive editor for placing these objects within dynamic graphic screens.

The system shall allow the user to link dynamic graphics objects directly to system database elements without low level code programming, use of initialization files, or program recompilation. The library shall also include dynamic objects allowing the user to define directional roadway links using a simple vector drawing facility. Proper representation of directional status attributes shall be available at all zoomed levels, on the system map.

All information shall be shown simultaneously and continuously displayed until canceled by the operator. Displays shall not affect system operation. All displays shall have a maximum refresh rate of one second.

System Graphics

These dynamic condition maps shall provide a simple mechanism for system navigation, presentation of status, and selections within the user interface.

Backgrounds for the system-wide graphic shall be capable of containing commercial vector images of geographically accurate maps or scanned images. These images shall be compatible with common GIS packages such as ARCGIS. These images shall be used as the display layers

of real-time graphics displays. The graphics for the entire system shall be developed in the ESRI map objects embedded environment, or approved equivalent.

Backgrounds for the control section and intersection displays shall be .bmp or .jpg formats. Resolution or file size shall not be limited.

Zooming, scrolling and automatic control layers of graphic presentations shall be included with the system.

All graphics for system maps, control section maps, and intersection displays shall be submitted to the Engineer for approval before being integrated with the software.

System Map

The ESRI-based system-wide map or approved equivalent shall provide a dynamic display of the entire surveillance area and any layers the agency requires, including but not limited to interstate highways, major arterial roads, railroads, jurisdiction boundaries, and bodies of water. It shall be possible to "zoom in" and "drill down" to any specific area of the map using the pointing device to select one corner of an area to view, and then select the opposite corner of the area to view. (Zoom out capability shall also be provided). The window containing the system-wide map shall be capable of being dynamically sized by a workstation user.

It shall be possible to display intersection icons in different formats, using the menu bar. The system map shall provide a dynamic display of the signal system signalized intersections in the following two modes:

- Intersection phasing
- Intersection plan

The graphic shall also dynamically display the status of the controllers (e.g., coordination, emergency vehicle preemption, railroad preemption, transition, free operation, flashing, failure, intersection phase status). Intersection status and roadway links shall change color dynamically based on user definable color selection.

Intersection phase status (green, yellow and red) shall be displayed in real-time on the intersection phasing icon. The intersection control status shall be displayed as the background color on the intersection plan icon. Intersection plan information shall be displayed as a number on the intersection plan icon.

Link status shall be shown as different (user defined) colors for differing traffic flow conditions.

The system display shall be capable of being dynamically sized by a workstation user. Resizing the window shall not reduce the amount of data displayed on a workstation monitor and the same aspect ratio shall be monitored as before the resizing.

Control Section Map

Create default subsection maps/zones or areas to provide a display. The default displays will be called control section maps, and shall provide a more detailed display of selected zones or areas of the system. A control section shall be able to be called from the system map display via a double mouse click or from a drop down menu. A minimum of fifteen (15) control section displays shall be capable of being simultaneously displayed while the system map is open and

the maximum number intersection display windows are open. The control section map interface shall be an integrated portion of the distributed processing system software and shall not be a stand-alone package.

The control section map shall provide a dynamic display of the signal system, including landmarks, streets, signalized intersections, interstate highways (if applicable), railroads (if applicable), system detectors, system detector actuation. Labels for these items shall also be displayed. All labeling shall be approved by the Engineer. The graphic shall also dynamically display the status of the controllers in the sub-area (e.g., coordination, emergency vehicle preemption, railroad preemption transition, free operation, flashing, failed, intersection phase status). Volume and occupancy levels shall be displayed as color bars on the map. Intersection phase status (green, yellow, and red) shall be displayed in real-time using arrow icons. Link status shall be shown as green for free flow or near free flow conditions. Yellow shall be shown for moderate congestion or transition conditions. Red shall be shown for congested conditions, and flashing red shall be used to indicate severe congestion or major delays. The control section display shall be capable of being dynamically sized by a workstation user. Resizing the window shall not reduce the amount of data displayed on a workstation monitor, and the same aspect ratio shall be monitored as before the resizing. The control section map graphic shall include a user-definable control section map title. North shall either be at the top or right side of the monitor when displaying a control sub-area. Vertical and horizontal scroll bars may be provided if the size of the sub-area is such that it cannot be displayed on a monitor at a scale (as determined by the Engineer) that is adequate for viewing by the operator. The City will provide to the Contractor the final control sections boundaries for each control section display to be developed by the Contractor. There will be a maximum of 30 control section Map displays. Submit a sample of a control section display or map for review by the Engineer.

Intersection Display

The intersection graphic shall display both static and dynamic information. The static information shall include the intersection name, geometrics of the intersection (including a graphic display of the number of lanes and their associated use), adjacent land use, the location of the controller, and a layout of the intersection with the intersections signal locations and number of heads. The dynamic information to be displayed shall include:

- All vehicle signal indications for each active phase, and up to sixteen (16) overlaps with red, yellow, and green indicators
- All pedestrian signal indications, for up to sixteen (16) active phases. WALK, flashing DONT WALK, and steady DONT WALK shall be shown
- Vehicle and pedestrian detector actuations for each active phase
- Cycle timer (central and local clocks)
- Timing plan in effect (with cycle length and offset)

Operational status of the intersection shall include the following, but not be limited to:

- Timing in effect (in coordination, TOD, TR, etc.)

- Status mode (transition, free operation, flash, pre-emption (railroad or emergency vehicle)
- Control mode (manual control, local control, failed, etc.)

The intersection display shall accommodate all OASIS® phasing.

The intersection display shall be capable of being dynamically sized by a workstation user. Resizing the window shall not reduce the amount of data displayed on a workstation monitor.

Headquarters Fire Station Display

Create a graphical map for displaying on the video monitors being installed in the Headquarters Fire Station the railroad preemption status of the following signalized intersections along Main Street in Downtown Rocky Mount:

- Main Street at Thomas Street
- Main Street at Sunset Street/Tarboro Street
- Main Street at Western Avenue/Hill Street
- Main Street at Nash Street/Marigold Street

The graphical displays on the new video monitors will be replacing an existing status board with indicator lights mounted on the side wall of the truck bays at the Headquarters Fire Station. The existing status board is a custom-made box with schematic map of the above section of Main Street printed on the face of the enclosure and a green and red indicator light at each intersection. A steady red light indicates that the signal is in preemption and a steady green light indicates that it is not. The purpose of the displays is to quickly and clearly show to the drivers of the fire apparatus when the traffic signals at each intersection listed above are in railroad preemption, thereby indicating to the driver that the associate grade crossing may be blocked by a railroad gates and a present train. This information enables the drivers to decide whether or not to take a longer alternate route via a grade separation on Raleigh Road to respond to emergencies west of the railroad tracks or to dispatch another vehicle from a station on the west side of the tracks. The existing device does not display any other information about the traffic signals such as red-yellow-green status, etc.

The graphic should by schematic and simple, conveying only the information needed by Fire Department personnel to make quick decisions about response routes immediately before exiting the station to respond to an emergency call. The critical information that must be conveyed is whether or not the signal is in railroad preemption. Other information about the signal, such as red-yellow-green status and which street has the green is not considered critical or useful to Fire Department personnel in making their response decision. The display needs to be legible and understandable to occupants of fire apparatus positioned in the second row of each of the three truck bays.

Before creating the graphic, visit the Headquarters Fire Station to view the existing railroad preemption status board and to discuss with station personnel, namely the drivers, their information needs and preferences with respect to the new graphic displays. Contact Mike Varnell, Assistant Fire Chief, and Wiley Lewis, Fire Engineer, at (252) 972-1491 at least 14 days in advance of such a site visit to confirm the availability of personnel to meet and to make

arrangements for gaining access to the Headquarters Fire Station building. Submit a prototype of the proposed new graphic to Assistant Chief Varnell and Mr. Lewis for review, comment and approval. Submit the example electronically in the form readily viewable on a computer, such as a MS PowerPoint slide, a bitmap image, a jpeg image, PDF, etc.

(13) Intersection Monitoring

The status of each controller shall be monitored and any detected error condition shall be logged. Error conditions shall be stored in a form that specifies the type, date, and time of the error. Error processing shall be performed during both coordinated and free operations.

The software shall monitor for the following conditions:

Communications Status

The system software shall report the present status of the communication system at the controller. Changes in status of the communication system shall be recorded in the system log.

Communication Error

If communication between the communications server and local intersection is lost for a number of consecutive seconds, a failure shall be identified and an error message shall be logged and the intersection shall be dropped from system monitoring. Upon identification of a communications error, the software shall continuously attempt to re-establish communications to the intersection and regain monitoring of the intersection.

Flash Conditions

The system shall have the following flash mode capabilities:

- **Central Flash**: Individual intersections and control sections shall be capable of being placed on flash by operator command or schedule entry.
- **Cabinet Flash**: Cabinet flash mode shall be indicated when a controller enters flash via manual selection at the cabinet.
- **Conflict Flash**: Conflict flash shall result from a tripped conflict monitor at the local intersection. Conflict flash shall be logged as a failure by the software system.

The type of flash mode (central, cabinet, or conflict), the intersection name, date and time shall be logged for each entry or exit from flash.

Local Preemption

The system shall monitor and recognize the occurrence of preemption at each local intersection. Accordingly, a preempted intersection shall not be erroneously diagnosed as having experienced a coordination failure. System log messages shall be recorded to note the beginning and ending times of local preemption and the type of preemption (e.g. emergency vehicle, railroad, etc.).

Implemented Local Manual Control

Local manual control shall be initiated and controlled by hardware at the intersection. The software shall identity any intersection that is in local manual control by means of a status

message. Accordingly, an intersection being operated under manual control shall not be erroneously diagnosed as having experienced a coordination failure. When the local manual control status has been removed, the local software shall initiate the transition back to normal operation and the system log messages shall be recorded at the start and end of local manual control condition.

Local and System Detectors

The system shall allow users to set up and gather detector data from local and system detectors for traffic responsive operation or other analytical purposes.

The software shall be able to recognize and report failed detectors (e.g. constant call, no calls, etc.). A detector shall be automatically suspended from use if it is failed. Parameters for determining under counting, over counting, maximum presence shall be adjustable by the user. Detectors classified as marginal shall remain in use, but shall be identified. A change in classification to either failed or marginal and the reason for the change shall be reported to the operator and automatically entered in the system log. A reclassification to acceptable shall also be logged. System detector activity reported from any local controller type shall be monitor for under counting, over counting, and maximum presence.

Regardless of the classification status of any detector, detector status reporting shall continue unless inhibited by an operator command. A detector that has been suspended from use due to a failure shall remain suspended until its operation has been reclassified as either acceptable or marginal, or until the operator enters a command that releases it from suspension.

Detector data smoothing shall be provided to prevent short-term fluctuations from incorrectly influencing traffic-responsive control algorithms. The system software shall automatically use historical data for the traffic-responsive control algorithms when detectors have been classified as failed.

Timing Plans

An intersection timing plan shall be defined as a unique combination of cycle length, split and offset at an intersection. The software shall monitor a minimum of sixty-four (64) timing plans for OASIS® controllers. In addition, the software shall enable selection of both flashing and free operation of any intersection.

Cycle lengths, offsets, and splits shall be reported in one-second increments, or as a percentage of the cycle length if selected by the user.

Whenever a new timing plan is implemented, each controller shall achieve the new offset by implementing a transition with respect to the new cycle clock reference. For each intersection on the system, the software shall recognize and display a message that local transition is in effect.

Phase Movements

The system shall monitor each independent movement of up to sixteen (16) phases, for the quad-ring OASIS® controller. This monitoring shall include force off points, and permissive periods for each phase.

Clock Updates

Following each update of the clock on the communications server, the system shall update the clocks in each local controller and the distributed system server.

The system shall be able to receive clock updates from an external time synchronization source. Clock updates shall be demonstrated and approved by the Engineer. The system shall broadcast, unicast, or use a combination of both to send time updates to controllers on a user-configurable schedule. The user shall be able to configure how often the broadcast is performed, the hour at which the broadcast begins, the number of times the broadcast is repeated, and the time period between repeated broadcasts.

The system shall provide a means of monitoring the time drift of clocks on controllers, provided the controller supports this functionality.

For each controller that supports this functionality, the system shall allow checking controller clock times on a user-specified interval.

The system shall display the time the controller's clock was last checked and the difference between that controller clock and the system time reference.

The system shall also provide the ability to automatically synchronize a controller's clock if the time drift exceeds a user-specified threshold.

The system shall provide a means to synchronize controller clocks with the system time reference upon user command.

This functionality shall be provided in addition to the scheduled time broadcasts previously specified.

(14) Intersection Control

The software shall allow any user to control and implement changes to any intersection controller via the GUI, either through scheduled events, manually controlled events, or time-of-day plans programmed in the local controller. All parameters and events that can be programmed from the controller front panel shall be available at central for remote implementation. Any aspect of the controller timing shall be assessable from central, and shall allow editing of all timings. Full upload and download of timings to controllers shall also be allowed.

Central Scheduler

It shall not be necessary to use a special function to implement any of the local controller's basic functions. These functions shall be inherited from the timing plans associated with each type of controller.

The system shall include a centrally based event scheduler that issues scheduled commands to local controllers. The set of schedulable events shall include:

- Coordination Plans
- Software Flash
- Free Operation
- Local TOD
- Traffic responsive Operation
- Special Functions (supported by local controller type)

The event scheduler shall support the following features:

- **Day Plans**: The scheduler shall support scheduling of up to 100 unique day plans. Each day plan shall support up to 100 individually schedulable events. The individual events shall be implemented for a specific controller or a control section. The time resolution of each event shall be one minute.
- **Week Plans**: The scheduler shall support up to 52 week plans. Each week plan shall support individual day plan selection for each day of the week.
- **Annual Calendar**: An annual calendar shall support both week plan and individual day plan selection. The calendar shall automatically roll permanently scheduled events from one year to the next.
- **Individual Event Scheduler**: The scheduler shall support up to 500 Individual events to be scheduled at a higher priority than the Calendar events.
- **Manual Command/Temporary Event Scheduler**: The scheduler shall support implementation of temporary events. These events shall be programmed to begin immediately or within a scheduled timeframe. These events shall be automatically deleted from the system upon completion.

Time-of-Day Operating Mode

The Time-of-Day/Day-of-Week/Day-of-Year (TOD/DOW/DOY) mode of operation shall allow the advance scheduling of the signal plan and timing plan to be implemented in each section. TOD/DOW/DOY scheduling shall be performed based on the schedule data stored locally at the controller and updated by upload/download operations.

Coordination Plan and Scheduler Resolution

Events in the scheduler (both turn-on and turn-off) shall be adjustable in minimum increments of one minute.

Section (Zone) Control

The software shall achieve coordinated operation across the boundaries of all control sections operating on the same cycle length or on multiples of the same cycle length by ensuring that all such control sections are synchronized to a common reference.

Timing plan selection shall not be limited to entire sections. Timing plans, at the discretion of the system operator, shall be implemented for a single intersection, section of intersections, or system-wide. The timing plan shall be selectable by the operator (Manual mode), by a time clock scheduler (Time-of-Day/Day-of-Week mode), or by the local controller itself.

Traffic-Responsive Operation

In traffic-responsive operation (TRO), the system software implement a V+kO, threshold matching algorithm, and shall select the timing plan based upon system detector information and coordination threshold parameters that have been defined by the user.

The system database shall identify the system detectors that are assigned to each control section for traffic-responsive operation. System detectors may be assigned to more than one control section.

In traffic-responsive operation, the software shall use weighted volume and occupancy from the active system detectors. When the system is running TRO, it shall monitor the control

section for failed detectors. Upon detection of failed detectors, TRO will continue to function until the percentage of failed detectors exceeds an operator-specified threshold. The section shall then automatically switch to the TOD/DOW/DOY timing plan. This plan shall remain in effect until the percentage of failed detectors is below a different operator specified threshold. At this time traffic-responsive operation shall automatically resume.

Minimum plan execution time and threshold hysteresis shall be established by the operator to prevent excessive switching between timing plans. The minimum time between timing plan changes for any given section shall be measured in one-minute increments; this value shall be separately defined for each section.

The user shall have the ability to run traffic responsive as a background process wherein a traffic responsive plan is selected, but not implemented. This shall allow the user to verify traffic responsive operation in an off-line mode.

(15) Database Management

The system shall be built around a multi-user commercial off-the-shelf (COTS) database software product. The database shall be used to store, retrieve, and maintain system data and parameter files and shall be available for common computer hardware platforms. The database system shall use structured query language (SQL) and conform to Microsoft's open database standards.

The software shall provide user-friendly database facilities that allow changes to be put into effect while the system remains fully operational. The system shall provide the following database management features.

The database management software shall allow programming of the intersection controller databases. Each intersection controller shall have separate database programming pages. These pages shall contain all the programming options unique to each intersection.

All programming entries shall primarily consist of numerical values, “Yes” or “No” entries, and bit data. During configuration data entry, the new data shall overwrite the old data. If the data is in error, changes shall not be permitted and the user shall be alerted by either an error message on the display or a warning tone.

All data items entered from any workstation shall be tested for data type (numeric or text) and allowed range. All string data items shall be tested to ensure that they do not exceed the allowed length. The program shall not terminate because any data item is incorrectly entered. When errors or potential errors are detected, the program shall either display a specific diagnostic message on the screen or shall give an audible alarm and shall place the cursor in the proper field. In any case, the system shall allow the operator to re-enter the item. Prior to or simultaneously with reentry, the diagnostic message, if any, shall be erased.

Whenever a logical grouping of data (such as a full screen or the complete database file) has been entered or edited satisfactorily, that data shall be written to the proper record. This may take place upon return to the main menu or, alternatively, it may take place as the entry or editing of each distinct file is ended.

The screen organization and data entry/edit method shall enable the operator to use all functions without the need to use reference manuals or cards. The software shall minimize the use of mnemonics to interface with the user on the screen, in printed reports, and in the system's

documentation or worksheets. Only mnemonics consisting of Engineer approved traffic engineering abbreviations and other straightforward abbreviations shall be acceptable.

All field descriptions and inputs shall be simple and all text shall be in simple English and common traffic engineering terminology. It shall not be necessary to perform any decoding to read the information. All necessary field descriptions shall be specifically and discretely provided on the same display screen as they are needed.

Copy Facility

It shall be possible to copy an entire controller database (except for intersection name and identification number) from one controller database to another controller database.

It shall be possible to copy from within the database software all logical segments of the controller database to other like segments of the same controller database using menu commands (IE Timing Table page 1 → Timing Table page 2).

It shall be possible to copy from within the database software all logical segments of the controller database to other like segments of another controller database using menu commands (IE Timing Table page 1 [intersection 100] → Timing Table page 2 [intersection 101]).

It shall be possible to copy from one cell within a database table to another like cell in the same table (IE min green phase 1 to min green phase 2).

Upload/Download of Database

Any workstation shall provide for uploading (copying) the database, and logical segments thereof, from any OASIS® local controller. The software shall similarly provide for downloading (copying) the database, and logical segments thereof, to a 2070 controller using OASIS® firmware from any workstation.

Uploading a controller database from the field to central (or downloading from central to the field) from one type of controller to another type shall not be permitted.

The upload/download feature shall use block transfer techniques with a cyclic redundancy check (CRC) to ensure data integrity. Non-verified data shall cause termination of the upload or download operation, with no transfer of the corrupted block occurring. A status message shall be displayed when improper termination of the upload or download operation occurs.

Database Comparison

Following an upload, the system shall allow the operator to compare the database of any intersection controller to the database stored for that intersection on the file server. This comparison shall identify any differences between the uploaded and stored file data. The system operator shall be able to correct, use, or substitute data values and proceed with further comparison. Provide a means to view/locate stored data on file server.

(16) Reports

The system shall generate a number of pre-configured reports. The database software shall permit the operator to use structured query language (SQL) to retrieve data and produce pre-configured reports. System report information shall be able to be exported to a XML file with report data, CSV (comma delimited), PDF file, TIFF file or a Microsoft Word file. All reports should show asset ID number, main street, cross street, asset type and prevalent information to the asset.

The formats (samples) of all pre-configured reports shall be submitted to the Engineer for approval.

The list of pre-configured reports shall include, but not be limited to, the following:

- System Errors/Alerts
- Communications Status Online/Offline
- System and Local Detector VOS Data
- Device Communications Configuration
- Device Configuration
- Events Log
- Control Section/Links Data
- Scheduler
- Signal Changes
- Signal Detector Events
- Split Monitor
- System Activity
- System Events
- Time Drift
- Upload and Compare
- User Login
- Detector VOS
- Daily
- Hourly
- Multi-date / Hourly
- Multi-date / Daily

Use of third party software for the development of custom reports shall be provided by the Contractor. The software shall interface with the signal system software and its data base to allow the user to create custom reports. The user shall be able to define the format of those reports. The system shall also provide a means by which user-specific reports can be created and added to the Reports menu item without the requirement of additional software or custom development work by the software provider.

Training shall be provided on the editing, creation, exporting and general use of pre-configured and custom reports.

(17) Security

In addition to the network security features provided by the operating system, the software shall provide customizable levels of access security. Each user must enter a login name a password before gaining access to the software.

The system shall accept any number of users to be configured onto the database. The system shall have 3 default levels of security, as follows:

- Admin User
- Read Write
- Read Only

The top level (Admin User) shall provide for total access (i.e. permit the operator to view and change all information in the system). Only users with this authorization shall be permitted to view or change access security codes, add new users and delete existing users.

A bottom level (Read Only) shall permit viewing of all information (except access security codes) yet not permit the operator to make any changes to the database.

