PROJECT SPECIAL PROVISIONS

CITY OF WILMINGTON
TRAFFIC SIGNAL SYSTEM UPGRADE/EXPANSION PROJECT
PHASE 1 – SOUTHERN SECTION

N.C. Project No. U-5017A (WBS #41439)
F.A. Project No. STP-0332 (24)
New Hanover County

Prepared for:

North Carolina Department of Transportation
ITS and Signals Unit

NORTH CAROLINA PROFESSIONAL SEAL 17586 ENGINEER J. TODD BROOKS

6/19/08

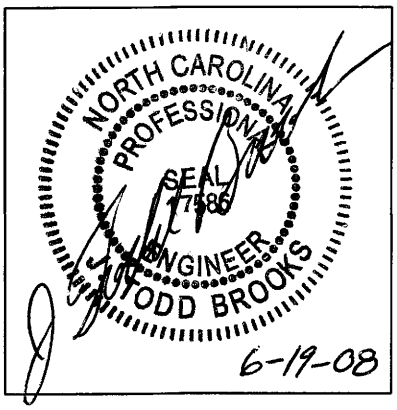
Prepared by:

PBS&J®
1616 East Millbrook Road, Suite 310
Raleigh, NC 27609
Phone: (919) 876-6888

June 19, 2008

This Page Intentionally Blank

24



Project Special Provisions

Based On

NCDOT ITSS Project Special Provisions

Version 06.5

Prepared By: HAB/JTB/JS/DJ
19-Jun-08

Contents

26

36

1. GENERAL REQUIREMENTS

1.1. DESCRIPTION

(A) Summary of Work

This project is the first phase of a multiphase construction project to rehabilitate and expand the City of Wilmington, North Carolina's existing computerized traffic signal system. Overall project work will be primarily comprised of communications system replacement and expansion, field equipment upgrades, replacement of the existing Traconex® closed-loop signal system with a new distributed processing traffic control system, enhancement of the Traffic Management Center, and the expansion of the video monitoring system; however, not all of this work is included in Phase 1. In its entirety, the overall multiphase project includes:

- Signal display upgrades at selected locations and replacement of existing controllers and cabinets with new Model 2070L controllers housed in Model 332A or 336S cabinets for the approximately 215 signalized intersections that will comprise the expanded system;
- Replacement of an existing copper-wire communications system with a new, predominantly fiber-optic communications system comprised of approximately 60 roadway miles of fiber-optic cable along with several wireless communications links; and
- Expanding the existing video surveillance system from 11 existing CCTV cameras to 25 CCTV cameras and replacing the central video equipment.

This Phase 1 project encompasses the southern geographic area of the city, bounded on the west by the Cape Fear River, on the north by Greenfield Street, 17th Street and Shipyard Boulevard, on the east by S. College Road (NC 132), and extending southward on the peninsula along Carolina Beach Road (US 421) to the Wilmington-Carolina Beach city limits.

Phase 1 will be comprised of 47 signalized intersections, 8 video surveillance cameras (install 4 new, replace 3 existing and retain 1 existing) and approximately 10 miles of new fiber-optic communications cable. The Phase 1 contractor will be responsible for integrating the Phase 1 traffic signals into the fiber-optic and wireless communications network. Integration of the Phase 1 traffic signal controllers, as well as those in all subsequent phases, into the central traffic control system (i.e., central softare) will be performed by City of Wilmington. The Phase 1 contractor will be responsible for replacing the existing video control system (video matrix switch, multiplexers, DVR, monitors, etc.) as described in these Project Special Provisions and as shown in the Plans. The Phase 1 contractor will be responsible for integrating the Phase 1 video surveillance cameras into the portion of the new fiber-optic communications network constructed in Phase 1 and into the central video surveillance system.

Most of the existing signals in Phase 1 have NEMA controllers and cabinets that are to be replaced with Model 2070L controllers in Model 332A or 336S cabinets under the Phase 1 project. However, Phase 1 does include some existing independent arterial closed-loop systems that have existing Model 2070L controllers in Model 332A/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 Phase 1 of the expanded and upgraded Wilmington Signal System.

New fiber-optic communications cable will be installed primarily by overlashing to existing aerial twisted-pair copper wire 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. An existing 96-strand fiber-optic trunk cable originating at the City of Wilmington TMC located at 265 Operation Center Drive off of River Road in Wilmington will be retained to provide a homerun communications link between the TMC and the new fiber-optic communications network being constructed in Phase 1 and subsequent phases. To migrate from the existing to the new communications system while minimizing disruptions to signal system operations, the existing twisted-pair communications system in Phase 1 