The system shall also provide the ability to customize each user's privileges with respect to system functionality. Specific privileges shall be configurable for each user, with respect to each of the following System Permissions:

- User Setup (Admin User Only)
- Asset Group
- Location
- System Preferences
- Archive Logs
- Export Logs
- Restore Logs
- Purge Logs

Specific privileges shall be configurable for each user, with respect to each of the following Traffic Permissions:

- ITS Communications Server Setup
- Detectors
- Sections
- ICM Port Configuration
- Scheduler
- Traffic responsive
- Time Space Diagram
- AEM

- W4 Special Functions
- Traffic Preferences

Specific privileges shall be configurable for each user, with respect to each of the following alarm assignments:

- Central Communications Failure
- Field Communications Failure
- Technician Flash
- Monitor / Conflict Flash
- Controller Error
- Stop Time
- Detector Failure
- Police Switch
- Door Open
- Local Clock Failure
- Special Function 1
- Special Function 2
- Special Function 3
- Special Function 4

Each user shall have separate privileges to each asset group (a group of intersections defined within the system, which may cross jurisdictional boundaries, allowing multiple agencies to use a single system). Specific privileges shall be configurable for each user, with respect to each of the following asset group functions:

- Properties
- Delete
- Graphics Editor
- Timing Tables
- Upload
- Download
- Manual Commands
- Real Time Clock

(18) Help

The signal system software shall have comprehensive, online help screens. The help screens shall be context sensitive, providing information specific to the highlighted fields or windows displayed.

(C) Local Controller Software

Local controller software shall be the latest version of the NCDOT-approved controller software. The Engineer will furnish the latest version of the software at the time of burn-in. Request the software from the Engineer a minimum of five business days prior to burn-in.

(D) System Support Software and Devices

(1) Devices

Furnish one (1) Garmin eTrex Legend GPS Receivers, or approved equivalent, with Cigarette Lighter Adapters (#010-10203-00).

(2) Productivity Software

Furnish a network version of the latest release of the Microsoft Office 2010, Professional Edition, including Excel, Access, Word, and PowerPoint. A license shall be provided for each workstation and notebook computer furnished with the project. Furnish and install a copy of the latest release of Microsoft Office 2010, Professional Edition, on each workstation and notebook computer furnished.

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.

(3) Utility Software

Furnish utility software for uploading and downloading timing plans locally at the signal cabinet. Furnish software that is compatible with local controller software and signal system central software. Furnish software with printing functionality. Provide a copy of the utility software on all notebook computers furnished under this project. In addition, provide a copy of the utility software to the Engineer prior to Final Acceptance.

33.3. INSTALLATION AND INTEGRATION

(A) General

Install and fully integrate distributed processing signal system software on ITS Application Server called for in "Computer Hardware and Peripherals" section of these Project Special Provisions. Install and fully integrate distributed processing signal system software on each workstation and notebook computers in the Rocky Mount traffic signal system.

Install and fully integrate distributed processing signal system software with the ITS Communications Server called for in "Computer Hardware and Peripherals" section 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 remote operations on the notebook computers.

Register all software products furnished with this project with the software supplier. The City of Rocky and NCDOT shall be identified as the registered owner of all software.

(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.

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 60-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. Contractor shall install all displays and fully integrate with system software. Submit all graphics to the Engineer for approval prior to the System Operational Test and prior to integration in the software.

Program all new system detectors installed under this project, and all existing system detectors being reused, in the signal system software. Install all associated graphics related to system detectors. Integrate system detector locations (based on the actual installation in the field) on all associated system graphics.

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) Local Controller Software

Install NCDOT-furnished local controller software on all new controllers. Use the latest version available at the time of installation as directed by the Engineer. Request local controller software from Engineer a minimum of one (1) week prior to use of software during burn-in period.

At locations where 2070L controllers are existing, and will not be replaced under this project, upgrade the local controller software to the current version of the NCDOT-approved software being installed in new controllers under this project. All controllers in the final Signal System shall have identical local software.

(D) System Support Software and Devices

Install software, devices, productivity software, and utility software on all workstations and notebook computers provided with the project.

33.4. Testing

(A) General

Provide the following tests and demonstration of the system software:

- System Demonstration Test, if required (see below)
- System Operational Test (as called for in "Testing and Acceptance" section)
- 60-Day Observation Period (as called for in the "Testing and Acceptance" section

(B) System Demonstration

If the signal system software package proposed for this project has not been deployed for a state or municipal system in North Carolina, a system demonstration is required. Otherwise, the system demonstration requirements are considered to have been fulfilled under previous projects.

Within one-hundred (100) calendar days after award of the contract, demonstrate ability to provide a working traffic control system that will be in general accordance with these Project Special Provisions. This shall be accomplished by conducting a demonstration of the major elements of the traffic control software at an existing, operational traffic signal system somewhere within the United States or Canada, excluding Alaska and Hawaii.

The demonstration shall take place at an actual, operating traffic signal system that features software developed and furnished by the same vendor proposed by the Contractor for this project. The candidate demonstration system shall have actual functional performance that is similar to, or better than the system required by these Project Special Provisions. A minimum of thirty (30) days prior to this demonstration, the Contractor shall submit to the Engineer a detailed description of the features provided by the candidate demonstration system and a narrative discussion of how that system differs from the functionality required by these Project Special Provisions. The Engineer shall be the sole judge as to whether or not the candidate demonstration system is sufficiently similar to the one required for the Rocky Mount System. All transportation, lodging and per diem costs for NCDOT and City personnel to witness the system demonstration will be borne by NCDOT or the City.

33.5. MEASUREMENT AND PAYMENT

Signal system software shall be measured and paid as a lump sum. This shall include the furnishing, installation, testing, and all materials, 3rd party software for reporting, 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: 50% of the lump sum price upon delivery and installation of the software and 50% of the lump sum price upon successful completion of the Observation Period. No payment will be made for providing software license and source code as required in these Project Special Provisions.

System support software and devices shall be measured and paid as a lump sum. 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 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 and source code as required in these Project Special Provisions.

Testing will not be paid for separately but will be considered incidental to equipment installation.

Payment will be made under:

Pay Item	**Pay Unit**
Signal System Software	Lump Sum
System Support Software and Devices	Lump Sum

34. COMPUTER HARDWARE AND PERIPHERALS

34.1. Description

Furnish and install all materials with the most recently developed and approved product versions that meet or exceed all applicable standards, specifications, and requirements before the system is considered for acceptance. Ensure that all equipment features, functions, and performance measures are met.

Furnish, assemble, fabricate and install new products obtained from the manufacturer or reseller. Provide commercial off-the-shelf materials, equipment, and components.

Furnish and install ITS servers, two computer workstations and four laptops in the TMC. Ensure that all workstation and laptop computers can access the ITS LAN and can be used to monitor, interact, and control all critical input and output parameters of the traffic signal system and ITS devices.

(A) ITS Servers

Furnish and install the ITS servers in the enclosed communications racks located in the TMC Server Room or TMC as described in the Plans and these Project Special Provisions. The ITS servers will consist of the signal system software application server, CCTV application server, communications server, and a backup server for system backups. Connect the ITS servers to the Gigabit Ethernet core switch and the UPS units.

(B) Computer Workstations

Furnish and install computer workstations consisting of a CPU, monitor, keyboard, UPS and mouse in City Hall and the Signal Shop

(C) Laptop Computers

Furnish and install laptop computers consisting of the computer, UPS, power supplies, carrying bag, and mouse for use by City staff.

(D) KVM Switch

Furnish and install a rack-mounted KVM switch assembly consisting of a monitor, keyboard, and mouse with switching hardware to control and access the servers supplied with this project.

(E) UPS

Furnish and install uninterruptible power supply (UPS) units for the computer workstations in both the TMC and the Signal Shop. Each UPS shall also include any ancillary equipment or incidental items, such as required mounting hardware and cabling.

(F) Printer

Furnish and install a color laser printer for use by City staff in the TMC.

(G) Existing Equipment

Remove all existing computer equipment as shown in the Plans.

34.2. MATERIALS

(A) ITS Servers

(1) Functional

The ITS servers shall integrate the workstations with other ITS systems and shall enable video and data accessibility and exchange between various systems. The servers shall function in automated fashion in unmanned mode supporting clients' control functions via ASN.1 and/or XML-defined protocols over TCP/IP. Provide the servers capable of operating in the following configurations:

- Single server configuration (environments with n*10 controlled objects).
- Multiple server configuration (environments with n*100 controlled objects).
- Thin server configuration (active control of local part in case of larger system).
- Redundant server configuration (two server nodes sharing a single IP address).

Provide ITS servers meeting the following functional requirements:

- Handle commands from system clients via ASN.1 and/or XML defined protocol over standard TCP/IP connection.
- Command underlying nodes (devices such as encoders, video servers).
- Report status of system nodes and alarms.
- Monitor system nodes connections.
- Store recent alarms in internal database.
- Receive Simple Network Management Protocol (SNMP) traps generated by network infrastructure, translate SNMP traps as system alarms, and send alarms as SNMP traps.
- Support remote configuration and diagnostics.
- Restore video and connections in case of system component restarts.
- Support protocols: TCP, UDP, NTP and IP Multicast IGMP.

(2) Performance

Provide ITS application servers meeting the following minimum requirements:

- Processor: Dual quad core Intel Xeon L5560 or better at 2.8 GHz or greater, 2x6 MB cache processor, L2 cache at 1333 Mhz,
- Memory: Minimum 4 GB single-ranked UDIMMS for two processors at 1333 MHz,
- Backplane: 1x6 backplane for 3.5 inch drives,
- Power Supply: Redundant power supplies with separate cords,
- Drive Controller: PERC6i SAS RAID 6 with PCIe 256 MB cache,
- Hard Drives: RAID 6 with 4x146 GB, 15k RPM serial SCSI drives, 3 Gbps, 3.5 inch, Hotplug,
- CD-ROM: DVD +/-RW SATA Drive, internal,
- Video Card: Integrated video chipset controller 8 MB SD RAM including 3D 60 MHz memory, 480 MB/s memory bandwidth and DirectX 5.0,
- Video Adaptor: 3D, SGVA,

- Network: Dual-port Gigabit Network Adaptor with TOE, PCIe-4, and
- Operating System: Microsoft Server 2008 Release 2 with Service Pack 2, Standard Edition and 5 CALs, and Microsoft SQL 2008 Standard Edition.
- Support Software: Microsoft SQL 2008.

Provide an ITS video server meeting the following minimum requirements:

- Processor: Dual quad core Intel Xeon L5560 or better at 3.0 GHz or greater, 8MB cache processor, L2 cache at 1333 Mhz,
- Memory: Minimum 4 GB DDR2, 1333 MHz,
- Backplane: 1x6 backplane for 3.5 inch drives,
- Power Supply: Redundant power supplies with separate cords,
- Drive Controller: PERC6i SAS RAID 5 with PCIe 256 MB cache,
- Hard Drives: 2x72 GB, 15k RPM serial SCSI drives, 3 Gbps, 3.5 inch, Hotplug,
- CD-ROM: DVD +/-RW SATA Drive, internal
- Video Card: Three (3) PCIe x16 dual link DVI video cards with 1024 MB GDDR3 or better memory each,
- Video Adaptor: 3D, SGVA,
- Network: Dual-port Gigabit Network Adaptor with TOE, PCIe-4, and
- Operating System: Microsoft Server 2008 Release 2 with Service Pack 2, Standard Edition and 5 CALs, and Microsoft SQL 2008 Standard Edition.

Provide an ITS communications server meeting the following minimum requirements:

- Processor: Quad core Intel Xeon L5560 or better at 2.8 GHz or greater, 8MB cache at 1333 MHz,
- Memory: Minimum 4 GB, single ranked UDIMMS for two processors at 1333 MHz,
- Power Supply: Redundant power supplies with separate cords,
- Drive Controller: Internal PERC6i SAS RAID 6 with RAID 1 OS, 2x4 connectors, PCIe, 256 MB cache,
- Hard Drives: Raid 6 with 4x 146 GB, 15k RPM serial attached SCSI drives, 3 Gbps 3.5 inch, Hotplug,
- CD-ROM: DVD +/-RW SATA Drive, internal,
- Video Card: Integrated video chipset controller 8 MB SD RAM including 3D 60 MHz memory, 480 MB/s memory bandwidth and DirectX 5.0,
- Video Adaptor: 3D, SGVA,
- Network: Dual-port Gigabit Network Adaptor with TOE, PCIe-4, and
- Embedded Management: iDRAC6 Express, and
- Operating System: Microsoft Server 2008 Release 2 with Service Pack 2, Standard Edition and 5 CALs, and Microsoft SQL 2008 Standard Edition.

Provide an ITS backup server for archiving data meeting the following minimum requirements:

- Processor: Quad core Intel Xeon L5506 or better at 2.13 GHz or greater, Memory: Minimum 6 GB, 1333 MHz,
- Backplane: 1x6 backplane for 3.5 inch drives,
- Power Supply: Redundant power supplies with separate cords,
- Drive Controller: PERC6i SAS RAID 5with RAID 1 OS,
- Hard Drives: Raid 5 with 4x1 TB, 7.2k RPM SAS drives, 3.5 inch, Hotplug,
- CD-ROM: DVD +/-RW SATA Drive, internal,Video Card: Integrated video chipset controller 8 MB SD RAM including 3D 60 MHz memory, 480 MB/s memory bandwidth and DirectX 5.0,
- Video Adaptor: 3D, SGVA,
- Network: Dual-port Gigabit Network Adaptor with TOE, PCIe-4, and
- Embedded Management: iDRAC6 Express.

(3) Physical Features

Provide rack-mounted ITS servers for proposed enclosed 19-inch communications rack located in the TMC Server Room and the TMC. Provide servers with a maximum size of three RUs.

Provide servers meeting the minimum following power requirements:

- Power supply: 110-130 VAC.
- Power consumption: Typical 700-900 W per power supply.

Provide servers meeting the following data port requirements:

- Serial: One standard serial port,
- Audio: Three jacks – channel out, line in, and microphone.
- Ethernet: Dual 1000 Base T Ethernet with RJ-45 connectors as described above and
- USB port: Six USB 2.0 ports.

Provide servers with at least one direct 10/100 Base T Ethernet LAN interface. The network connector shall be RJ-45 for Category 5e UTP for interfacing with the signal system's Gigabit Ethernet core switch.

(B) Computer Workstations

(1) Functional

Provide computer workstations that can operate the signal system software and the video control software over an Ethernet network in City Hall and the Signal Shop.

(2) Performance

Provide computer workstations meeting the following requirements:

- Processor: Quad core Intel Xeon L5405 processor at 2.3 GHz or greater, 2x6MB cache, L2 cache at 1333 Mhz,
- Memory: 4 GB Dual Channel DDR2 ECC SDRAM, 667 Mhz,

- Network: 10/100/1000 Base T Ethernet with RJ-45 connector,
- Hard Drive Controller: C1, All SATA drives, non-RAID,
- Hard Drive: 250 GB SATA, 3.0 Gbp/s, operating at 7200 RPM, 8 MB data burst cache,
- CD-ROM: 16X DVD and 16x DVD+/- RW,
- Keyboard: PS/2 104-key model,
- Mouse: Three-button optical mouse with center scroll,
- Sound: 16-bit integrated audio with external speakers,
- Video Card: 512 MB PCIe with dual DVI video outputs,
- Video Output: RGB and DMI connector,
- Desktop Monitor: Dual 20-inch, digital flat panel display, 27 dpi, SXGA and DVI ports,
- Desktop Monitor Resolution: 1,600 x 1,600 dpi,
- Desktop Monitor Color: 16.7 million colors,
- Operating System: Windows 7 Professional, latest version, and
- Application software: Enterprise version of Norton antivirus software compatible with City requirements, and DVD burning software.

For the workstation in the TMC, provide an HDMI cable between the workstation and one of the wall monitors that will permit the display of content from the operator's workstation.

For the workstation in the Signal Shop, provide two dual video output cards to drive the workstation monitor and two wall monitors as follows:

- Video Card: PCIe x 16 dual link DVI video cards with 1024 MB GDDR3 or better memory each.

(3) Physical Features

Provide computer workstations meeting the minimum power requirements:

- Input voltage: 90-135 V at 50/60 Hz,
- Output wattage: 460 W, and
- Heat Dissipation: 93.1 BTU/hour (fully loaded computer without monitor).

Provide computer workstations meeting the minimum port requirements:

- Serial: One standard serial port,
- Parallel: One parallel port,
- Keyboard: One 6-pin mini-DIN connector or use USB connection,
- Mouse: One 6-pin mini-DIN connector or use USB connection,
- Audio: Miniature phone jacks – line out, line in, and microphone,
- Ethernet: 10/100 Base T Ethernet with RJ-45 connector, and
- USB Port: Six USB 2.0 ports.

Equip all computer workstations with at least one direct 10/100 Base T Ethernet LAN interface. The network connector shall be RJ-45 for Category 5e or 6 UTP for interfacing with the Gigabit Ethernet core switch.

(C) Laptop Computers

(1) Functional

Provide laptop computers that can operate the signal system software and the video control software over an Ethernet network in City Hall and the Signal Shop.

(2) Performance

Ensure that the laptop computers meet the following requirements. Ensure that the laptops have the capability to be networked with ITS LAN via an Ethernet cable connection through the Gigabit Ethernet core switch located in the TMC and over the Internet. Configure the laptop computers for connection anywhere in the network to facilitate maintenance and troubleshooting activities.

- Processor: Intel dual core Xeon T8300 at 2.4 GHz or greater, 2x6MB cache processor, L2 cache at 800 Mhz,
- Memory: 2 GB DDR2 using 2x1 GB, 667 MHz,
- Network: Integrated 10/100/1000 Base T Ethernet with RJ-45 connector, 802.11g wireless LAN card,
- Hard Drive Controller: C1, All SATA drives, non-RAID,
- Hard Drive: 250 GB SATA operating at 4,200 RPM,
- CD-ROM: 8X DVD+/-RW combo drive,
- Keyboard: 104 key model,
- Mouse: 2 three-button optical mice,
- Audio: Miniature phono jacks – line out, line in, and microphone
- Sound: Integrated audio with external speakers,
- Modem: 3G Data/Fax card,
- Video Adaptor: 4X AGP with 128 MB DDR video,
- Internal Monitor: 14.1-inch, 27 dpi, XGVA,
- Operating System: Windows 7 Professional, latest version,
- Application software: Enterprise version of Norton antivirus software compatible with City requirements, and DVD burning software, and
- Other Accessories: Two AC adaptors per laptop, spare battery and nylon travel bag.

(3) Physical Features

Ensure that the laptop computers operate on an input voltage of 90 to 135 VAC at 50/60 Hz. Provide laptop computers meeting the following minimum port requirements:

- Parallel: One parallel port,
- Keyboard: One 6-pin mini-DIN connector or use USB connection,
- Mouse: One 6-pin mini-DIN connector or use USB connection,
- Audio: Three jacks – channel out, line in, and microphone,
- Ethernet: 10/100 Base T Ethernet with RJ-45 connector, and
- USB Port: Two USB 2.0 ports.
- Monitor: Anti-glare screen (for outdoor use in sunlight)

Equip the laptop computers with at least one direct 10/100 Base T Ethernet LAN interface. Ensure that the network connector is an RJ-45 for Category 5e UTP to interface with the Gigabit Ethernet core switch.

(D) KVM Switch

(1) Functional

Provide keyboard-video-mouse (KVM) assembly that can access and provide operator interface for at least six (6) servers.

(2) Performance

Provide KVM meeting the following requirements:

- Meets EIA-310C & IEC-3 specifications,
- The KVM assembly shall include KVM switch, keyboard, flat screen display, and associated cabling,
- Port selection by pushbuttons, on-screen display, or hot keys,
- Active port status LEDs,
- Administrative and user assignable rights,
- IP addressable,
- Compatible with Windows 7 Professional and Windows Server 2008,
- Support video resolution up to 1,600 x 1,200 at 75 Hz, and
- Servers: Minimum of six.

(3) Physical Features

Furnish a KVM switch meeting the following material requirements:

- Monitor: 17-inch, TFT 1,280 x 1,024, 27 dpi, SGVA, LCD, folding rack-mounted, contrast ratio of 350:1, frame rate of 60Hz (typ), 75Hz (Max),
- Keyboard: 104 key model,
- Mouse: PS/2, three-button optical mouse,
- KVM switch: Rack-mounted, maximum 2 RU size,
- Cabling: All power, keyboard, mouse and display cabling between each server and the KVM assembly; and mounting brackets, and
- Power Supply: 120 VAC.

(E) UPS

(1) Functional

Provide UPS units that produce uninterruptible power and power conditioning for the computers workstation in both the TMC and the Signal Shop.

Each UPS shall provide adequate capacity to run its respective workstation and monitor(s) without commercial power for twenty minutes. For the workstation in the Signal Shop, the UPS shall also supply power to the managed Ethernet switch. Provide load calculations for each configuration of equipment connecting to a UPS.

(2) Performance

Provide UPS meeting the following performance requirements:

- Output voltage distortion: less than 5 percent,
- Nominal input voltage: 120V,
- Nominal output voltage: 120V,
- Input frequency: 50/60 Hz ±3Hz, auto-sensing,
- Output frequency (sync to mains): 57-63 Hz for 60 Hz nominal frequency,
- Waveform type: Sine wave, and
- Noise filtering: Full time multi-pole noise filtering shall meet 0.3% IEEE surge let-through; zero clamping response time shall meet UL 1449.

Verify that the UPS meets all specifications and is capable of performing all of its functions during and after being subjected to:

- Operating temperature: 0-104° F,
- Operating relative humidity: 95 percent,
- Storage temperature: 5-113° F, and
- Storage relative humidity: 95 percent.

(3) Physical Features

Supply each UPS unit with twenty-five (25) percent spare outlets. Ensure that the UPS meets the following material requirements:

- Floor mounted for the TMC workstation and rack-mounted for the Signal Shop workstation,
- Sealed AGM type, maintenance free batteries,
- USB interface port,
- Status Lights: power on, power source and overload,
- Alarms: audible and remote notification, and
- Manual power on/off switch.

Supply UPS unit with multi-pole noise filtering. Ensure that the UPS remote monitoring software performs the following functions:

- Data logging,
- Event logging,
- Fault notification,
- Unattended system shutdown,
- Hibernation,
- Operating system shutdown, and
- Power event summary.

(F) Printer

Furnish a color laser printer with the following features:

• Memory:	Minimum of 16 MB of RAM,
• Communications:	Ethernet 10/100 Base-T network card with RJ-45 connector, bi-directional IEEE 1284 ECP-compliant parallel interface, and one (1) open EIO expansion slot,
• Typefaces:	Latest version of Windows print typefaces,
• Printer Language:	PCL 6 with commands for fully integrated HP-GL/2 vector graphics and advanced imagery/special effects printing with a minimum of 80 internal and scaleable fonts,
• Printer Speed:	17 pages per minute (ppm) for both color and black and white prints,
• Paper Tray Capacity:	1,100 sheet capacity, and
• Tray Sizes:	8.5 x 11 inch, 8.5 x 14 inch, and 11 x 17 inch.

34.3. CONSTRUCTION REQUIREMENTS

(A) General

Receive approval for the System Design Report described in these Project Special Provisions before submitting products submittal data, purchasing, installing and configuring the computer and communications hardware at each facility. Implement the plan upon approval.

Integrate all servers, workstations, laptops, and printers on the ITS LAN so all applications will be fully functional. Install the operating system, software and antivirus software to the City IT standards.

Furnish all tools, equipment, materials, supplies, and manufactured hardware, and perform all operations and equipment integration necessary to provide a complete, fully operational network. Mount all equipment as shown in plans in enclosed 19" communications racks. All cabling shall be:

- Neatly tagged with permanent labels at both ends of every cable,
- Secured with wire ties and cable management hardware in the communications racks, and
- Grounded to rack grounding hardware.

Ensure that all project IP addresses are assigned as defined in the System Design Report. Ensure the as-built documentation includes the identification of all IP addresses and VLANs, and associated hardware devices and device locations.

(B) ITS Servers

Install the ITS servers in the proposed enclosed 19-inch communications rack located in the TMC Server Room. Install the software packages described in these Project Special Provisions.

Install all software necessary to support the signal system software and to meet all of the data communications requirements described in these Project Special Provisions, including once-per-second polling of all traffic signal controllers.

Connect the ITS servers to the Gigabit Ethernet core switch. Plug power supplies into outlets on separate circuits. Connect network cables. Connect servers to KVM switch. Power up and run diagnostics.

Configure the ITS LAN for remote access through the firewall with remote access software for up to four laptop licenses.

(C) Computer Workstation

Install the computer workstations in locations as shown in the Plans. Install the client software packages described in these Project Special Provisions.

Connect the TMC operator's workstation to a wall monitor to display content from the workstation desktop on the wall. Use an HDMI cable. Configure the monitor and remote to permit the operator to select the video source.

Perform the following operational tests for each computer component in accordance with the test plans. After the equipment has been installed, perform the following:

- Connect all components (displays, mice, keyboards, printers, network cables, power supplies),
- Install all software required in these Project Special Provisions,
- Configure network communications,
- Map network drives and printers,
- Run diagnostic utilities on the hardware, and
- Print test pages for each workstation on each printer to verify printer configuration.

(D) Laptop Computers

Install the laptop computers with supporting hardware in the TMC and in the Signal Shop.

Perform the following operational tests for each computer component in accordance with the test plans. After the equipment has been installed, perform the following:

- Connect all components (displays, mice, keyboards, printers, network cables, power supplies),
- Install all software required in these Project Special Provisions,
- Configure network communications,
- Map network drives and printers,
- Run diagnostic utilities on the hardware, and
- Print test pages for each laptop on the printer to verify printer configuration.

(E) KVM Switch

Install the KVM assembly in the enclosed 19-inch communications rack.

After the KVM assembly has been installed, perform the following operational tests on the KVM assembly in accordance with the test plans:

- Connect <u>all</u> servers, monitors, keyboards, mice, and power supplies,

- Program the on-screen display to assign ports and bank numbers and to enter the names of each server in the menu,
- Program the KVM switch for scan features and access privileges, and
- Select each server and ensure the mouse and keyboard work the selected server and the monitor displays the appropriate server.

(F) UPS

Install the UPS unit in the TMC in City Hall as close as possible to the TMC workstation. Mount the Signal Shop UPS unit inside the wall-mounted enclosed communications rack inside the Traffic Signal Supervisor's office as shown in the Plans.

Connect the UPS unit to a power outlet. Connect the UPS monitoring port to a USB port of its respective workstation.

Install the UPS monitoring software on the workstations in both the TMC and the Signal Shop for remote monitoring of the respective units. Run the UPS diagnostics. Configure the remote monitoring to send email alerts.

(G) Printer

Install a color laser printer in the TMC as directed by the Engineer. Coordinate the location with the City. Connect the printer to the Ethernet network, setup laptops and workstations on the network to use the printer and print a test page from each printer and laptop.

(H) Existing Equipment

Remove all existing servers, computers, monitors, and associated support equipment. Deliver all servers, workstations and flat screen monitors to the City. Dispose of all other equipment.

34.4. DOCUMENTATION

Furnish the Department two copies of the following materials prior to acceptance: installation, operation, training and troubleshooting manuals, wiring diagrams, including cable pinouts, parts lists, warranty materials, and serial and model numbers of all equipment furnished. Furnish all software and operating system on CD or DVD with original license information registered to the City of Rocky Mount.

34.5. WARRANTY

Provide a minimum of three-year manufacturer's warranty to guarantee the materials supplied are free of defects and workmanship. The manufacturer's warranty period starts upon the date of final acceptance.

34.6. MEASUREMENT AND PAYMENT

ITS server will be measured and paid as the actual number of ITS servers furnished, installed, and accepted.

Computer workstation will be measured and paid as the actual number of computer workstations with UPS furnished, installed, and accepted.

Laptop computer will be measured and paid as the actual number of laptop computers furnished, installed, and accepted.

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

Printer will be measured and paid as the actual number of printers furnished, installed, and accepted.

No separate measurement will be made for coaxial cables, communication cables, electrical cables, mounting hardware, nuts, bolts, brackets, connectors, risers, grounding equipment, or surge suppression, as these will be considered incidental to the pay items for ITS server, laptop and workstation computer, and KVM switch.

No separate measurement will be made for UPS units supplied with each workstation computer. The UPS units for workstation computers will be considered incidental to the pay items for workstation computers.

No measurement and payment will be made for removal of existing computer hardware and peripherals and existing communications hardware in the TMC and Signal Shop as such work will be considered incidental to furnishing and installing computer hardware and peripherals and communications hardware at those two locations.

Payment will be made under:

Pay Item	Pay Unit
ITS Server	Each
Computer Workstation	Each
Laptop Computer	Each
KVM Switch	Each
Printer	Each

35. COMMUNICATIONS HARDWARE

35.1. DESCRIPTION

Furnish and install or furnish only as noted below all equipment described below for a fully functional Gigabit Ethernet network for communication to the signal system and CCTV.

(A) Gigabit Ethernet Core Switch

Furnish and install a central Layer 3 Gigabit Ethernet core switch (hereafter "core switch") along with an Ethernet patch panel for the TMC. Ensure that the core switch provides Gigabit Ethernet connectivity at transmission rates of 1000 megabits per second (Mbps).

(B) Firewall

Furnish and install firewall appliances in the TMC to provide network security from Internet-based traffic, as well as to provide an IPsec Virtual Private Network (VPN) connectivity.

(C) Managed Ethernet Switch

Furnish and install managed Ethernet switches for use in the TMC and Signal Shop. Ensure that the managed Ethernet switch provides wire-speed, Ethernet connectivity at transmission rates of 1000 megabits per second to/from each device on the switch to the core switch.

(D) Ethernet Edge Switch

Furnish and install a hardened, field Ethernet edge switch (hereafter "edge switch") for field devices. Ensure that the edge switch provides wire-speed, Ethernet connectivity at transmission rates of 100 megabits per second from each remote ITS device location to the core switch.

(E) UPS

Furnish and install rack-mounted uninterruptible power supply (UPS) units for the core switch and servers in the Server Room and in the TMC. Each UPS shall also include any ancillary equipment or incidental items, such as required mounting hardware and cabling. Furnish and install monitoring software to provide email alerts.

Furnish all materials with the most recently developed and approved product versions that meet or exceed all applicable standards, specifications, and requirements before the system is considered for acceptance. Size the UPS to provide at least 20 minutes of UPS power. Provide the UPS a 25% reserve of receptacles. Provide load calculations for each configuration of equipment connecting to a UPS.

(F) Network Management Software

For the communications network, utilize network management software (NMS) for configuration, troubleshooting, security, and system monitoring. The software shall be furnished and installed by the Contractor from the same manufacturer as the core switch and edge switches. The Contractor shall perform the initial system integration of all core and edge switches installed on the project.

Install the network management software on all relevant communications hardware, including workstations, laptops and servers, as recommended by the manufacturer's instructions. Ensure that the network management software is compatible with all elements of the network, including the core switch, edge switch, workstations, laptops, and servers. Ensure the system meets the minimum technical requirements and is capable of handling expansion within the ITS

network. Ensure that the software manages third party switches and hardware via Simple Network Management Protocol (SNMP) v1 or v3.

Provide system that has a graphical user interface (GUI) for the operator and shall graphically depict the equipment and maintenance/operational status using a graphical map of the system. Include setup and diagnostic utility software for both the server and client computers (licenses to be provided by the Contractor). Ensure that the system is interoperable with all end-to-end communications elements (video encoder, edge switch, core switch, and video decoder that connect each CCTV camera to analog and digital video monitors.

35.2. MATERIALS

(A) General

Ensure that the Ethernet switches are fully compatible and interoperable with the trunk Ethernet network interface and that the Ethernet switches support half and full duplex Ethernet communications.

Furnish Ethernet switches that provide 99.999% error-free operation, and that complies with the Electronic Industries Alliance (EIA) Ethernet data communication requirements using single-mode fiber-optic transmission medium and copper transmission medium. Ensure that the Ethernet switches have a minimum mean time between failures (MTBF) of 10 years, or 87,600 hours, as calculated using the Bellcore/Telcordia SR-332 standard for reliability prediction.

Provide all SMFO jumpers required to connect the core switch, managed Ethernet switches, and Ethernet edge switches with the connector panels of fiber-optic splice centers. Provide SMFO jumpers with factory-assembled PC-ST connectors one end (i.e., the fiber-optic interconnect center/connector housing end) and, on the other end, factory-assembled connectors of the same type provided on the core switch, manage Ethernet switch and Ethernet edge switch. Provide SMFO jumpers that are a minimum of 3 feet in length Ethernet switches inside controller cabinets, CCTV cabinets, the Headquarters Fire Station and the Signal Shop. Furnish SMFO jumpers that are a minimum of 6 feet in length for the communications racks inside the TMC Server Room. Ensure SMFO jumpers meet the operating characteristics of the SMFO cable with which it is to be coupled.

(B) Core Switch

(1) Standards

Provide a core switch that complies with the following IEEE networking standards for Ethernet communications:

- IEEE 802.1D Spanning Tree Protocol (STP),
- IEEE 802.1P Quality of Service (QoS),
- IEEE 802.1Q Virtual Local Area Networks (VLAN Tagging),
- IEEE 802.1S Multiple Spanning Tree Protocol (MSTP),
- IEEE 802.1X Port-Based Network Access Control,
- IEEE 802.1W Rapid Spanning Tree Protocol (RSTP),
- IEEE 802.3X Flow Control,
- IEEE 802.3Z Standards Compliant 1000 Base-SX and 1000 Base-LX optics,
- IEEE 802.3ad Link Aggregation,
- RFC 821 – Simple Mail Transfer Protocol,

- RFC 854 – Telnet Protocol Specification,
- RFC 1112 – IGMP v1,
- RFC 2131 – Dynamic Host Configuration Protocol for IPv4,
- RFC 2236 – IGMP v2,
- RFC 3315 – Dynamic Host Configuration Protocol for IPv6 (DCHCPv6),
- RFC 3376 – IGMP v3,
- RFC 2362 – Protocol Independent Multicast Sparse Mode (PIM-SM),
- RFC 3973 – Protocol Independent Multicast Dense Mode (PIM-DM),
- RFC 2328 – Open Shortest Path First (OSPF) v2,
- RFC 2338 – Virtual Router Redundancy Protocol (VRRP),
- RFC 2570:2575 – SNMP v3,
- RFC 2030 – Simple Network Time Protocol (SNTP), and
- RFC 2267 – Denial of Service (DoS).

Ensure that the core switch has a minimum mean time between failures (MTBF) of 10 years, or 87,600 hours, as calculated using the Bellcore/Telcordia SR-332 standard for reliability prediction.

(2) Physical Features

Physical: Provide a core switch that is rack mountable into a standard 19-inch EIA rack and not exceed 15 RU in height. Provide all mounting kits, brackets, and hardware for mounting into a standard 19-inch rack.

Power Supply: Provide the core switch that is equipped with auto-sensing, auto-switching primary and redundant power supplies. Ensure that the design and construction of the core and switch permits swapping of the power supplies while the switch is running without opening the chassis and that the removal of one of the power supplies shall not interrupt switch operation and outputs of video decoders (hot-swappable).

Chassis Fan Assembly: Equip the core switch with at least one cooling fan assembly per power supply to cool the CPU, main memory, and voltage regulators. Ensure that the fan has sufficient capacity and airflow to cool the switch.

(3) Electrical Specifications

Ensure that the core switch operates and power is supplied with 115 volts of alternating current (VAC) at 60 Hz input frequency. Ensure that the core switch has a minimum operating input of 110 VAC and a maximum operating input of 130 VAC. Ensure that if the device requires operating voltages other than 120 VAC, supply the required voltage converter. Ensure that the maximum power consumption does not exceed 1500 watts for the core switch. Ensure that the core switch and GBICs have diagnostic light emitting diodes (LEDs), including link, TX, RX, speed (for Category 5e ports only), and power LEDs.

(4) Functional

Provide a core switch that is capable of a minimum 160 Gbps total switching capacity. Ensure the core switch complies with the EIA's Ethernet data communication requirements using a single-mode fiber-optic transmission media; and Category 5e copper transmission media.

Provide a chassis-type design with a minimum of eight slots that meets the following minimum requirements:

Power:

- Redundant power supplies,
- Hot swappable,
- 110 VAC single phase power source,
- Switch fabric / processor, and
- Redundant switch fabric modules.

I/O:

- Minimum of four (4) I/O slots,
- Ethernet single mode fiber-optic blades shall support a minimum of 24 ports per blade at full wire speed with support for Standard (10 km) and Long Haul (70+ km) optics, and
- Ethernet copper blade shall support a minimum of 24 ports per blade at full wire speed.

Security Features:

- IEEE 802.1X – RADIUS Authentication,
- TACACS+,
- Secure Shell (SSH v2),
- Access Control List (ACL), and
- Denial of Service (DoS) Protection.

Ports: Provide auto-negotiation circuitry that automatically negotiates the highest possible data rate and duplex operation possible with attached devices supporting the IEEE 802.3 Clause 28 auto-negotiation standard.

Optical Ports: Ensure that all single mode fiber-optic link ports operate at 1310 or 1550 nanometers. Include Type SC or LC connectors, as specified in the Plans or by the Engineer. Do not use mechanical transfer registered jack (MTRJ) type connectors. Provide 36 fully functional single mode fiber-optic ports with optics installed in the core switch. Ensure that each optical port shall consist of fiber pairs; one fiber will transmit (TX) data and one fiber will receive (RX) data. Provide GBICs or small form-factor plug-able (SFP) ports that are capable of transmitting data at 100 Mbps and are user-configurable with 10 km or 25 km optics. For the link between the TMC and the Signal Shop, provide GBICs or small form-factor plug-able (SFP) ports.

Provide 10/100 Mbps optical ports that consist of fiber pairs; one fiber will transmit (TX) data and one fiber will receive (RX) data. Provide optical ports that meet the following minimum requirements:

- Optical receiver sensitivity: -21 dBm,
- Optical transmitter power: -4 dBm,
- Maximum transmission distance: 25 km, and
- Operating wavelength: 1310 nm.

Provide 10/100/1000 Mbps optical ports that consist of fiber pairs; one fiber will transmit (TX) data and one fiber will receive (RX) data. Provide optical ports that meet the following minimum requirements:

- Optical receiver sensitivity: -20 dBm,
- Optical transmitter power: -9.5 dBm,
- Maximum transmission distance: 10 km, and
- Operating wavelength: 1310 nm.

Copper Ports: Provide 24 fully functional copper ports installed in the core switch. Provide copper ports that are Type RJ-45 and that auto-negotiate speed (i.e., 10/100/1000 Base) and duplex (i.e., full or half). Ensure that all 10/100/1000 Base TX ports meet the specifications detailed in this section and are compliant with the IEEE 802.3 standard pinouts. Ensure that all Category 5e unshielded twisted pair/shielded twisted pair network cables are compliant with the EIA/TIA-568-A standard.

Ensure that the core switch (10/100/1000 Mbps ports) supports jumbo frames and full Layer 3 routing. Ensure that the switch includes support for dynamic IP routing protocols such as RIPv1/v2 and OSPF, and support for multicast routing, including PIM-SM, PIM-DM, and DVMRP.

Port Security: Supply a core switch that supports/complies with the following (remotely) minimum requirements:

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

(5) Management Capabilities

Ensure that the core switch includes management capabilities, as defined in the following:

- Have a non-blocking architecture,
- Route and switch unicast and multicast traffic simultaneously at wire speed,
- Support fully redundant load sharing and hot swappable power supplies (N+1 support),
- Incorporate an internal temperature sensor capable of sending system log and/or SNMP traps should the switch exceed a specified warning level,
- Support automatic powering off should the temperature exceed a specified level to prevent damage to the switch,
- Support port mirroring and monitoring to aid in troubleshooting,
- Be capable of utilizing the following standard protocols:
  - Support VLAN (IEEE 802.1Q),
  - Support Rapid Spanning Tree Protocol (IEEE 802.1W),
  - Support IGMP Versions 1 and 2 (RFC 1112 and 2236),
  - Support RIP Versions 1 and 2 (RFC 1058 and 1723),
  - Support OSPF Version 2 (RFC 1583 and 2328),
  - Support PIM (SM & DM),
  - Support IGMP Version 1 and 2 (RFC 1112 and 2236),
  - Support DVMRP,

- Support VRRP (RFC 2338),
- Support ToS/DSCP mapping to priority queue,
- Support QoS queue management using weighted round robin (WRR) and strict priority (SP),
- Support 10/100/1000 BaseTX ports (RJ-45),
- Support a minimum of (2) 10-Gigabit Ethernet ports per blade,
- Support Flow Control (IEEE 802.3x),
- Support Gigabit Ethernet (IEEE 802.3z),
- Support SNMP Version 1 and 3,
- Support 4 groups of RMON-I (Groups 1-3, 9),
- Be managed through console (RS-232), telnet, and Web interface, and
- Support download and upload of images and configurations via TFTP.

Ensure that the core switch fully supports all Layer 2 and Layer 3 management features related to multicast data transmission and routing, including, but not be limited to:

- An STP healing/convergence rate that meets or exceeds specifications published in the IEEE 802.1 D standards.
- An RSTP healing/convergence rate that meets or exceeds specifications published in the IEEE 802.1w standard.
- A core switch that is a port-based VLAN and supports VLAN tagging that meets or exceeds specifications as published in the IEEE 802.1Q standard.
- A multicast forwarding database that supports a minimum of 2048 entries in hardware.
- A forwarding/filtering rate that is a minimum of 14,880 packets per second for 10 megabits per second and 148,800 packets per second for 100 megabits per second.
- Support of Traffic Class Expediting and Dynamic Multicast Filtering.
- Support of, at a minimum, Version 2 of the Internet Group Management Protocol (IGMP).
- Support of remote and local setup and management via telnet or secure Web-based GUI and command line interfaces.
- Support of the SNMP. Verify that the core switch can be accessed using the resident EIA-232 management port, a telecommunication network, or the Trivial File Transfer Protocol (TFTP).
- Port security through controlling access by the users. Ensure that the core switch has the capability to generate an alarm and shut down ports when an unauthorized user accesses the network.
- Support of remote monitoring (RMON-I) of the Ethernet,
- Support of the TFT-and the SNTP. Ensure that the core switch supports port mirroring for troubleshooting purposes when combined with a network analyzer.

(6) Environmental Specifications

Supply core switch that adheres to the following environmental constraints:

- Operating Temperature Range: 32° F to 104° F,
- Storage Temperature Range: 14° F to 158° F, and
- Operating Relative Humidity Range: 10% to 95%, noncondensing.

(C) Firewall

(1) Standards

Ensure that the firewall appliances comply with all applicable IEEE networking standards for Ethernet communications, including but not limited to:

- RFC 854: Telnet Protocol Specification.
- RFC 4271: Border Gateway Protocol (BGP).
- RFC 2328: Open Shortest Path First (OSPF).
- RFC 2338: Virtual Router Redundancy Protocol (VRRP).
- RFC 2453: Routing Information Protocol (RIP) version 2.
- RFC 2362: Protocol Independent Multicast Sparse Mode (PIM-SM).
- RFC 2236: Internet Group Management Protocol (IGMP) version 2. and
- IEEE 802.1X: Port-Based Network Access Control.

Ensure that the firewall appliances s have a minimum mean time between failures (MTBF) of 10 years, or 87,600 hours, as calculated using the Bellcore/Telcordia SR-332 standard for reliability prediction.

(2) Performance Requirements

Ensure that the firewall appliances meet the following minimum performance requirements:

- Firewall Throughput: 350+ Mbps.
- Advanced Encryption Standard (AES) VPN Throughput: 100 Mbps.
- 3DES Encryption VPN Throughput: 100 Mbps.
- Maximum Concurrent Sessions: 48,000.
- Virtual Routers: 6, and
- Security Zones: 40.

Provide sufficient memory to enable optional features such as IPS, antivirus, and antispam with no additional hardware upgrades.

(3) Functional Requirements

Ensure that the firewall appliances support the following features which shall include, but not be limited to:

- IPsec VPN Capabilities:
  - 500 Concurrent VPN Tunnels.
  - DES, 3DES, and AES.
  - MD-5 and SHA-1 Authentication.
  - Manual Key, Internet Key Exchange (IKE), IKEv2, and EAP Public Key Infrastructure (PKI) (X.509).
  - Remote Access VPN.
- Authentication:
  - Web-based Authentication.
  - 802.1X.
- Modes of Operation:
  - Layer 2 Mode.
  - Layer 3 Mode.

- Address Translation:
  - Network Address translation (NAT).
  - Port Address Translation (PAT).
  - Mapped IP (MIP) (L3 Mode).
  - Virtual IP (VIP) (L3 Mode).
- High Availability (HA):
  - Active/active – L3 mode.
  - Active/passive – Transparent & L3 mode.
  - Configuration Synchronization.
  - VRRP.
- Quality of Service / Traffic Management:
  - Guaranteed Bandwidth.
  - Maximum Bandwidth.
  - Priority Bandwidth Utilization.
- Support for optional Intrusion Prevention System (IPS) (Deep Inspection) subscription.
- Support for optional Antivirus, antispam, and web filtering subscription.
- Network Attack Detection.
- DoS and DDos Protection.
- TCP Reassembly for Fragmented Packet Protection.
- Brute Force Attack Mitigation.
- SYN Cookie Protection.
- Zone-based IP Spoofing, and
- Malformed Packet Protection.

(4) Physical Features

Copper Ports: Provide a firewall appliance that includes a minimum of six (6) Ethernet 10/100 Base-T copper ports and two (2) Ethernet 10/100/1000 Base-T copper ports. Provide Type RJ-45 copper ports that auto-negotiate speed (i.e., 10/100/1000 Base) and duplex (i.e., full or half). Ensure that all ports meet the specifications detailed in this section and are compliant with the IEEE 802.3 standard pinouts. Ensure that all Category 5e unshielded twisted pair/shielded twisted pair network cables are compliant with the EIA/TIA-568-A standard. Provide auto-negotiation circuitry that will automatically negotiate the highest possible data rate and duplex operation possible with attached devices supporting the IEEE 802.3 Clause 28 auto-negotiation standard.

(5) Electrical Specifications

Ensure the firewall appliance meets the following electrical requirements:

- Input voltage range: 110 VAC to 130 VAC, auto ranging, and
- Input frequency: 60 Hz.

Ensure that if the firewall appliances require operating voltages other than 120 VAC, supply the required voltage converter. Ensure that the maximum power consumption does not exceed 50 watts.

(6) Management Capabilities

Ensure that the firewall appliance supports all Layer 2 management features and certain Layer 3 features related to multicast data transmission and routing. These features shall include, but not be limited to:

- Support of remote and local setup and management via telnet or secure Web-based GUI and command line interfaces, and
- Support of the Simple Network Management Protocol (SNMP). Verify that the Ethernet core switch can be accessed using the resident EIA-232 management port, a telecommunication network, or the Trivial File Transfer Protocol (TFTP).

Network Capabilities: Provide a firewall appliance that supports/complies with the following minimum requirements:

- Provide full implementation of IGMP v2,
- Provide full implementation of SNMPv1, SNMPv2c, and/or SNMPv3,
- Provide full implementation of RMON I and RMON II,
- Password manageable,
- Telnet/CLI,
- HTTP (Embedded Web Server) with Secure Sockets Layer (SSL), and
- Full implementation of RFC 783 (TFTP) to allow remote firmware upgrades.

Network Security: Provide a firewall appliance that supports/complies with the following (remotely) minimum network security requirements:

- Multi-level user passwords,
- RADIUS centralized password management (IEEE 802.1X),
- SNMPv3 encrypted authentication and access security,
- Support of remote monitoring (RMON) of the Ethernet agent and the ability to be upgraded to switch monitoring (SMON), if necessary, and
- Support of the TFTP and SNTP.

(7) Environmental Specifications

Provide a firewall appliance that adheres to the following environmental constraints if located within a climate-controlled environment:

- Operating temperature range: 32 degrees F to 104 degrees F,
- Storage temperature range: 14 degrees F to 158 degrees F, and
- Operating relative humidity range: 10% to 90%, non-condensing.

(D) Managed Ethernet Switch

(1) Standards

Ensure that the managed Ethernet switches comply with all applicable IEEE networking standards for Ethernet communications, including but not limited to:

- IEEE 802.1D standard for media access control (MAC) bridges used with the Spanning Tree Protocol (STP),
- IEEE 802.1Q standard for port-based virtual local area networks (VLANs),
- IEEE 802.1P standard for Quality of Service (QoS),

- IEEE 802.1w standard for MAC bridges used with the Rapid Spanning Tree Protocol (RSTP),
- IEEE 802.1s standard for MAC bridges used with the Multiple Spanning Tree Protocol,
- IEEE 802.1x standard for port based network access control, including RADIUS,
- IEEE 802.3 standard for local area network (LAN) and metropolitan area network (MAN) access and physical layer specifications,
- IEEE 802.3ad standard for Link Aggregation Control Protocol,
- IEEE 802.3u supplement standard regarding 100 Base TX/100 Base FX,
- IEEE 802.3x standard regarding flow control with full duplex operation, and
- IEEE 802.3Z Standards Compliant 1000 Base-SX and 1000 Base-LX optics,
- RFC 821 – Simple Mail Transfer Protocol,
- RFC 854 - Telnet Protocol Specification,
- RFC 1112 – IGMP v1,
- RFC 2131 - Dynamic Host Configuration Protocol for IPv4,
- RFC 2236 – IGMP v2,
- RFC 3315 - Dynamic Host Configuration Protocol for IPv6 (DHCPv6),
- RFC 3376 – IGMP v3,
- RFC 2328 – Open Shortest Path First (OSPF) v2,
- RFC 2570:2575 – SNMP v1, v2 and v3,
- RFC 2030 – Simple Network Time Protocol (SNTP).

Ensure that the managed Ethernet switches have a minimum mean time between failures (MTBF) of 10 years, or 87,600 hours, as calculated using the Bellcore/Telcordia SR-332 standard for reliability prediction.

(2) Functional

Ensure that the managed Ethernet switches support all Layer 2 management features and certain Layer 3 features related to multicast data transmission and routing. These features shall include, but not be limited to:

- An STP healing/convergence rate that meets or exceeds specifications published in the IEEE 802.1D standard,
- An RSTP healing/convergence rate that meets or exceeds specifications published in the IEEE 802.1w standard,
- Ssupport port-based VLAN and support VLAN tagging that meets or exceeds specifications as published in the IEEE 802.1Q standard, and have a minimum 4-kilobit VLAN address table (254 simultaneous),
- A forwarding/filtering rate that is a minimum of 14,880 packets per second for 10 megabits per second and 148,800 packets per second for 100 megabits per second,
- A minimum 4-kilobit MAC address table,
- Support of Traffic Class Expediting and Dynamic Multicast Filtering,
- Support of, at a minimum, snooping of Version 2 of the Internet Group Management Protocol (IGMP),
- Support of remote and local setup and management via telnet or secure Web-based GUI and command line interfaces,

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

(3) Physical Features

Mounting: Provide rack mount managed Ethernet switches.

Optical Ports: Ensure that all fiber-optic link ports operate at 1310 or 1550 nanometers in single mode. Provide fully-functional ports with Type LC connectors and the optics for the optical ports. Do not use mechanical transfer registered jack (MTRJ) or ST type connectors.

For the Signal Shop provide a managed Ethernet switch having a minimum of two optical 10/100/1000 Base FX ports capable of transmitting data at 1000 megabits per second. Ensure that each optical port consists of a pair of fibers, one fiber will transmit (TX) data and one fiber will receive (RX) data. Provide optical ports that meet the following minimum requirements:

- Optical receiver sensitivity: -20 dBm,
- Optical transmitter power: -9.5 dBm,
- Typical transmission distance: 10 km, and
- Operating wavelength: 1310 nm.

Copper Ports: Provide managed Ethernet switches that include a minimum of twelve 10/100/1000 Base TX ports. For the TMC location provide two (2) 1000 Base TX uplink ports. Provide Type RJ-45 copper ports and that auto-negotiate speed (i.e., 10/100/1000 Base) and duplex (i.e., full or half). Ensure that all 10/100/1000 Base TX ports meet the specifications detailed in this section and are compliant with the IEEE 802.3 standard pinouts. Ensure that all Category 5e unshielded twisted pair/shielded twisted pair network cables are compliant with the EIA/TIA-568-A standard.

Port Security: Ensure that the managed Ethernet switches support/comply with the following (remotely) minimum requirements:

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

Network Capabilities: Provide managed Ethernet switches that support/comply with the following minimum requirements:

- Provide full implementation of IGMPv2 snooping (RFC 2236),

- Provide full implementation of SMTP for email alerts and events
- Provide full implementation of SNMPv1, SNMPv2c, and/or SNMPv3,
- Provide support for the following RMON–I groups, at a minimum,
  - Part 1: Statistics
  - Part 2: History
  - Part 3: Alarm
  - Part 9: Event
- Capable of mirroring any port to any other port within the switch,
- Meet the IEEE 802.1Q (VLAN) standard per port for up to four VLANs,
- Meet the IEEE 802.3ad (Port Trunking) standard for a minimum of two groups of four ports,
- Telnet/CLI,
- HTTP (Embedded Web Server) with Secure Sockets Layer (SSL), and
- Full implementation of RFC 783 (TFTP) to allow remote firmware upgrades.

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

- Multi-level user passwords,
- RADIUS centralized password management (IEEE 802.1X),
- SNMPv3 encrypted authentication and access security,
- Port security through controlling access by the users: ensure that the Ethernet edge switch has the capability to generate an alarm and shut down ports when an unauthorized user accesses the network,
- Support of remote monitoring (RMON) of the Ethernet agent, and
- Support of the TFTP and SNTP. Ensure that the Ethernet edge switch supports port mirroring for troubleshooting purposes when combined with a network analyzer.

(4) Electrical Specifications

Ensure that the managed Ethernet switches operate and power is supplied with 115 VAC. Ensure that the edge switch has a minimum operating input of 110 AC and a maximum operating input of 130 VAC. Ensure that if the device requires operating voltages other than 120 VAC, supply the required voltage converter. Ensure that the maximum power consumption does not exceed 60 watts.

Ensure that the managed Ethernet switches have diagnostic light emitting diodes (LEDs), including link, port activity, duplex mode, speed (for Category 5e ports only), and power LEDs.

(5) Environmental Specifications

Provide managed Ethernet switches that adhere to the following environmental constraints if located within a climate-controlled environment:

- Operating temperature range: -40 degrees F to 130 degrees F,
- Storage temperature range: -40 degrees F to 185 degrees F, and
- Operating relative humidity range: 5% to 90%, non-condensing.

Verify that the managed Ethernet switch manufacturer certifies their device has successfully completed environmental testing as defined in the environmental requirements section of the NEMA TS 2 standard. Verify that vibration and shock resistance meet the requirements of Sections 2.1.9 and 2.1.10, respectively, of the NEMA TS 2 standard.

(E) Edge Switch

(1) Standards

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

- IEEE 802.1D standard for media access control (MAC) bridges used with the Spanning Tree Protocol (STP),
- IEEE 802.1Q standard for port-based virtual local area networks (VLANs),
- IEEE 802.1P standard for Quality of Service (QoS),
- IEEE 802.1w standard for MAC bridges used with the Rapid Spanning Tree Protocol (RSTP),
- IEEE 802.1s standard for MAC bridges used with the Multiple Spanning Tree Protocol,
- IEEE 802.1x standard for port based network access control, including RADIUS,
- IEEE 802.3 standard for local area network (LAN) and metropolitan area network (MAN) access and physical layer specifications,
- IEEE 802.3u supplement standard regarding 100 Base TX/100 Base FX,
- IEEE 802.3x standard regarding flow control with full duplex operation, and
- RFC 821 – Simple Mail Transfer Protocol,
- RFC 854 - Telnet Protocol Specification,
- RFC 1112 – IGMP v1,
- RFC 2131 - Dynamic Host Configuration Protocol for IPv4,
- RFC 2236 – IGMP v2,
- RFC 3315 - Dynamic Host Configuration Protocol for IPv6 (DHCPv6),
- RFC 3376 – IGMP v3.

Ensure that the edge switch has a minimum mean time between failures (MTBF) of 10 years, or 87,600 hours, as calculated using the Bellcore/Telcordia SR-332 standard for reliability prediction.

(2) Functional

Ensure that the edge switch supports all Layer 2 management features and certain Layer 3 features related to multicast data transmission and routing. These features shall include, but not be limited to:

- An STP healing/convergence rate that meets or exceeds specifications published in the IEEE 802.1D standard,
- An RSTP healing/convergence rate that meets or exceeds specifications published in the IEEE 802.1w standard,
- An Ethernet edge switch that is a port-based VLAN and supports VLAN tagging that meets or exceeds specifications as published in the IEEE 802.1Q standard, and has a minimum 4-kilobit VLAN address table (254 simultaneous),
- A forwarding/filtering rate that is a minimum of 14,880 packets per second for 10 megabits per second and 148,800 packets per second for 100 megabits per second,
- A minimum 4-kilobit MAC address table,
- Support of Traffic Class Expediting and Dynamic Multicast Filtering,

- Support of, at a minimum, snooping of Version 2 of the Internet Group Management Protocol (IGMP),
- Support of remote and local setup and management via telnet or secure Web-based GUI and command line interfaces,
- Support of the Simple Network Management Protocol version 3 (SNMPv3). Verify that the Ethernet edge switch can be accessed using the resident EIA-232 management port, a telecommunication network, or the Trivial File Transfer Protocol (TFTP),
- Port security through controlling access by the users. Ensure that the Ethernet edge switch has the capability to generate an alarm and shut down ports when an unauthorized user accesses the network,
- Support of remote monitoring (RMON-I) of the Ethernet agent, and
- Support of the TFTP and SNTP. Ensure that the Ethernet edge switch supports port mirroring for troubleshooting purposes when combined with a network analyzer.

(3) Physical Features

Mounting: Provide shelf mount edge switches. Optionally, if cabinet space dictates provide mounting kit to attach the edge switch to a vertical rack rail or a DIN rail in the cabinet. If the Contractor elects to use DIN rail mounting supply the DIN rail with the edge switch.

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

Optical Ports: Ensure that all fiber-optic link ports operate at 1310 or 1550 nanometers in single mode. Provide fully-functional ports with Type LC connectors and the optics for the optical ports. Do not use mechanical transfer registered jack (MTRJ) or ST type connectors.

Provide an edge switch having a minimum of two optical 100 Base FX ports capable of transmitting data at 100 megabits per second. Ensure that each optical port consists of a pair of fibers, one fiber will transmit (TX) data and one fiber will receive (RX) data.

Provide 10/100 Mbps optical ports that consist of fiber pairs, one fiber will transmit (TX) data and one fiber will receive (RX) data. Provide optical ports that meet the following minimum requirements:

- Optical receiver sensitivity: -32 dBm,
- Optical transmitter power: -15.5 dBm,
- Typical transmission distance: 20 km, and
- Operating wavelength: 1310 nm.

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

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

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

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

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

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

- Multi-level user passwords,
- RADIUS centralized password management (IEEE 802.1X),
- SNMPv3 encrypted authentication and access security,
- Port security through controlling access by the users: ensure that the Ethernet edge switch has the capability to generate an alarm and shut down ports when an unauthorized user accesses the network,
- Support of remote monitoring (RMON) of the Ethernet agent, and
- Support of the TFTP and SNTP. Ensure that the Ethernet edge switch supports port mirroring for troubleshooting purposes when combined with a network analyzer.

(4) Electrical Specifications

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

(5) Environmental Specifications

Provide Ethernet edge switches that adhere to the following environmental constraints as defined in the environmental requirements section of the NEMA TS 2 standard if located within a climate-controlled environment:

- Operating temperature range: -30 degrees F to 165 degrees F,
- Storage temperature range: 14 degrees F to 158 degrees F, and
- Operating relative humidity range: 10% to 90%, non-condensing.

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

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

- IEEE 1613 (electric utility substations),
- IEC 6185003 (electric utility substations),
- IEEE 61800-3 (variable speed drive systems), and
- IEC 61000-6-2 (generic industrial).

(F) UPS

(1) Standards

Ensure that the UPS units comply with the following standards:

- ANSI,
- ASTM,
- CSA, and
- UL.

(2) Functional

Each UPS shall provide adequate capacity to run its respective equipment without commercial power for twenty minutes. Size the two UPS units in the TMC Server Room to split the load as equally as possible. A third UPS, located in the TMC, shall supply power to the ITS video server, test controller and managed Ethernet switch. Provide load calculations for each configuration of equipment connecting to a UPS.

Ensure that the UPS and its remote monitoring software perform the following functions:

- Remote environmental monitoring of temperature and humidity,
- Data logging,
- Event logging,
- Fault notification,
- Hibernation,
- Radius authentication,
- Protocols: HTTP, HTTPS, IPv4, IPv6, SMTP (v1-v3), Telnet, SSH v2, SSL,

- Manage all network UPS units,
- Operating system shutdown,
- Load shedding to turn off selected devices or groups of devices,
- Outlet control to turn off, reboot, or shutdown outlets,
- Power event summary,
- Recommended actions,
- Risk assessment summary,
- Run command file, and
- System event log integration.

(3) Physical Features

Supply each UPS unit described above with 25 percent spare outlets. Ensure that the UPS meets the following material requirements:

- Rack-mountable in 19-inch EIA rack,
- Sealed AGM type, maintenance free batteries,
- Minimum of nine NEMA 5-15R and two NEMA 5-20R outlets,
- NEMA L5-30P input plug,
- Ethernet network management card using 10/100 Base TX communications,
- USB interface port,
- Remote environmental monitoring of temperature and humidity with telnet management,
- Status lights: power on, power source and overload,
- Alarms: audible and remote notification,
- Manual power on/off switch, and
- Supply UPS unit with multi-pole noise filtering. Supply UPS with a terminal for connecting the UPS to a surge protection device.

(4) Environmental Specifications

Verify that the UPS meets all specifications and is capable of performing all of its functions during and after being subjected to:

- Operating temperature: 0° F to 104° F,
- Operating relative humidity: 95 percent,
- Storage temperature: 5° F to 113° F, and
- Storage relative humidity: 95 percent.

(G) Network Management Software

Provide network management software that provides configuration, troubleshooting, security and system monitoring for the ITS communications network. Ensure that the system includes the following features:

- Able to create and maintain system and user identification and passwords,
- GUI interface,
- Syslog and SNMP alarm manager,
- Distributed server support for scalable management,

- Physical and logical topology for viewing every element on the network and how it is connected,
- Fault management and alarm view to see the health and status of every element on the network,
- Configuration management for configuring multiple elements and images, perform multi-step upgrades and archive device configurations,
- HTML report generator for Web-based reports,
- Switch configuration and monitoring,
- Inventory tool for the managed devices,
- VLAN manager,
- IP/MAC Address finder,
- Administration tool,
- Abstract Type Library for adding support for future hardware and software in the field,
- Spanning Tree monitor,
- Monitoring of third-party devices,
- Support industry standard protocols such as SNMP, ANS.1, and XML,
- Handle commands from system clients via ASN.1 and/or XML-defined protocol over a standard TCP/IP connection,
- Command underlying nodes (devices such as decoders, encoders, and switches),
- Report status of system nodes and alarms,
- Monitor system node connections,
- Store recent alarms in an internal database,
- Cooperate with another server in redundant set (when working in redundant configuration),
- Receive SNMP traps generated by network infrastructure, translate SNMP traps as system alarms, and send alarms as SNMP traps,
- Support remote configuration and diagnostics, and
- Restore video and connections in case of system component restarts.

Interface: Ensure that the network management software interface meets the following requirements:

- Network interface: Any network/telecom adapter supporting MS Windows TCP/IP stack.
- Network: Microsoft TCP/IP service software must be installed and configured correctly in the project's network environment.

Furnish client-server based application that supports installed client application and browser based client.

(H) Ethernet Patch Panel

Furnish a rack-mountable 24-port Ethernet patch panel for installation in the enclosed 19-inch communications rack inside the TMC Server Room. Provide a patch panel designed for Category 5e cable and that meets TIA/EIA-568-A-5 Category 5e and ISO 11801 Class D standards. All ports shall be RJ-45 eight-wire jacks. Provide all mounting screws and mounting hardware needed to mount the patch panel in a 19-inch equipment rack.

35.3. CONSTRUCTION METHODS

(A) General

Ensure that all communications hardware is UL listed.

Verify that network/field/data patch cords meet all ANSI/EIA/TIA requirements for Category 5e four-pair unshielded twisted pair cabling with stranded conductors and RJ-45 connectors.

Receive approval for the System Design Report described in these Project Special Provisions before submitting products submittal data, purchasing, installing and configuring the computer and communications hardware at each facility.

Ensure that all project IP addresses are assigned as defined in the System Design Report. Ensure the as-built documentation includes the identification of all IP addresses and VLANs, and associated hardware devices and device locations. Configure the Ethernet network so the traffic signals and CCTV cameras are in separate VLANs.

(B) Core Switch

The core switch shall act as the central data aggregation node for the new communications network. Ensure that the core switch is capable of handling future expansion within the overall signal system and communications networks within the forecasted lifecycle of the new optical communications network. Ensure that the core switch communicates with the edge switches at Ethernet data transmission rates (100 Mbps).

Ensure that the network administrator will be able to remotely manage the core switch for switch configuration, performance monitoring, and troubleshooting. Locate the core switch in the TMC Server Room as shown in the Plans and provide full Layer 3 functionality.

Install and configure the core switch to be fully compatible with the edge switches as defined in these Project Special Provisions.

Ensure all fiber connections of the core switch are connected to two pairs of single mode fiber strands via fiber-optic interconnect center for redundant communications.

(C) Firewall

Install the firewall appliance in a rack as shown in the Plans in the TMC Server Room. Install the latest General Availability (GA) software release available from the manufacturer. Ensure all firewall appliances are running the same revision of software.

Configure a minimum of two (2) zones. Configure appropriate security policies to protect the City's internal ITS network from Internet-based attacks. Configure an IPsec VPN on each firewall to connect to NCDOT via a secure link over the Internet. This VPN connection shall be a site-to-site VPN and shall not require VPN client software. Configure remote access VPN capability to allow City staff to access the network remotely via a secure connection from the Internet. If a VPN client is required for the remote access VPN, the Contractor shall provide a sufficient number of licenses for the required client software. If a server license is required, the Contractor shall provide all licenses for the server software as well.

Furnish and install proper cables to connect the firewall to the Gigabit Ethernet Core Switch and the WAN connection. Ensure that the firewall appliance communicates with the Gigabit Ethernet Core switch at Gigabit Ethernet data transmission rates (1000 Mbps).

Ensure that the network administrator will be able to remotely manage each firewall appliance for configuration, performance monitoring, threat detection, and troubleshooting.

Install and configure the firewall appliance to be fully compatible with the Gigabit Ethernet core switch.

(D) Managed Ethernet Switches

Ensure that the ITS network administrator will be able to manage each managed Ethernet switch individually or as a group/cluster for switch configuration, performance monitoring, and troubleshooting. Note that these specifications require additional minimum management intelligence (i.e., Layer 2+) typical of most current industrial Ethernet deployments. Ensure that the managed Ethernet switches include Layer 2+ capability providing architecture standardization, open connectivity (i.e., interoperability), bandwidth management, rate limiting, security filtering, and general integration management of an advanced Ethernet switching architecture.

Ensure that all project IP addresses and VLAN IDs are assigned as defined in the System Design Report.

Mount and secure the managed Ethernet switches inside communications racks in the TMC and in the Signal Shop. Ensure that the managed Ethernet switches are fully accessible by technicians without blocking access to other equipment Verify that fiber-optic jumpers consist of a length of cable that is connectorized on both ends, primarily used for interconnecting termination or patching facilities and/or equipment. Use fiber-optic jumpers that are factory assembled and connectorized and are certified by the fiber-optic jumpers' manufacturer to meet the relevant performance standards required below. Verify that network/field/data jumper cables meet all ANSI/EIA/TIA requirements for Category 5e 4-pair unshielded twisted pair cabling with stranded conductors and RJ45 connectors.

For the TMC location, connect the managed Ethernet switch to the core switch in the Server Room and to the following items in the TMC half-rack: UPS, the video server (2 ports), 2070 test controller, and NVR. In addition, connect the managed Ethernet switch to the TMC workstation.

For the Signal Shop location, connect the managed Ethernet switch to the following items in the Signal Shop: two 2070 test controllers with conflict monitors (four ports total), test CCV cabinet, and workstation using Ethernet patch cords and to the core switch over single-mode fiber-optic cable to the Server Room.

(E) Edge Switch

Ensure that the ITS network administrator will be able to manage each edge switch individually or as a group/cluster for switch configuration, performance monitoring, and troubleshooting. Note that these specifications require additional minimum management intelligence (i.e., Layer 2+) typical of most current industrial Ethernet deployments. Ensure that the edge switch includes Layer 2+ capability providing architecture standardization, open connectivity (i.e., interoperability), bandwidth management, rate limiting, security filtering, and general integration management of an advanced Ethernet switching architecture.

Ensure that all project IP addresses and VLAN IDs are assigned as defined in the System Design Report.

Mount the edge switch inside each field cabinet by securely fastening the edge switch to the vertical rail of the equipment rack or to a shelf using manufacturer-recommended or Engineer-approved attachment methods, attachment hardware and fasteners. Ensure that the edge switch is mounted securely in the cabinet and is fully accessible by field technicians without blocking access to other equipment Verify that fiber-optic jumpers consist of a length of cable that is connectorized on both ends, primarily used for interconnecting termination or patching facilities and/or equipment. Use fiber-optic jumpers that are factory assembled and connectorized and are certified by the fiber-optic jumpers' manufacturer to meet the relevant performance standards required below. Verify that network/field/data jumper cables meet all ANSI/EIA/TIA requirements for Category 5e 4-pair unshielded twisted pair cabling with stranded conductors and RJ45 connectors.

(F) UPS

Install two UPS units in the Server Room as described above to protect the communications, applications and backup servers, firewall, KVM switch, and core switch in the enclosed communications racks as shown in the Plans. Allocate the load of the equipment to balance the load while using 120 VAC. Install one UPS in the half-rack in the TMC to protect the video server, test controller and NVR within the TMC.

Connect each UPS unit to a power outlet. Connect the UPS monitoring port to the core switch.

Install the UPS monitoring software on the ITS communications server in the TMC for remote monitoring of both units in the TMC Server Room and the UPS serving the video server. Run the UPS diagnostics. Configure the remote monitoring to send email alerts.

Plug the power strip mounted on the respective rack frame into the UPS. Plug all communications hardware into the UPS or the power strip.

(G) Network Management Software

Install the NMS server application on the ITS communications server. Configure the NMS to monitor and manage the ITS servers, and edge switches. Install software to provide access to the NMS software from the workstations and laptop computers connected to the network. Establish user access rights, designate who has administrative, manager and monitoring rights. Build the database through an automatic utility within the NMS or manually enter the data. Establish groupings of devices with like functions or features, this would include geographically related, device types, owners. Setup automatic database and configuration backups. Setup system and device alarms and alarm notifications.

Setup graphical network views. Use mapping images provided by manufacturers to geographically locate devices.

(H) Ethernet Patch Panel

Mount the Ethernet patch panel in the enclosed communications rack inside the TMC Server Room as shown in the Plans. Terminate the Ethernet cables from outside the TMC server room on the punch down block. Follow manufacturer's installation instructions for cable termination and panel assembly. Install Ethernet patch cables between the patch panel and the core switch.

35.4. MEASUREMENT AND PAYMENT

The switches include all appropriate ports, cabling, grounding, redundancies, labeling and any integration between the switches and the communications network as necessary to make a fully working installation. For furnish and install and for furnish only materials, all power supplies, power cords, adapters, mounting hardware, DIN rail mounting brackets, DIN rails, connectors, serial cables, signs, decals, disconnect switches, installation materials, and configuration software necessary to complete this work, will be included and will be incidental.

Gigabit Ethernet core switch will be measured and paid as the actual number of Gigabit Ethernet core switches furnished, installed, and accepted. No separate measurement will be made for fiber-optic ports modules. No separate measurement will be made of Ethernet patch panels as they will be considered incidental to furnishing and installing the core switch.

Firewall will be measured and paid as the actual number of firewalls furnished, installed, and accepted.

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

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

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

Network management software will be measured and paid as lump sum furnished, installed, and accepted.

UPS will be measured and paid as the actual number of rack-mounted UPS units furnished, installed in the enclosed communications racks inside the Server Room and the TMC, and accepted. No separate measurement will be made for UPS units supplied with the computer workstations in the TMC and the Signal Shop as they will be considered incidental to furnishing and installing the computer workstations.

No separate measurement will be made for SMFO jumpers, coaxial cables, communication cables, Ethernet patch cables, electrical cables, mounting hardware, nuts, bolts, brackets, connectors, risers, grounding equipment, surge suppression, or training as these will be considered incidental to the pay items listed above.

Payment will be made under:

Pay Item	Pay Unit
Gigabit Ethernet Core Switch	Each
Firewall	Each
Managed Ethernet Switch	Each
Ethernet Edge Switch	Each
Furnish Ethernet Edge Switch	Each
Network Management Software	Lump Sum
UPS	Each

36. CENTRAL VIDEO EQUIPMENT

36.1. DESCRIPTION

Furnish and install, or furnish only as noted below, video display interface units, video monitors, digital video encoders for converting analog and digital video.

Furnish and install a network video recorder (NVR) with an integrated DVD/CD writer in the TMC Server Room.

36.2. MATERIALS

(A) Digital Hardware Video Encoder (DVE) and Digital Software Decoder (DSD)

Furnish and install digital hardware video encoder hardware and digital software decoders to create a video-over-IP network system, as shown in the Plans. The video encoder units may be shelf or rack-mounted. The video decoders shall be software based and installed on the video server.

Furnish digital hardware video encoder components and digital software decoders that utilize the Moving Picture Experts Group's MPEG-4 Part 10/H.264 video compression technology in accordance with the International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) requirements detailed in the ISO/IEC 13818 and 14496-14 standards, respectively. Provide the ability for the user to select the video compression technology. Ensure that the hardware video encoder and software video decoder are capable of unicast and multicast operation, and that they support the Session Announcement Protocol (SAP) as recommended by the Internet Engineering Task Force (IETF) RFC 2974, and Differentiated Services/Quality of Service (DiffServ/QoS) software components. Ensure that the digital video encoder provides 99.999% error-free operation.

Provide a DVE that is a hardware-based network device able to accept a minimum of one analog National Television System Committee (NTSC) video input and digitize it for transport across IP networks. Use a digital video encoder that provides a minimum of two serial data interfaces for transmission of command and control data to other devices (typically camera PTZ commands), as well as console and configuration functions. Provide compatible decoder software along with the digital video encoder at no additional cost.

(1) Video Specifications

Ensure that any video input utilizes a BNC connector and delivers one-volt peak-to-peak (Vp-p) NTSC composite video signals for encoding. Ensure that the DVE and DSD operate with both color and monochrome video, and that they allow the user to select and adjust video resolution. Ensure that the DVE and DSD support resolutions that include, but are not limited to those in table below. Ensure that the MPEG-4 DVE and DSD are capable of delivering color and monochrome video at 30 fps regardless of resolution, and that they can do so using variable, programmable bit rates from 32 Kbps to 4 Mbps. Ensure that the DVE and DSD provides fixed and variable bit rate modes.

Resolution Specifications

Compression Technology	Resolution	NTSC Requirements
MPEG-4	QCIF	176 horizontal x 120 vertical
MPEG-4	CIF	352 horizontal x 240 vertical
MPEG-4	2CIF	704 horizontal x 288 vertical

Note: The resolutions attained depend on the data transmission rate.

(2) Environmental Specifications

Unless stated otherwise in the Plans, provide digital video encoders that meet all specifications during and after being subjected to an ambient operating temperature range of -30° F to 165° F as defined in the environmental requirements section of the NEMA TS 2 standard, with a maximum non-condensing relative humidity of 95 percent.

Ensure that cabinets housing system components comply with the environmental requirements detailed in the NEMA TS 2 standard. House the digital video encoder in a field cabinet with protection from moisture and airborne contaminants, blowing rain, wind, blowing sand, blowing dust, humidity, roadside pollutants, vandalism, and theft. Ensure that the digital video encoder is resistant to vibration and shock, and conforms to Sections 2.1.9 and 2.1.10, respectively, of the NEMA TS 2 standard.

(B) TMC and Signal Shop Video Display Monitor

Provide six (6) 52-inch LCD monitors that shall comprise a 3 monitor wide x 2 monitor high video wall in the TMC. Provide two (2) 32-inch LCD monitors that shall mounted side-by-side in the Signal Shop. Provide only new video monitors; do not furnish used or refurbished monitors. Furnish monitors made by the same manufacturer, regardless of whether they are being installed in the TMC or the Signal Shop. Provide the same model monitor for all monitors installed at a given location. Provide power cords for all monitors of sufficient length to plug into duplex wall receptacle adjacent to monitor mounting location.

Provide mounting brackets specifically designed for mounting the size of LCD monitors described below on both metal and wood stud walls. Provide brackets that allow vertical and horizontal tilt to optimize viewing angles. Provide brackets with locking setscrews to prevent the monitor from falling or sliding off the bracket. Provide all mounting hardware and fasteners and plywood backboard necessary for securely attaching monitor mount brackets to metal stud and wood stud walls.

Provide monitors meeting the following requirements:

- Display Type: TFT active matrix, widescreen flat panel,
- Mounting: Wall-mount,
- Pixel Pitch: 0.6 mm,
- Pixels per Inch: 42 pixels at native resolution,
- Resolution: 1,920 x 1,080 dpi,
- Colors: Minimum 16.7 million colors,
- Horizontal Scanning Frequency: >85 kHz,

- Vertical Scanning Frequency: 50-86 Hz,
- Response Time: 6 ms,
- Contrast Ratio: 1000:1,
- Aspect ratio: 16:9,
- Viewing Angle (Horizontal): 178 degrees,
- Viewing Angle (Vertical): 178 degrees,
- Brightness: 500 cd/m^2, and
- Signal Compatibility: VGA to UXGA, and
- HDTV Supported Formats: 480i, 480p, 575i, 575p, 720p, 1035i, 1080i, 1080p,
- Digital Inputs: DisplayPort, HDMI, and DVI-D
- Analog Inputs: HD-15 VGA in, RGB. BNC composite, RCA component and S-video,
- Audio Inputs: RCA Audio, stereo mini-jack, DisplayPort audio, HDMI audio, and
- External Control: RS-232 and infrared remote.

Provide DVI-D video cables with the monitors to reach from the video server outputs in the TMC to the wall monitors in the TMC. Provide DVI-D cables and connectors meeting the following requirements:

- Cable: Individually insulated, 28 AWG copper conductors,
- Connectors: 24x1 pin male on both ends,
- Pins: Gold Plated,
- Maximum Resolution: 1920x 1200,
- Bit Rate: 24-bit, and
- Bandwidth Rating: 9.9 Gbps.

(C) Headquarters Fire Station Video Display Monitor

Provide two (2) 40-inch LCD monitors each with built-in on-board computer for conveying railroad crossing preemption status. Ensure that both monitors are made by the same manufacturer and are the same model. Provide power cords for all monitors of sufficient length to plug into duplex wall receptacle adjacent to monitor mounting location.

Provide mounting brackets specifically designed for mounting the size and weight of LCD monitors described below on masonry walls. Provide brackets that both tilt and swivel to permit adjustment of both vertical and horizontal viewing angles. Furnish brackets that provide incremental forward tilt adjustment up to 30 degrees and swivel at least 45 degrees horizontally. Provide brackets with locking setscrews to prevent the monitor from falling or sliding off the bracket. Provide all mounting hardware and fasteners and wall anchors necessary to securely attach monitor mounting brackets to concrete block wall inside truck bays of Headquarters Fire Station and designed to support the weight of the monitors provided plus the weight of the mounting brackets.

Prior submitting the catalog cuts and shop drawings for the brackets to the Engineer for review and approval and before ordering and purchasing the mounting brackets, visit the Headquarters Fire Station to field investigate the proposed mounting locations and confirm the desired mounting height and position with Fire Department personnel. Contact Mike Varnell, Assistant Fire Chief, and Wiley Lewis, Fire Engineer, at (252) 972-1491 at least 14 days in

advance to schedule the site visit. During the site visit, hold a single sheet of poster board, cardboard, foam-core board or Corplast cut to the dimensions of the proposed video monitors in the approximate position of the monitors as shown in the Plans. Have a driver(s) of the fire apparatus sit in the driver's seat of all the vehicles parked in the truck bays to help "sight-in" the mounting height and position of the monitor cutouts. Once the mounting height and position is confirmed by Fire Department personnel, record the measurements and prepare shop drawings illustrating the monitor mounting. Provide an appropriate monitor wall mounts that will position the video display monitors at the approved mounting height when installed in accordance with the manufacturer's instructions, including any required drop-down extensions and adapters if required.

Provide monitors meeting the following requirements:

- Display Type: TFT active matrix, widescreen flat panel,
- Mounting: Wall-mount,
- Pixel Pitch: .46 mm,
- Pixels per Inch: 55 pixels at native resolutioin,
- Resolution: 1,920 x 1,080 dpi,
- Colors: Minimum 16.7 million colors,
- Horizontal Scanning Frequency: >90 kHz,
- Vertical Scanning Frequency: 85 Hz,
- Response Time: 8 ms,
- Contrast Ratio: 3000:1,
- Aspect Ratio: 16:9,
- Viewing Angle (Horizontal): 178 degrees
- Viewing Angle (Vertical): 178 degrees
- Brightness: 500 cd/m^2, and
- HDTV Supported Formats: 480i, 480p, 575i, 575p, 720p, 1035i, 1080i, 1080p,
- Digital Inputs: DisplayPort, HDMI, and DVI-D,
- Analog Inputs: HD-15 VGA in RGB, BNC composite, RCA component and S-video.
- Audio Inputs: RCA Audio, stereo mini-jack, DisplayPort audio, HDMI audio, and
- External Control: RS-232 and infrared remote.

Provide an on-board computer in each monitor meeting the following requirements:

- Processor: Dual core Intel Xeon L5405 at 1.6 GHz or greater, 2x6MB cache processor, L2 cache at 1333 Mhz,
- Memory: 2 GB Dual Channel DDR2 ECC SDRAM, 667 Mhz,
- Network: 10/100/1000 Base T Ethernet with RJ-45 connector,
- Hard Drive Controller: C1, All SATA drives, non-RAID,
- Hard Drive: 160 GB SATA, 3.0 Gb/s, operating at 7200 RPM, 8 Mb data burst cache,
- Video Card: 256 MB (DVI/VGA/TV out) PCIe,
- Operating System: Windows 7 Professional, latest version, and

- Application software: Enterprise version of Norton antivirus software compatible with City requirements.

(1) Physical Features

Provide computer workstations meeting the minimum power and environmental requirements:

- Input Voltage: 90-135 VAC at 50/60 Hz.
- Output Wattage: 175 W,
- Operating Temperature: 40-104 degrees F, and
- Operating Humidity: 20-80%.

Equip all computer workstations with at least one direct 10/100 Base T Ethernet LAN interface. The network connector shall be RJ-45 for Category 5e or 6 UTP for interfacing with the edge switch.

(D) Network Video Recorder (NVR)

The network video recorder (NVR) shall interface to the IP network and be able to record video images from cable TV and the CCTV camera video images and write those images to a DVD for viewing on a workstation. Furnish and install a network-based NVR in the TMC Server Room. Provide an NVR with the capability to record from IP streams two IP cameras simultaneously. Provide an NVR meeting the following requirements:

- Processor: Quad core Intel Xeon L9400 processor at 2.66 GHz or greater,
- Memory: 4 GB RAM,
- Network: Dual 10/100/1000 Base T Ethernet with RJ-45 connectors,
- Hard Drive: Internal 2 TB SATA, 3.0 Gaps, operating at 15.2 RPM,
- Video Card: 512 MB RAM with DirectX 9.0c,
- Video Output: SVGA connector, and
- Operating System: Windows 7 Professional, latest version.

Provide an NVR meeting the minimum power requirements:

- Input voltage: 90-135 V at 50/60 Hz, and
- Output wattage: 255 W.

Provide an NVR meeting the minimum port requirements:

- Keyboard: One 6-pin mini-DIN connector or use USB connection,
- Mouse: One 6-pin mini-DIN connector or use USB connection,
- Audio: Minature phono plugs for line in, line out and microphone,
- Ethernet: Dual 10/100 Base T Ethernet with RJ-45 connector, and
- USB Port: Six USB 2.0 ports.

Provide the NVR capable of reading and writing DVDs (digital video discs) and CDs (compact discs) and meeting the following minimum functional requirements:

- Compression Formats: MJPEG, MPEG-4 part 10, H.264,
- DVD Read Speed – 12X,
- DVD Write Speed – 8X,
- DVD Rewrite Speed – 4X,
- CD Read Speed – 40X,

- CD Write Speed – 24X,
- CD Rewrite Speed – 24X,
- Type of Drive – DVD +/- RW,
- Interface – Hi-Speed USB, IEEE 1394 (FireWire),
- Access Time – 140ms,
- Cache Size – 2MB,
- Recording Modes – Multi-session,
- Load Type – Tray,
- CD Support Formats – CD Text, CD-DA, CD-ROM, Photo CD, Video CD, and
- Media Supported – DVD+R, CD-Rom, CD-R, CD-RW, DVD-ROM, DVD-R, DVD-RW, DVD+RW, DVD+R.

36.3. CONSTRUCTION METHODS

(A) General

Receive approval for the System Design Report described in these Project Special Provisions before submitting products submittal data, purchasing, installing and configuring the central video equipment described in this section of the Project Special Provisions.

(B) Digital Hardware Video Encoder

(1) Serial Interface

Use hardware-based digital video encoders having a minimum of two serial data interfaces and connectors that conform to EIA-232/422/485 standards. Ensure that the serial interfaces support EIA-232 as well as 2-wire and 4-wire EIA-422/485 connections. Ensure that the serial port(s) support data rates up to 115.2 Kbps. Serial interface parameters, such as data format, number of bits, handshaking, and parity, shall be software programmable through local connection to the digital video encoders and through connections over the network. Serial interface ports may utilize RJ-45 connectors, D-sub connectors, or screw terminals.

(2) Network Interface

Ensure that the digital video encoder local area network (LAN) connection supports the requirements detailed in the IEEE 802.3 standard for 10/100 Ethernet connections. Provide a DVE having a minimum of one Ethernet port, which shall be a 10/100 Base-TX connection or 100 Base-FX ST interface connection. Ensure that the connector complies with the EIA and Telecommunications Industry Association (TIA) requirements as detailed in the EIA/TIA-568-A standard. Provide copper-based network interface ports that utilize RJ-45 connectors.

Ensure that all Category 5e unshielded twisted pair/shielded twisted pair network cables are compliant with the EIA/TIA-568-A standard. Ensure that the network communication conforms to User Datagram Protocol (UDP), Version 4 of the Internet Protocol (IP) and Version 2 of the Internet Group Multicast Protocol (IGMP).

(3) Front Panel Status Indicators

Ensure the digital video encoders have light-emitting diode (LED) displays, liquid crystal displays (LCDs), or similar illuminated displays to configuration and management. Provide digital video encoders that support local and remote configuration and management. Configuration and management functions shall include access to all user-programmable features, including but not limited to addressing, serial port configuration, video settings, device monitoring, diagnostic utilities, and security functions. Ensure that the digital video encoders and digital video decoders support configuration and management via serial login, telnet login, and Simple Network Management Protocol (SNMP).

(4) Electrical Specifications

Ensure that all wiring meets NEC requirements and standards. Provide equipment that operates on a nominal voltage of 120 VAC. The equipment shall operate within a voltage range of 89 VAC to 135 VAC. The operating frequency range for power shall be 60-hertz ±3 Hz. If the device requires operating voltages of less than 120 VAC, supply the appropriate voltage converter.

Furnish, install and integrate the video encoders in each CCTV cabinet shown in the Plans. Connect the analog input of the video encoder to the CCTV camera as defined above. Connect the Ethernet output of the video encoder to Ethernet edge switch. Use standard coax cable with BNC (gold-plated center pin) connectors. Connect the RS-422 PTZ serial communications from the camera to the serial port of the video encoder. Configure ports and IP addresses for multicast broadcast and VLANs.

(C) Digital Software Video Decoder

Install a software decoder for processor on the video server so that each processor drives a separate monitor.

(D) TMC Video Display Monitor

Use mounting brackets specifically designed for wall mounting of monitors. Use mounting brackets specifically designed for wall mounting of LCD monitors. Ensure the mounting brackets are secured to wall studs or plywood backboard according to the manufacturer's recommendations.

Conceal all video cabling between each monitor and the video server in the wall as shown in the Plans using low voltage outlet boxes installed by others. Connect the DVI-D video input of a monitor with a DVI-D video output of the video server.

Mount the 52-inch LCD Monitors on the TMC video wall area. The monitors shall align vertically and horizontally with each other.

Connect power cords to adjacent receptacles (provided by others) in wall.

Connect on wall monitor to the TMC operator's workstation and configure so it will display content from the operator's workstation.

Ensure when completed the power and video cables will be concealed behind the monitors.

(E) Headquarters Fire Station Video Display Monitor

Attach the video display monitor mounts on the concrete block wall above the window between each pair of garage doors as shown in the Plans and at the position and height determined and approved by Fire Department personnel during the earlier field investigation/site visit. Securely mount the 40-inch LCD video display monitors in the monitor mounts in accordance with the manufacturer's instructions. Coordinate with Fire Department personnel to adjust vertical tilt and horizontal viewing angle (i.e., pivot) as necessary to ensure and optimize visibility of the monitors by drivers seated in the driver's seat of fire trucks in both the second row of each bay.

Use mounting brackets specifically designed for wall mounting of LCD monitors. Connect the Ethernet port of each monitor to the edge switch mounted inside the communications closet

in the fire station office using Ethernet cable. Connect the power cables to adjacent electrical outlets installed by others.

(F) Network Video Recorder (NVR)

Install the NVR in proposed server rack and connect to Ethernet network. Configure the NVR for remote control and scheduled recording.

36.4. MEASUREMENT AND PAYMENT

The materials provided in this section include all appropriate ports, cabling, grounding, redundancies, labeling and any integration between the devices and the communications network as necessary to make a fully working installation.

For furnish and install and for furnish only materials all power supplies, power cords, adapters, mounting hardware, connectors, serial cables, signs, decals, installation materials, and configuration software necessary to complete this work, are to be included and will be incidental.

Digital hardware video encoder will be measured and paid as the actual number of digital hardware video encoders furnished, installed, and accepted.

Furnish digital hardware video encoder will be measured and paid as the actual number of digital hardware video encoders furnished and accepted.

Digital software video decoder will be measured and paid as the actual number of digital software video decoders furnished, installed and accepted.

TMC video display monitor will be measured and paid as the actual number of video display monitors furnished, installed, and accepted in the TMC.

Signal shop video display monitor will be measured and paid as the actual number of video display monitors furnished, installed, and accepted in the Signal Shop.

Fire station video display monitor will be measured and paid as the actual number of video display monitors furnished, installed, and accepted in the Headquarters Fire Station. The Ethernet cables between the fire station video display monitors in the truck bays and the Ethernet edge switch in the communications closet inside the fire station office will be measured and paid for in accordance with the "Ethernet Communications Cable" section of these Project Special Provisions.

Network video recorder will be measured and paid as the actual number of network video recorders furnished, installed, and accepted.

No separate measurement will be made for coaxial or DVI-D cables, cable connectors, communication cables, Ethernet cables between equipment housed within the same room/rack/cabinet, electrical cables, video display monitor mounts, mounting hardware, nuts, bolts, brackets, connectors, grounding equipment, surge suppression or documentation as these will be considered incidental to the pay items listed above.

Payment will be made under:

Pay Item	Pay Unit
Digital Hardware Video Encoder	Each
Furnish Digital Hardware Video Encoder	Each
Digital Software Video Decoder	Each
TMC Video Display Monitor	Each
Signal Shop Video Display Monitor	Each
Fire Station Video Display Monitor	Each
Network Video Recorder	Each

37. ENCLOSED COMMUNICATIONS RACKS

37.1. DESCRIPTION

Furnish and install freestanding enclosed communications racks at City Hall in the TMC and TMC Server Room. Furnish and install wall-mounted enclosed communication rack for the Signal Shop.

37.2. MATERIALS

(A) Freestanding TMC and Server Room Racks

Provide enclosed communications racks meeting these minimum performance requirements:

- All equipment shall comply with ANSI/EIA RS-310D,
- Provide frame and external components with zinc coating per ASTM B633,
- Paint interior and exterior components per RAL 7035, and
- The thermostatically controlled fans shall provide up to 300 cubic feet per minute (cfm) of exhaust. Thermostats shall monitor both humidity and temperature.

Provide enclosed communications racks meeting the following minimum material requirements:

- 19-inch EIA single-bay,
- Nominal height of less base and wheels
    - Full Size Rack Cabinet for TMC Server Room: 42 rack units high (approx. 78 inches,
    - Half Size Rack Cabinet for TMC: 16 rack units high (approx. 30”),
- Nominal 4-inch-high ventilated base,
- Nominal depth: 30 inches,
- All-metal components,
- Full-height locking window door on the front,
- Urethane gaskets for window sealing,
- ¼-inch-thick Plexiglas® window panes,
- Solid metal removable side panels with bottom vents,
- Full-height solid metal door for the back of each cabinet, and
- Vented top with three integral, thermostatically controlled, prewired fans.
- Set of four (4) heavy-duty, locking casters on base.

Mechanical: Construct all rack frames from 12-gauge, cold-formed steel. Construct all side panels and door panels of 14-gauge steel. Construct the vented base from 16-gauge steel. Construct the 19-inch electrical rack angles from 12-gauge steel.

Doors: Equip all doors with grounding brackets and doorstop kits. Door hinges shall have a maximum opening range of 130-140 degrees. Hinge kits shall permit left or right side mounting. Furnish the racks with tamper-proof hinges and removable hinge pins.

Provide the rack with flush swing handles with tamper resistant locks on all doors. Key all locks to the same key with two sets of keys provided for each unit. Locks shall have a three-point latch mechanism.

Wall Panels: Provide removable solid side panels with hanger tabs for easy alignment and assembly. Provide vents on front and rear panels, along with wire entry access plates with dust-tight seals.

Finish: Furnish factory-applied paint or powder-coating that is black in color on the exterior and interior of all components.

Furnish and install one metal shelf kit per communications rack. Provide each shelf the full width and depth of the rack angles and attach directly to the rack angles. Furnish and install one metal keyboard slide out drawer per full-height communications rack.

(B) Wall-Mounted Communications Rack

Furnish a wall-mounted EIA 19-inch equipment rack cabinet for mounting in the Signal Shop to house of a fiber-optic splice/termination center, a managed Ethernet switch and a rack-mounted UPS. The unit shall be an enclosed rack at least 20 rack units high with approximate dimensions of 36"H x 21" W x 26" D. The rear mounting plate that attaches the cabinet to the wall shall be hinged along one side with latches on the opposite side so that the cabinet can be swung open to access the rear of the cabinet.

Provide a power strip inside that uses 120 VAC 60 Hz power; the power strip shall contain at least six outlets and a six-foot power cord. Provide grounding bus bar system to ground rack-mounted electrical equipment.

Provide racks constructed of all metal components. Supply all screws, nuts, washers, lock nuts, brackets and hardware necessary to assemble equipment described herein. Vents shall be on front and rear panels. Furnish wire entry access plates with dust tight seals.

Provide cable management hardware for attachment to rack frame and between 19-inch rack angles. The hardware shall include cable organizers and clamps to provide strain relief and cable mounting. Provide one shelf.

Construct all rack frames and rack angles of 12-gauge steel or greater. Construct the sides, top and bottom panels of 16-gauge steel or greater.

Paint the panels, rack frames, and rack angles with black polyester powder coating or baked on paint.

37.3. CONSTRUCTION METHODS

(A) General

Ground the racks to a building ground.

(B) Freestanding TMC and TMC Server Room Racks

For the full height racks, furnish and install an outlet strip and 10-foot power cord along one rear vertical rack frame. Furnish and install strips that use 120 VAC 60 Hz power and shall contain at least 10 outlets over the 70 inches for full size racks. No power strip is required from the TMC half-size rack. Furnish and install grounding bus bar system to ground the rack-mounted electrical equipment. Equip door with grounding studs.

Furnish and install cable management hardware for attachment vertically along the rack frame and horizontally between 19-inch rack angles. Cable management hardware shall run vertically up one rear rack frame and shall include six horizontal runs per rack. Provide hardware including cable organizers and clamps to provide strain relief and cable mounting.

(1) **TMC Server Room**

Install the full-height communications rack cabinets in the TMC Server Room as shown in the Plans.

Install a keyboard shelf at a height comfortable for operator use when sitting on a stool. Provide tamper-resistant but removable screws through hinges and exterior panels. Furnish any special tools required to remove tamper resistant screws.

(2) **TMC**

Install the half-size enclosed communications rack in the TMC as shown in the Plans. Install the video server, 2070L test controller, NVR, managed Ethernet switch and UPS in the cabinet and terminate all video cabling on the video server.

(C) **Wall-Mounted Communications Rack**

Install the wall-mounted communications rack cabinet on the wall of the Traffic Signal Supervisor's office at the Signal Shop as shown in the Plans. Remove the existing wall-mounted cabinet shell and mount the wall-mounted communications rack to the walled-in column in its place. Install the fiber-optic splice center, managed Ethernet switch and rack-mounted UPS in the rack inside the cabinet.

Furnish and install a power strip and 10-foot power cord on the rear of the rack frame. Furnish and install strip that uses 120 VAC 60 Hz power and that contains at least 5 outlets. Furnish and install grounding bus bar system to ground the rack-mounted electrical equipment. Equip door with grounding studs.

Furnish and install cable management hardware for attachment vertically along the rack frame and horizontally between 19-inch rack angles. Cable management hardware shall run vertically up one rear rack frame. Provide hardware including cable organizers and clamps to provide strain relief and cable mounting.

37.4. MEASUREMENT AND PAYMENT

Enclosed communications rack (full size) will be measured and paid as the actual number of full-size enclosed communications racks furnished, installed, and accepted.

Enclosed communications rack (half size) will be measured and paid as the actual number of half-size enclosed communications racks furnished, installed, and accepted.

Wall-mounted communications rack will be measured and paid as the actual number of wall-mounted communications racks furnished, installed, and accepted.

No separate measurement and payment will be made for rack set-up and assembly, mounting of all accessories and equipment specified for installation within the rack, all brackets, fasteners, and hardware required for properly mounting equipment in the rack, as such materials and work will be considered incidental to furnishing and installing the communications racks.

Payment will be made under:

Pay Item	Pay Unit
Enclosed Communications Rack (Full Size)	Each
Enclosed Communications Rack (Half Size)	Each
Wall-Mounted Communications Rack	Each

38. BUILDING MODIFICATIONS AND FIBER-OPTIC CABLE TERMINATION

38.1. Description

At locations called for in the Plans, route fiber-optic cable in new and/or existing conduits and install conduits into buildings as shown. Terminate fiber-optic cable in fiber-optic splice centers in building as shown in the Plans. Furnish and install cable and cable routing facilities as shown in the Plans.

All construction to reach a building is paid for using other pay items in these Project Special Provisions. All construction to enter a building (including all work from creating a new entrance or integrating with an existing entrance) and making internal provisions for terminating cables are covered under these building modification pay items.

38.2. Materials

(A) General

Use risers and conduit materials 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 intermediate metallic conduit (IMC) that complies with the NEC and EIA/TIA Standard 569 and commercial building standards for telecommunications pathways.

The City will be providing any furniture noted in the Plans.

(B) Fiber-Optic Splicing and Termination

Furnish SMFO pigtails with each splice housing, connector housing and interconnect center. Provide pigtails that are a maximum of 6 feet in length with a factory assembled PC-ST connector on one end. Ensure that the SMFO pigtails 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 one end (i.e., the splice/interconnect center end) and, on the other end, factory-assembled connectors of the same type provided on the Ethernet edge switch and provided on the Ethernet core switch. Ensure that SMFO jumpers meet the operating characteristics of the SMFO cable with which it is to be coupled. Provide all of SMFO jumpers with all of the connector combinations necessary to provide the connectivity indicated in the Plans and required by these Project Special Provisions to produce a fully-functional Ethernet communications system.

Provide connector panels with ST-type connectors for connector housings and interconnect centers installed in all facilities.

For each splice housing and interconnect center, 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.

(C) Rack-Mounted Connector and Splice Housings for TMC

Furnish two rack-mountable connector housings (i.e., distribution panel) and a matching splice housing for splicing the fibers in the two incoming signal system trunk cables to SMFO fiber optic pigtails and terminating on patch panels in the communications cabinet being installed in the TMC Server Room at City Hall (i.e., one connector housing for each incoming cable). Each connector housing shall have ST-compatible connector panels and shall have a capacity for terminating a minimum of 72 fibers on the patch panel. The connector housing shall occupy no more than 6 rack units. Provide a matching splice housing and necessary splice trays for fusion splicing the incoming single-mode fibers in the two 48-fiber trunk cables to the pigtails. The splice housing shall occupy no more than 6 rack units, shall be of the same manufacturer as the associated connector housing and designed to work with the connector housing. The splice housing shall have the capacity to splice up to 144 fibers. Store a minimum of 20 LF of each fiber-optic cable inside the communications rack cabinet that contains the splice and connector housings. Provide all hardware needed to install these units in the Communications Cabinet in the TMC Server Room at City Hall.

(D) Wall-Mounted Splice Cabinet for City Hall Building Entrance

Provide a wall-mounted splice cabinet to house the rack-mounted splice housing for transitioning the fiber-optic communications cable from outdoor to plenum-rated cable upon entering the City Hall building. Provide a cabinet with the following features:

- NEMA Type 3, 4 or 12 enclosure fabricated from stainless steel, natural aluminum or powder-coated steel (16 gauge or better).
- Windowless front door, hinged on one side, equipped with a key lock and at least 2 keys, and either with or without a handle.
- Equipped with 19" EIA rack rails for rack-mounting equipment such as the splice housing to be mounted inside.
- Can accommodate up to two conduit entrances up to 4" in nominal diameter in both the top and the bottom of cabinet.
- Sized to accommodate the rack-mounted splice housing plus storage of slack cable as follows:
    - 10 LF minimum for each outdoor fiber-optic communications cable that enters the cabinet from outside the building;
    - 30 LF minimum for each plenum-rated cable that exist the cabinet en route to the TMC Server Room.
- Have dimensions that do not exceed the following: depth, 20 inches; width, 24 inches, height, 48 inches.

Furnish a rack-mounted splice housing for fusion splicing (i.e., transitioning) the outdoor fiber-optic cables to the indoor, plenum-rated fiber-optic cables at the entrance to the City Hall Building. Size the splice housing for the number of cables and fibers to be spliced in accordance with the Plans. Provide all necessary splice trays and splice protectors. Provide splice trays that are designed for use with the splice housing being provided. Furnish all fasteners and mounting

hardware needed to mount the splice housing in the 19" EIA rack inside the wall-mounted splice cabinet.

(E) Rack-Mounted Interconnect Center for Signal Shop

Furnish a compact, modular interconnect center designed to be rack-mounted in a standard 19" rack cabinet for splicing and terminating 24 of the 48 fibers in the incoming 48-fiber plenum-rated cable at the Signal Shop. Furnish an interconnect that complies with the requirements of interconnect centers in the "Splice Centers" section of these Project Special Provisions, except height of interconnect center mounting in the Signal Shop may be up to 3 RU high. Store a minimum of 20 LF of slack fiber-optic cable inside the wall-mounted cabinet.

(F) Wall-Mounted Interconnect Center for Headquarters Fire Station

Furnish a compact, wall-mounted interconnect center for terminating a fiber-optic drop cable inside the Headquarters Fire Station. Provide an interconnect center that is no more than 13 inches wide and that is equipped with the following:

- Durable metal housing with powder-coated finish.
- Connector panel with a minimum of six ST connectors
- Blank panels to cover any unused connector panel slots.
- Capacity to terminate up to 12 fibers on connector panels with ST connectors.
- A hinged metallic door to cover and protect the jumpers and the connector panel(s).
- Locks with a minimum of two keys to secure the jumper/connector panel door and the door covering the splice trays and pigtails.
- Openings or ports at the top and bottom of the housing to permit cables to pass in and out of the interconnect center with the connector panel one side of the interconnect center.

Provide all necessary splice trays, splice protectors and SMFO pigtails for terminating the drop cable inside the interconnect center. Provide all fasteners and wall anchors needed to securely attach the wall-mounted interconnect center to the wall inside the communications closet in the Headquarters Fire Station office as shown in the Plans.

(G) Wall-Mount Enclosure for Edge Switch

Furnish a compact, wall-mount NEMA Type 12 enclosure to cabinet to house the Ethernet edge switch in the Headquarters Fire Station. The cabinet shall be designed to mount flat against a wall and have the following features:

- Constructed of 18-gauge or better steel with a black powder-coated finish.
- Have a hinged front cover with a quarter-turn locking latch to secure the cabinet, along with at least 2 keys.
- Have ground studs at rear or bottom of cabinet.
- Sized to house a single Ethernet edge switch either surface mounted to the back panel of the enclosure or DIN rail mounted to the back of the enclosure, but no more than 12 inches wide to ensure that it can be mounted within the available wall space in the communications closet as shown in the Plans.

- Have grommeted holes in top and bottom of the enclosure for passing cables in and out of the enclosure.

Provide all fasteners and wall anchors needed to securely attach the enclosure to the wall inside the communications closet in the Headquarters Fire Station office as shown in the Plans.

(H) Conduit, Conduit Fasteners and Fittings for Entrances to TCC and Shop

Furnish all conduit, conduit fittings, outlet bodies, conduit straps, conduit-to-beam fasteners, rod-to-beam fasteners, threaded rods, conduit fasteners and any other hardware required to provide a conduit to convey the fiber-optic communications cable above the drop ceiling in the City Hall building and the Signal Shop building as shown in the Plans.

Provide NEMA Type 4 or 4X wall-mounted junction box constructed of galvanized steel or stainless steel with screw-on galvanized or stainless steel cover for the conduit entrance to the Headquarters Fire Station building. Provide a junction box that is square in shape and has minimum dimensions of 12" W x 12" H x 6" D. Provide appropriate fasteners/wall anchors for mounting the junction box to the surface of the building's brick exterior.

38.3. 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 or through an interior wall, obtain approval of methods and materials from the Engineer. In all cases create entrances through exterior walls that are weatherproof and watertight and through interior walls that are properly sealed with an approved, UL-listed fire-block sealant.

Whenever possible, use existing cable raceways, ducts 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 splice centers unless otherwise shown on the Plans.

Install splice centers with connector panels, splice trays, storage for slack cable or fibers, mounting and strain relief hardware, and all necessary hardware. Comply with all requirements of the "Fiber-Optic Splice Centers" section of these Project Special Provisions.

(B) Traffic Management Center (TMC)/City Hall

Install equipment and route cables into City Hall to the TMC Server Room and TMC as shown in the Plans. Contact Michael Webb, at (252) 972-1132 at least 30 days in advance of work to confirm work schedule, work restrictions and to make arrangements for gaining access to the building. Perform all work in accordance with NESC regulations and guidelines.

When working inside the City Hall, cover all furnishings, including chairs and electronic/computer equipment with drop cloths to protect them from debris from above-ceiling work and to aid in cleanup. Carefully remove ceiling panels and fiberglass insulation above the removed panels. Replace the insulation and panels and clean up all dust and debris by the end of each work period unless otherwise approved by the Engineer. Replace any drop ceiling panels damaged during installation of the above ceiling conduit at no expense to the Department.

When working in a stairwell, do not block access to fire doors or to the stairs at any time and keep floor in front of stairwell door and stairs free from tripping hazards.

Install a wall-mounted splice cabinet on the ground floor wall inside the stairwell adjacent to and above the existing communications cable entry point as shown in the plans. Install a large radius 3-inch rigid galvanized conduit elbow (i.e., sweep) between the near side of existing wall-mounted junction box and bottom of the new wall-mounted splice cabinet. Protect the existing fiber-optic cables from damage when cutting new conduit entrance into the side of existing junction box. Core drill a hole in the second floor stairwell landing above and install a new 2" rigid galvanized steel riser parallel to the existing communications cable riser from the top of the splice cabinet up through the second floor landing. Core drill a new conduit entrance adjacent to the existing communications riser entry point above the second floor drop ceiling. Insert a piece of 2-inch rigid galvanized conduit through the new hole, attach the new riser, and seal gaps between the hole and the conduit/riser in the second floor stairwell landing and second floor wall with approved UL-listed fire-blocking sealant.

Carefully inspect the proposed route above the second floor drop ceiling prior to ordering beam fasteners, conduit hangers and/or conduit clips to verify route and determine the appropriate method for securing the conduit above the drop ceiling. Working above the drop ceiling on the second floor of City Hall, install a 2-inch IMC between the newly installed riser at its point of entry through the south wall of the City Hall building to a point above the TMC Server Room. Install 1-inch IMC conduits between the TMC Server Room and the TMC as well as between the TMC Server Room and the Assistant City Engineer's office as shown in the Plans. Attach the IMC conduit to the open-web roof joists using beam fasteners, conduit clips and conduit hangers approved by the Engineer.

Neatly cut a round hole approximately 2 inches in diameter in drop ceiling panel directly below end of the IMC conduit and directly above the communications cabinet in the TMC Server Room. Install 2-inch non-metallic tubing from the bottom of the end of the IMC conduit through the ceiling panel to the cable entry hole in the top communications cabinet.

Feed the cables down through the tubing, into the communications cabinet. Install the required rack-mounted fiber connector housing and splice housing in the communications rack in the TMC server room as shown in the Plans. Fusion splice all fibers in the entering fiber-optic cables to SMFO pigtails inside rack-mounted splice housing, then connect the pigtails to the appropriate connectors in the connector housing. Terminate all pigtails from one incoming cable on one connector housing and all pigtails from the second incoming fiber-optic cable on the second connector housing. Clearly label the connector housing using an approved labeling method. Install SMFO jumpers between the connector panels and the Ethernet core switch.

Install an Ethernet wall outlet in the Assistant City Engineer's office at location approved by the Assistant City Engineer and terminate the Ethernet cable from the TMC Server Room on the wall-mounted outlet.

(C) Signal Shop

Contact Chet Christman, at (252) 467-4937 at least 14 days in advance of work to confirm work schedule, work restrictions and to make arrangements for gaining access to the building housing the Signal Shop and Traffic Signal Supervisor's office. Perform all work in accordance with NESC regulations and guidelines.

Do not access, perform any work or route any cable or conduit over or through the areas designated as prohibited areas in the plans. Confirm the limits of the prohibited areas with Mr. Christman prior to beginning and work in the building.

Follow the procedures for installing IMC conduit above the drop ceiling and routing fiber-optic cable to the communications rack as discussed above for the TMC. Apply an Engineer-approved, UL-listed fire-stop sealant (putty, caulk, mortar, etc.) to seal gaps between any new conduits installed and holes cut through interior building walls and partitions.

(D) Headquarters Fire Station

Contact Mike Varnell, Assistant Fire Chief, and Wiley Lewis, Fire Engineer, at (252) 972-1491 at least 14 days in advance of work to confirm work schedule, work restrictions and to make arrangements for gaining access to the Headquarters Fire Station building. Since the new fiber-optic communications cable, interconnect center, Ethernet edge switch and Ethernet cables will share conduits, raceways and a communications closet that currently house City of Rocky Mount Information Solutions (IS) Department cables and equipment, contract Dale Land, City of Rocky Mount IS Network Administrator at (252) 972-1213 at least 7 days in advance to coordinate construction activities at the Headquarters Fire Station. Take necessary precautions to prevent disturbing or damaging existing cables and equipment housed in existing conduits and raceways at the fire station and inside the communications closet in the fire station office. Confirm the space available for installing wall-mounted equipment and enclosures inside the communications closet as shown in the plans and use only equipment and enclosures that fit within the spaces available. Perform all work in accordance with NESC regulations and guidelines.

Carefully remove the existing non-metallic LB conduit body that attaches the existing IS Department underground conduit to the existing conduit entrance on the exterior wall of the Headquarters Fire Station, taking care not to damage the existing IS Department fiber-optic cable housed inside. Replace the removed LB with a larger metallic NEMA Type 4 wall-mounted junction box as shown in the Plans. Attach the new underground conduit that conveys the signal system drop cable to the bottom of the newly installed wall-mounted junction box. Feed the fiber-optic drop cable into the building through the existing conduit entrance as shown in the plans.

Remove the abandoned existing wall-mounted interconnect center and mount the new wall-mounted interconnect center on the wall of the communications closet above and to the left of the existing riser as shown in the Plans. Mount the locking enclosure for the Ethernet edge switch on the wall above or the wall to the left of the wall-mounted interconnect center. Install the edge switch inside the enclosure. Fusion splice the drop cable fibers to SMFO pigtails and terminate them on the connector panel in the interconnect center. Install a communications cable identification marker (i.e., cable wrap) on the fiber-optic drop cable just outside the point where the cable enters the interconnect center. Install SMFO jumpers between the interconnect center patch panel and the Ethernet edge switch housed inside the adjacent wall-mount enclosure.

Route Ethernet cables between the Ethernet edge switch and the video monitors out in the truck bays by following the existing cable raceway inside the office. Core drill a hole through the brick wall between the office and the bays. Install 1" EMT conduit on the walls inside the bays to route the Ethernet cables to the video display monitors.

Do not take existing railroad preemption status board out of service until new display monitors have been installed and made fully functional to display the status of railroad preemption at downtown intersections. Subsequently remove and dispose of existing status board and remove existing signal system fiber-optic cable.

38.4. MEASUREMENT AND PAYMENT

TMC/City Hall modifications will be measured and paid at the contract lump sum price. The price and payment will be full compensation for all work required to route and terminate the fiber-optic cable into the City Hall building as shown in the Plans, all work for furnishing and installing conduit to route Ethernet cables between the server room and other rooms in the building, as well as any other work not called for under other items but required to accomplish the building modifications. The Ethernet cables between the TMC Server Room and the TMC and between the TMC Server Room and the Assistant City Engineer's office will be measured and paid for in accordance with the "Ethernet Communications Cable" section of these Project Special Provisions.

Signal shop modifications will be measured and paid at the contract lump sum price. The price and payment will be full compensation for all work required to route and terminate the fiber-optic cable into the buildings as shown in the Plans as well as any other work not called for under other items but required to accomplish the building modifications.

Headquarters fire station modifications will be measured and paid at the contract lump sum price. The price and payment will be full compensation for all work required to route and terminate the fiber-optic cable into the Headquarters Fire Station, to furnish and install conduit to route the Ethernet cable from the Ethernet switch to the video monitors as shown in the Plans as well as any other work not called for under other items but required to accomplish the building modifications. The Ethernet cables between the video display monitors in the truck bays and the Ethernet edge switch in the communications closet inside the fire station office will be measured and paid for in accordance with the "Ethernet Communications Cable" section of these Project Special Provisions.

No separate payment will be made for wall-mount splice cabinets, splice housings, connector housings, interconnect centers, patch panels, splice trays, splicing, conduit, conduit fittings, conduit hangers, conduit surface mounting hardware and brackets, and fire-stop sealant as these will be considered incidental to the building modifications.

No separate measurement will be made for mounting hardware, nuts, bolts, brackets, connectors, grounding equipment as these will be considered incidental to the pay items listed above.

No separate measurement will be made for computer hardware, Ethernet switches, video head-end equipment, and rack cabinets, as these will be measured and paid for elsewhere in these Project Special Provisions.

Payment will be made under:

Pay Item	Pay Unit
TMC/City Hall Modifications	Lump Sum
Signal Shop Modifications	Lump Sum
Headquarters Fire Station Modifications	Lump Sum

39. SUBMITTAL DATA

39.1. DESCRIPTION

Provide project documentation as described below.

39.2. SUBMITTALS

(A) General

All documentation will be either 11" x 17" or 8½" x 11" format. No documentation may be smaller or larger than these formats. All submittals will be reviewed and approved by the Department. Absence of comment will not grant approval.

(B) Project Construction Schedule

Prepare and submit for approval by the Engineer a schedule of the proposed working progress on the project in accordance with the instructions and on forms furnished by the Department. Update and submit the schedule monthly.

The project schedule shall include a monthly schedule of values. At the end of each calendar month shown on the schedule, show a value (in dollars) of the cumulative project work projected to be completed. The proposed project schedule shall be submitted no later than 7 days prior to the date of the project preconstruction conference and shall be approved before any work is begun on the project.

When conditions beyond the Contractor's control have adversely affected the Contractor's progress, or the Department has extended the completion date, the Contractor may submit a revised progress schedule to the Department for approval. Such revised progress schedule will not be approved unless accompanied by a detailed written statement giving the Contractor's reasons for the proposed revision.

The project construction schedule shall show at least:

- Major Activities,
- Critical Path,
- Task Dependencies,
- Float Time for Each Task,
- Project Start and Completion,
- Task Durations,
- Task Begin and End Dates,
- Milestones,
- Material Submittals,
- Submittal Review Periods,
- Equipment Deliveries,
- Sample and Material Testing,
- Acceptance and Demonstration Testing,
- Training,
- Observation Period,
- Final Acceptance.

(C) 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.

The ITS & Signals Qualified Products List (QPL) is available on the North Carolina Department of Transportation's Website. 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.

(D) System Design Report

Prepare a System Design Report to describe the proposed network architecture and its configuration. Provide a detailed description of the hardware and software to be installed. The report shall depict and describe the entire layout of the equipment and their connectivity. Provide a detailed listing of the hardware including brand and model numbers, functions and descriptions. Provide a detailed listing of the VLAN configuration and IP addresses.

Submit the report and obtain approval before providing material submittals for the following packages of items as described below: central video equipment, software, computer hardware, and communications equipment.

(E) Submittal Requirements

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.

The intent of submittals is to show completely the materials meet the requirements of the Plans and Project Special Provisions and how the Contractor intends to construct or configure the materials. The Contractor shall clearly demonstrate in the submittals that the desired materials shall meet or exceed the requirements of the Plans and Project Special Provisions. Each submittal shall be sufficiently complete and detailed for the Department to review and approve the submittal. If the Department deems the submittal insufficient in detail or completeness for review or approval, the submittal will be returned as rejected. Additional time will not be granted for resubmittal.

Before material submittal data begins, provide to the Department a list of all submittals with approximate dates of submission that the Contractor intends to make. It is incumbent upon the Contractor to schedule reviews in a timely manner that will not delay his schedule.

Certain groups of materials are related in function and operate as a subsystem together. To ensure individual and subsystem compliance with the project requirements materials shall be submitted as packages as follows:

Submittal Package	Description
System Design Report	See subsection 39.2 (D) above.
Controllers and Cabinets	2070L Controllers, 332 and 336S Cabinets, 336S Cabinets, Conflict Monitors, Base Adapters, Special Base Adapters, Base Extenders, Preformed Cabinet Foundations, Special Coating for Cabinets
Fiber-optic Cable	Fiber-optic Cable, Drop cables, Splice Enclosures, Interconnect Centers, Rack-mounted Splice Housing and Connector Housings, Wall-mounted Splice Cabinets, Delineator Markers, Underground Cable Markers, Communications Cable Identification Markers
CCTV Equipment	Composite Video Cable, CCTV camera, CCTV cabinet
Central Video Equipment*	Encoders, Software Decoders, Video Monitors, Network Video Recorder (NVR), Headquarters Fire Station Video Display Monitors
Software*	Signal System Software, CCTV System Software, System Support Software
System Support Equipment	Fiber-optic Restoration Kit, Fiber-optic Power Meter, Optical Light Generator, Visual Fault Locator, Video Monitor, Conflict Monitor Tester, Test Controllers with Cabinets, CCTV Test Cabinet
Computer Hardware*	ITS Servers, Workstations, Laptops, KVM Switch, UPS (see "Computer Hardware and Peripherals" section of these Project Special Provisions for further requirements)
Communications Equipment*	Core Switch, Managed Ethernet Switches and Ethernet Edge Switches, (see "Communications Hardware" section of these Project Special Provisions for further requirements), Firewall, Network Management Software, Communications Racks, UPS
Field Infrastructure	Conduit, Junction Boxes, Terminal Splice Boxes/Cabinets, Electrical Service Equipment (Disconnects, Meter Bases, Combination Panels), and Misc. Hardware

* Indicates submittal packages that cannot be submitted for review until the System Design Report has been submitted and approved.

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 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. For submittals showing a variety of models and parts available from the manufacturer, clearly identify by circles, marking our other means the specific materials for which approval is requested.

Allocate 40 days for the Department to review and respond to a submittal. Do not deviate from what is approved without approval by the Department. Do not fabricate or order material until receipt of the Department's approval. All submittals will be returned as either "Approved (as submitted)", "Approved as Noted" or "Rejected". The Contractor may proceed with fabrication or ordering for items marked "Approved". If an item is marked "Approved as Noted" without any stipulation for resubmittal, then the Contractor may proceed with fabrication or ordering. For any other notations, the Contractor shall revise the submittal, address comments and resubmit for approval.

39.3. 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.

40. TRAINING

40.1. DESCRIPTION

Provide training for the installation, operation and maintenance of:

- Gigabit Ethernet core switch,
- Managed Ethernet switches,
- Ethernet edge switches,
- Servers,
- Network configuration,
- Network management software,
- Fiber-optic communications cable,
  - Fiber-optic interconnect centers,
  - Splice enclosures (aerial and underground)
  - Splice trays and other related fiber-optic equipment in accordance with the Plans and Project Special Provisions,
- CCTV field equipment,
- CCTV central equipment,
- CCTV central software
- Signal System Software
- Controller hardware and local controller software including:
  - 2070L Controllers,
  - Cabinets,
  - Conflict monitors,
  - Detectors,
  - OASIS® IP (Version) controller software,
- UPS,
- Ethernet radios, and
- System support and test equipment.

40.2. MATERIALS

(A) General

Provide training in the installation, operation, maintenance, troubleshooting and repair of all equipment and software. Prepare training outline, agenda, training manuals, training exercises, instructor resumes and any other teaching aids and submit them for approval by the Department prior to conducting training. For each course, provide a training exercise to demonstrate through hands-on activities the subject matter covered in the course lecture or course section. For exercises requiring computers, furnish enough computers to have one computer per two students.

Provide all laptop computers, projectors and projector screens needed for the training. Provide all audiovisual equipment needed for presentations and demonstrations, including video players. Provide new test cabinets, controllers and conflict monitors for use during the training. Furnish all power cords, extension cords, power strips and other cables required for the equipment used in the training.

Provide draft-training material to the Department for review and approval at least 60 days prior to the scheduled training. Provide adequate time for review and revision of the draft training materials. Furnish all audio-visual equipment, demonstration equipment, including a test cabinet, and "hands-on" equipment in support of the envisioned training. Each training participant shall receive a copy of course materials including both comprehensive and presentation manuals. Assume there will be a maximum of 15 students in each class session. Provide two additional copies of these documents to the Department.

Utilize training personnel well versed in the subject matter and with extensive field experience dealing with real world problems. Utilize training personnel that have been certified by the respective manufacturers.

The City shall provide the training facility. Provide the Department with a 30-day notification to carry out the training so that arrangements can be made for attendance. Coordinate a mutually agreeable date, time and location with the City through the Engineer. The Engineer shall approve the training schedule time and location. A "day" of training shall consist of 8 hours of training.

When two sessions are required, conduct the first session early in the project, scheduling it to occur immediately prior to the first implementation of the given software or hardware so that City and Department staff can become familiar with the software or hardware prior to its implementation on the project. Conduct the second session near the conclusion of the project. If more than two sessions are required, conduct the remaining sessions approximately midway between the first and last sessions. Do not conduct multiple sessions back-to-back or near end of project. **Conduct the first session of training on 2070 traffic signal controllers, cabinets, conflict monitors and controller firmware at least one week prior to installing the first new controller with cabinet on the project.**

Develop the course content specifically for the products supplied for this project. The course shall include the following topics:

- Introductory-level briefing to familiarize attendees;
- Terminology;
- Theory of operation;
- Installation;
- Hardware and software configuration;
- Operating procedures and capabilities;
- Testing, diagnostics and troubleshooting;
- Software applications;
- Use of the system documentation to operate, diagnose, maintain, and expand the system; and
- "Hands-on" use of the system, laptop computer and software, system test equipment, and any other system equipment supplied.

Provide course lengths as follows:

Course	Type of Training	Total Students	No. of Sessions	Length (Days)
Ethernet Communications and Networking*	Lecture and Hands-on Exercises	15	2	4
Fiber-Optic Communications	Lecture and Hands-on Exercises	15	2	3
CCTV Field Equipment	Lecture and Hands-on Exercises	15	1	1
CCTV Central Video Equipment	Lecture and Hands-on Exercises	15	1	0.5
CCTV Central Software	Lecture and Hands-on Exercises	15	1	0.5
Signal System Software	Lecture and Hands-on Exercises	15	2	3
2070 Traffic Signal Controllers, Conflict Monitors, Cabinets, and Controller Firmware	Lecture and Hands-on Exercises	15	3	5
Wireless communications equipment	Lecture and Hands-on Exercises	15	1	1
UPS	Lecture and Demonstration	15	1	0.25

* Do not conduct any training on this topic until the System Design Report has been submitted for review and subsequently approved by the Department.

Provide additional specific training as described below.

(B) Ethernet Communications and Networking

Provide training using the test and repair equipment furnished for the project. The training session shall be presented by field service specialist(s) employed by the suppliers of the communications system components. Provide training for the Ethernet communications and networking for the following categories and for the minimum number of hours shown:

Course	Type of Training	Length (Days)
Ethernet Communications and Networks		2
Terminology	Lecture	
Theory of design	Lecture	
Network configuration	Lecture	
VLANs	Lecture	
Equipment overview	Lecture	
Network maintenance	Lecture, Demonstration and Hands-on	
System backup, data archiving		
Routine		
Troubleshooting procedures		
Testing		
System restart and recovery		
Question and answer session	Lecture	
Ethernet Switches (all types and configurations)		1
Introduction	Lecture	
Configuration and programming	Lecture	
Review of Maintenance Manual	Lecture and Hands-on	
Review of Operations Manual	Lecture and Hands-on	
Maintenance	Lecture, Demonstration and Hands-on	
Routine		
Troubleshooting procedures		
Testing		
System restart and recovery		
Question and answer session		
Network Management Software		1
Introduction	Lecture	
Network Configuration	Lecture	
Menu Structure	Lecture	
Maintenance	Lecture, Demonstration and Hands-on	
System backup		
Routine		
Troubleshooting procedures		
System restart and recovery		
Testing		
Class project (configure devices on network made by attendees)	Lecture, Demonstration and Hands-on	
Question and answer session.	Lecture	

(C) Fiber-Optic Cable

Provide training using the test and repair equipment furnished for the project. Provide training for the fiber-optic system for the following categories and for the minimum number of hours shown:

Course	Type of Training	Length (Days)
Ethernet Switches – Optics		1
Safety	Lecture	
Introduction to Ethernet switch optics	Lecture	
Review of Maintenance Manual – optics	Lecture	
Review of Operations Manual - optics	Lecture	
Question and answer session	Lecture	
Fiber-Optic Cable System		2
Safety	Lecture	
Introduction to fiber-optics, theory, and principles	Lecture	
Fiber and cable types	Lecture and Hands-on	
National Electrical Code considerations	Lecture and Hands-on	
Plenum and riser type cable		
Outdoor cable, etc.		
Introduction to terminating hardware, end equipment, and applications	Lecture, Demonstration and Hands-on	
Connectors (ST, SC, LC, etc.)		
Splice enclosure, splice trays, and connector panels		
Cable placement techniques		
Question and answer session		
Cable handling and preparation (sheath removal, grip installation, etc.)	Lecture, Demonstration and Hands-on	
Splicing and terminating methods	Lecture, Demonstration and Hands-on	
Mechanical splicing using various techniques		
Fusion splicing		
Field termination of connector types		
Introduction to cable plant testing procedures	Lecture, Demonstration and Hands-on	
Proper usage of optical light generator and power meter		
Class project (build working system using cables/connectors made by attendees)	Lecture, Demonstration and Hands-on	
Question and answer session.		
Class project -- Testing and troubleshooting	Lecture, Demonstration and Hands-on	
Cable system maintenance and restoration	Lecture	
Question and answer session.		

(D) CCTV Field Equipment

Provide CCTV field equipment training that includes operational theory and procedures of the field components of the CCTV system. This training shall be oriented towards the users and maintenance personnel of the system. The training session shall be presented by field service specialist(s) employed by the suppliers of the CCTV field components. This training session shall include exercises that should take one-half of the day. Provide training for the CCTV field equipment and the local CCTV camera software as described below:

Course	Type of Training	Length (Days)
Operations	Lecture	0.5
Theory of operation	Lecture, Demonstration	
Local camera programming	Lecture, Demonstration and Hands-on	
Camera addresses		
Presets		
Privacy zones		
Privacy zones		
Tours		
Other features		
Maintenance	Lecture	0.5
Routine maintenance	Lecture, Demonstration and Hands-on	
Testing	Lecture, Demonstration and Hands-on	
Troubleshooting	Lecture, Demonstration and Hands-on	

(E) CCTV Central Video Equipment

Provide CCTV central video equipment training that includes operational theory and procedures of the central components of the CCTV system. This training shall be oriented towards users and maintenance personnel of the system. This training session shall include hands-on exercises that should take approximately one-half of the session. The training shall address the use of, but not limited to, the following devices: NVR encoders, software decoder, monitors, and the video server. Provide training for the CCTV central equipment as described below:

Course	Type of Training	Length (Days)
Operations and Theory of operations	Lecture	0.25
Programming	Lecture, Demonstration and Hands-on	0.25
Maintenance	Lecture	
Routine maintenance	Lecture, Demonstration and Hands-on	
Testing	Lecture, Demonstration and Hands-on	
Troubleshooting	Lecture, Demonstration and Hands-on	

(F) CCTV Software

Provide CCTV central software training that includes operational theory and procedures of the central CCTV software. This training shall be oriented towards users and maintenance

personnel of the system. This training session shall include hands-on exercises that should take one-half of the total session. Provide training for the CCTV central software as described below:

Course	Type of Training	Length (Days)
Programming	Lecture, Demonstration and Hands-on	1.5
Database updates		
Map updates		
Adding and deleting devices		
Tours		
Macros		
Data backups		
Operator and access rights		
Alarms		
Operations	Lecture	
Theory of operation	Lecture, Demonstration	
Testing	Lecture, Demonstration and Hands-on	
Maintenance	Lecture	
Routine maintenance	Lecture, Demonstration and Hands-on	
Troubleshooting	Lecture, Demonstration and Hands-on	

(G) Signal System Software

Provide training that includes operational theory and procedures of the signal system software. This training shall be oriented towards users and maintenance personnel of the system. This training shall included hands-on exercises that should take approximately one-half of the total session. The training session shall be presented by field service specialist(s) employed by the suppliers of the signal system software. Provide training for the signal system central software as described below:

Course	Type of Training	Length (Days)
Part 1	Lecture & Demonstration	1
Overview of Part 1		
Time-of-day operation and event scheduling		
Traffic responsive pattern selection algorithms		
Reporting Capabilities	Lecture, Demonstration and Hands-on	
Interactive database manipulation		
Theory and application of traffic responsive operations		
Special functions		
Part 2	Lecture and Hands-on	1
Review of Part 1/Overview of Part 2		
System operations and recommended procedures		
Part 3	Lecture, Demonstration and Hands-on	2
Review of Parts 1 & 2/Overview of Part 3		
Development and modification of system graphics		
Preparation of dynamically functioning graphics		

(H) 2070 Controllers, Conflict Monitors, Cabinets and Controller Firmware

Provide three identical training sessions in the basic theory, operation, routine maintenance and troubleshooting of the 2070 controller equipment, cabinets, conflict monitors, auxiliary output files and other related equipment. Conduct one of these training sessions prior to the installation of any new controllers and cabinet on the project. Assume the attendees have no working knowledge through their current use of 2070 controllers.

Provide training, both lecture (i.e., classroom instruction) and hands-on exercise in the use of the local controller firmware, including how to load the firmware onto a new controller.

Training for controllers and cabinets shall be integrated into a single session with training exercises for cabinets and training exercises for controllers running concurrently. Instructors from the controller vendor and instructors from the cabinet vendor shall be in attendance during all days of the session.

Controller-specific instruction during the 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. Cabinet-specific instruction during the session shall be taught by a field service specialist(s) employed by the manufacturer.

The signal controller and cabinet assemblies session shall include, but not be limited to, the following:

- Formal classroom presentation of the functional operation of the signal cabinet, including a discussion on each individual component of the cabinet that details its function, installation techniques, and normal operation
- Formal classroom presentation of the functional operation of the 2070L controller.
- Formal classroom presentation of proper cabinet wiring procedures
- Hands-on workshop on installation of electrical components and surge protection for cabinets.
- Formal classroom presentation and hands-on workshop on operation of signal monitor tester
- Hands-on workshop on timing data entry for 2070L controller.
- All local intersection timing parameters
- All coordination timing parameters
- All parameters and threshold levels associated with traffic responsive operation
- Formal classroom presentation and hands-on workshop on operation of local controller utility software
- Formal classroom presentation and hands-on workshop on operation of controller tester
- Hands-on workshop of proper installation, programming, and troubleshooting of conflict monitors
- Hands-on workshop of proper installation, programming, and troubleshooting of detector cards and lead-in cable
- Hands-on workshop wherein maintenance personnel will troubleshoot simulated controller and cabinet assembly faults to the component level

The lecture, demonstration; hands-on class shall include the following sessions specific to the 2070 related family of hardware and software (controllers, cabinets, signal monitors and detectors):

Course	Type of Training	Length (Days)
Programming	Lecture, Demonstration and Hands-on	1.5
Phasing,		
Timing,		
Preemption,		
Coordination,		
Data transfer		
Operations	Lecture	1.5
Theory of operation	Lecture, Demonstration and Hands-on	
Testing	Lecture, Demonstration and Hands-on	
Maintenance	Lecture	2
Routine maintenance	Lecture, Demonstration and Hands-on	
Troubleshooting	Lecture, Demonstration and Hands-on	

Each of the identical training sessions shall consist of five consecutive days, beginning on a Monday.

(I) Ethernet Radio

Provide training for the Ethernet radio equipment as described below:

Course	Type of Training	Length (Days)
Operations	Lecture, Demonstration	1
Theory of operation	Lecture	
Safety	Lecture	
Antenna alignment	Lecture	
Site Surveys	Lecture, Demonstration and Hands-on	
Procedures		
Interpreting and understanding the results		
Programming and software	Lecture, Demonstration and Hands-on	
Configuration		
Repeater applications		
Maintenance	Lecture	
Routine maintenance	Lecture, Demonstration and Hands	
Testing	Lecture, Demonstration and Hands	
Troubleshooting	Lecture, Demonstration and Hands	

(J) UPS

Provide training for the UPS units that is 2 hours in length, including both classroom and "hands-on" training.

40.3. MEASUREMENT AND PAYMENT

Training will be measured and paid at the contract lump sum price. The price and payment will be full compensation for all work required by this section of these Project Special Provisions.

Payment will be made under:

Pay Item	Pay Unit
Training	Lump Sum

41. TESTING AND ACCEPTANCE

41.1. GENERAL

Conduct and complete successfully the following progressive series of tests before acceptance: field demonstration test prior to installation, installed standalone tests, system test of the network hardware, network management software and an operational test. Develop a comprehensive series of test plans for each device to determine the equipment was correctly installed and meets the requirements of materials, workmanship, performance, and functionality required in the plans and project special provisions. The test plans shall describe the functions to be tested, purpose of test, setup requirements, procedures to be followed, any inputs and expected outputs for each test, criteria for pass/fail and any required tools or test equipment. Any software testers shall be pre-approved by the Department.

Develop as part of the Test Plan a Traceability Matrix of all the individual subsystem functional requirements to be used to cross-reference each planned test to a specific contract requirement to be verified. This Test Evaluation/Traceability Matrix shall be used by the Engineer to crosscheck the functional requirements and the results.

A key element of test plans, where appropriate, is the introduction of forced errors into the functional test. The test plan shall check the actual result of the forced error against the anticipated result. Tests will be performed by the Contractor and witnessed by the Department and the City. No deviation from the written test procedure shall be permitted without approval from the Engineer. Any changes to the approved test procedure to accommodate unforeseen events during the time of testing shall be documented in a copy of the master test procedure. Immediately following the conclusion of each test, the Department, the City and the Contractor shall meet to agree on the results observed and recorded during the testing. This will form the basis for the conclusions reported in the test plan. All test results, notes, and observations shall be maintained in both electronic and hard copy. Maintain complete records of all test results during all stages of testing.

41.2. INSTALLED SITE TESTS

Conduct an approved, standalone equipment installation test at the field site. Test all standalone functions of the field equipment using equipment installed as detailed in the plans, or as directed by the Engineer.

Complete approved test plan forms and turn them over to the Engineer for review as a basis for rejection or acceptance. Provide a minimum notice of 30 calendar days prior to all tests to permit the Engineer or his representative to observe each test.

If any unit fails to pass its stand-alone test, correct the unit or substitute another unit in its place, then repeat the test.

If a unit has been modified as a result of a standalone test failure, prepare a report describing the nature of the failure and the corrective action taken and deliver it to the Engineer prior to re-testing the unit. If a failure pattern develops, the Engineer may direct that design and construction modifications be made to all units without additional cost to the Department or an extension of the contract period.

Utilize vendor supplied device software to perform diagnostic tests of each device. The vendor supplied diagnostic software shall be provided to the Department before final acceptance. Test the following features of each competent as described below.

(A) Fiber-Optic Cable

Conduct optical time domain reflectometer (OTDR) tests on the cable on the reel and after the cable is installed and terminated. Provide written notification a minimum of ten days before beginning fiber-optic cable testing.

After splicing is completed, perform bi-directional OTDR tests on each fiber, including unused fibers, to ensure the following:

- Fusion splice loss does not exceed 0.05 dB,
- Terminations and connections have a loss of 0.5 dB or less, and
- Reflection loss is 40 dB or greater for each connector.

Install a 1000-foot pre-tested launch cable between the OTDR and fiber-optic cable to be tested.

If exceeded, remake splices until the loss falls below 0.05 dB. The Engineer will record each attempt for purposes of acceptance.

Test the fiber-optic cable at both 1310 and 1550 nm.

Furnish durable labeled plots and electronic copies on a CD or DVD of test results for each fiber including engineering calculations demonstrating that OTDR test results meet or exceed the attenuation requirements and that optical properties of the cable have not been impaired. Clearly label each OTDR trace identifying a starting and ending point for all fibers being tested.

Provide engineering calculations and tests for fiber-optic cable that demonstrate the loss budget where the fiber originates and where the fiber meets an electronic device. The calculations shall summarize the optical losses versus the allowable losses for the communications equipment between each pair of communications hardware. Provide a summary section or spreadsheet with a labeled tabular summary showing each test segment with begin and end points and actual versus allowable losses. Label the manufacturer's make, model number and software version of the OTDR used for testing.

Furnish one hard copy of each of the OTDR trace results and electronic copies of all trace results on a CD or DVD.

If any fiber exceeds the maximum allowable attenuation or if the fiber-optic properties of the cable have been impaired, take approved corrective action including replacement of complete segments of fiber-optic cable if required. Corrective action will be at no additional cost to the Department.

(B) Ethernet Communications System

(1) Rocky Mount TMC Wiring

Test any cable installed as part of this project per TIA 568 specifications for continuity, opens, shorts, split pairs, mis-wiring and reversed pairs. Test for DC resistance, impedance, and line capacitive loading. Correct any faults and retest. If retest fails, replace defective cable or connectors.

(2) ITS Servers, Workstations, and Laptop Computers

The following operational tests shall be performed for each ITS server, workstation, and laptop computer in accordance with the test plans. After the equipment has been installed:

- Connect all components (displays, mice, keyboards, printers, network cables, power supplies),
- Configure network communications,
- Map network drives,
- Test connections to all devices by pinging,
- Run diagnostic utilities on the hardware,
- Map all network servers, and
- Print test pages for each workstation on each printer to verify printer configuration.

(3) Ethernet Switches

Once the core switch, managed Ethernet switches and Ethernet edge switches have been installed, conduct local field acceptance tests of the Ethernet edge switch field site according to the submitted test plan. Perform the following:

- Verify that physical construction has been completed as detailed in the Plans,
- Inspect the quality and tightness of ground and surge protector connections,
- Verify proper voltages for all power supplies and related power circuits,
- Connect devices to the power sources,
- Verify all connections, including correct installation of communication and power cables, and
- Perform testing on multicast routing functionality.

Repair or replace defective or failed equipment and retest.

Upon satisfactory completion of operational test, begin an Observation Period of 60 days prior to system acceptance.

(4) KVM Assembly

The following operational tests shall be performed for each KVM assembly in accordance with the test Plans. After the KVM assembly has been installed:

- Connect all servers, monitors, keyboards, mice, and power supplies,
- Program the on-screen display to assign ports and bank numbers and to enter the names of each server in the menu,
- Program the KVM switch for scan features, access privileges, and
- Select each server and ensure the mouse and keyboard work the selected server and the monitor displays the appropriate server.

(C) Traffic Signal Controllers and Conflict Monitors

The following items, not otherwise required to be tested elsewhere, shall be tested: cable continuity, grounding, power-up self-test, proper controller sequencing, detector and pedestrian pushbutton calls.

(D) Communications System Support Equipment

Perform self-diagnostic tests on all electronic test equipment provided to the Department to ensure the equipment is proper operating order. Utilize the supplied test equipment in the training for the fiber-optic cable.

(E) CCTV Field Equipment

Develop an operational test plan that demonstrates all requirements of the equipment and software. Submit for approval before conducting tests.

Notify the Department at least 14 calendar days prior to the proposed date for the tests. The Department and the City shall have the right to witness such tests, or to designate an individual or entity to witness such tests.

Perform the following local field operational tests at the camera assembly field site in accordance with the test Plans. A laptop computer shall provide camera control and positioning. After completing the installation of the camera assembly, including the camera hardware, power supply, and connecting cables, the Contractor shall:

- Furnish all equipment, appliances, and labor necessary to test the installed cable and to perform the following tests before any connections are made,
- Verify that physical construction has been completed,
- Inspect the quality and tightness of ground and surge protector connections,
- Check the power supply voltages and outputs,
- Connect devices to the power sources,
- Perform continuity tests on the surveillance camera's stranded conductor element using a meter having a minimum input resistance of 20,000 ohms per volt and show that each conductor has a resistance of not more than 16 ohms per 984.3 feet of conductor;
- Measure the insulation resistance between the conductors, and between each conductor, ground, and shield using a Megger® meter. The resistance must be infinity. Perform all resistance testing after final termination and cable installation, but prior to the connection of any electronics or field devices; and
- Replace any cable that fails to meet these parameters, or if any testing reveals defects in the cable, and retest new cable as specified; and
- Verify installation of specified cables and connections between the camera, PTZ, camera control receiver, and control cabinet,
- Perform the CCTV assembly manufacturer's initial power-on test in accordance with the manufacturer's recommendation,
- Set the camera control address,
- Verify the presence and quality of the video image in the field cabinet with a portable NTSC-approved monitor or laptop computer
- Exercise the pan, tilt, zoom, focus, iris opening, and manual iris control selections, and the operation, preset positioning, and power on/off functions,
- Demonstrate the pan and tilt speeds and extent of movement to meet all applicable standards, specifications, and requirements,
- Verify proper voltage of all power supplies, and

- Interconnect the communication interface device with the communication network's assigned fiber-optic trunk cable and verify that there is a transmission LED illuminated.

Test the grounding system per ANSI/IEEE C62.41 and ANSI/IEEE C62.45 as applicable. Measure the ground impedance utilizing an instrument designed specifically to measure and document the ground impedance. Provide written test results of the ground impedance for each location to the engineer prior to backfilling the grounding electrode. The test results shall include the instrument model, date of instrument calibration, and local environmental conditions at the time of testing. Certify and sign the test results by the Contractor.

Repair or replace defective or failed equipment and retest

(F) CCTV Central Equipment

Test the components of the CCTV central equipment as follows:

- Check all ground, power, data, Ethernet and analog video connections,
- Run power up self test on each piece of equipment,
- Run all available vendor-supplied self-diagnostics.

(G) UPS

Perform the following operational tests for each UPS in accordance with the test plans. After the UPS has been installed:

- Connect all field devices to UPS,
- Connect UPS monitoring cable to managed Ethernet switch,
- Install and configure UPS monitoring software from Rocky Mount TMC, and
- Configure monitoring software for remote notifications of power outage and use of battery power.

Repair or replace defective or failed equipment and retest.

(H) Ethernet Radio Equipment

Test the spread spectrum radios as follows:

- Check all ground, power, data, Ethernet and analog video connections,
- Run power up self test on each piece of equipment,
- Run all available vendor-supplied self-diagnostics,
- Check received signal strength, noise levels, bandwidth, and accuracy of test data transmission between each pair of nodes,
- Adjust hopping patterns as necessary to maximize the quality of the signal strength,
- If adjusting the hopping pattern does not significantly improve the quality of the signal strength, then adjust antenna as necessary to maximize the quality of the signal strength, and
- Test the transmission of data to ensure the transmission of data from the spread spectrum radios to the edge switches. Run the system diagnostics from end to end.

41.3. SYSTEM TESTING

(A) General

Conduct tests as described below of the traffic signal and CCTV subsystems. Conduct approved device subsystem tests on the field equipment with the Rocky Mount TMC equipment including, at a minimum, all remote communications hardware monitoring and control functions. These tests shall be a demonstration of overall system stability. During this test period, limit downtime due to mechanical, electrical, or other malfunctions to a maximum of eight hours. The Engineer has the right to suspend the test to correct deficiencies and restart the test or to extend the test period by time equal to the downtime in excess of eight hours.

Conduct device and subsystem tests of any repaired or replaced equipment.

Display the event log from the traffic signal and CCTV software for a minimum of seven days. Complete approved data forms and turn them over to the Engineer for review, and as a basis for rejection or acceptance.

The Engineer has the right to suspend the test to correct deficiencies and restart the test or to extend the test period by time equal to the downtime in excess of eight hours. If a component has been modified as a result of a test failure, prepare a report and deliver it to the Engineer prior to retesting.

(B) CCTV Subsystem

After completing the integration of the CCTV cameras into the CCTV subsystem software, conduct a minimum of a seven-day test of the CCTV subsystem hardware and software. This will include that portion of the communications network serving the CCTV subsystem. The Engineer has the right to suspend the test to correct deficiencies and restart the test or to extend the test period by time equal to the downtime in excess of eight hours. If during that time it is determined by the Department or the City there are hardware or software failures that are the responsibility of the Contractor, the Contractor shall make repairs or replacements to the satisfaction of the Department and the City.

Test the following features of each competent as described below.

(1) CCTV Field Equipment

The following items, not otherwise required to be tested elsewhere, shall be tested for each CCTV site <u>from the Rocky Mount TMC</u>:

- NTCIP objects,
- Power-up self-tests,
- Iris control,
- Preset functions,
- Presence and quality of the video image,
- Preset positioning, and power on/off functions,
- Camera and controller access and security from all laptops and workstations,
- Disconnect camera and take local control and reconnect camera at local cabinet to the communications and verify Rocky Mount TMC control is regained,
- Confirm ability to change camera ID,
- Verify unique camera identifier and icons on GUI,
- Viewing of camera image on each monitor.

(2) CCTV Central Equipment

Verify that all CCTV images can be displayed correctly on each monitor using the CCTV central software.

(3) CCTV Central Software

Thoroughly test all functions of the software from the Rocky Mount TMC and Division 4 to ensure correct operation. Test the components of the CCTV central equipment from both the signal shop and the Rocky Mount TMC as follows:

- Use the GUI interface to select and view each camera,
- Use and the GUI interface to test the ability to control the pan-tilt-zoom and iris settings of each camera,
- Use the GUI interface and test the ability to select and place any camera on any monitor,
- Utilizing a Division 4 workstation demonstrate the ability to select, control and tview the camera images, and
- Use the image capture software to test the ability to capture video images and transport them to NCDOT via the existing EIC Server.

(C) Traffic Signal Subsystem

After completion of the integration of the traffic signals into the new signal system central software, conduct a minimum of a seven-day test of the traffic signal subsystem hardware and that portion of the communications network serving the traffic signal subsystem. The Engineer has the right to suspend the test to correct deficiencies and restart the test or to extend the test period by time equal to the downtime in excess of eight hours. If during that time it is determined by the Department that there are failures that are the responsibility of the Contractor, the Contractor shall make repairs or replacements to the satisfaction of the Department.

Verify communications port addressing from the traffic signal controllers.

41.4. OBSERVATION PERIOD

(A) General

A 60-day Observation Period shall begin upon the successful completion of the installed site tests and the system tests described in the preceding subsections as well as the correction of all known deficiencies, including minor construction items and punch-list items developed by the Engineer. During this period the Department and the City shall observe equipment and software operation to determine that all components of the fiber-optic communications system operate properly and interface with the traffic signal subsystem components and CCTV subsystem components according to the requirements of the Plans and these Project Special Provisions over an extended period of time.

During the Observation Period, respond to failures of the Contractor's equipment within two hours and make repairs within eight hours. For items that pose a traffic safety hazard such as a controller failure, make repairs within four hours. If any failures affect major system components for more than 48 hours, the Department shall suspend the Observation Period beginning when the failure occurred. Resume the Observation Period after successful repair or replacement. Failures of the following types will cause the Department to terminate the

Observation Period and restart the Observation Period from zero once the failures have been corrected:

1. System or component failures that necessitate a redesign of any component; and
2. Three or more major system component failures of like nature within any 30-day period.

Major system components include:

- Ethernet core switch, managed Ethernet switch and Ethernet edge switches;
- The fiber-optic communications network;
- The LAN and the Rocky Mount TMC and Signal Shop computer equipment; and
- CCTV equipment.

Begin a new 60-day Observation Period with the approval of the Engineer after the faulty equipment has been repaired or replaced and the redesigned components have been installed.

A successful 60-day Observation Period shall consist of continuous operation with no more than a total of five calendar days of non-operation due to mechanical, electrical, or other malfunctions.

The Observation Period shall be completed by the project completion date and prior to final acceptance of the project. The Observation Period shall not begin until the both the CCTV and traffic signal subsystem tests have been successfully completed. The Observation Period shall not begin without the approval of the Engineer.

(B) CCTV Subsystem

During the Observation Period, the Department and the City will observe equipment and software operation according to the requirements of the Plans and these Project Special Provisions. Verify that Division 4 can view and control the proposed cameras.

Major subsystem components include the CCTV cameras, Ethernet switches, fiber-optic cable, and CCTV cabinets.

(C) Traffic Signal Subsystem

During the Observation Period, the Department and the City will observe equipment and software operation according to the requirements of the Plans and these Project Special Provisions.

Major subsystem components include the all Ethernet switches, Ethernet radio equipment, fiber-optic cable, controllers and conflict monitors, and cabinets.

41.5. FINAL ACCEPTANCE

Final system acceptance is defined as the time when all work and materials described in the Plans and these Project Special Provisions have been furnished and completely installed by the Contractor; all parts of the work have been approved and accepted by the Engineer; and the CCTV and signal subsystems have been operated continuously and successfully for the 60-day Observation Period.

Final acceptance shall not occur until:

- all field demonstration, installed site, system, and operational tests have been satisfactorily completed;
- all punch-list discrepancies have been rectified;
- all documentation has been delivered; and
- all required training has been completed.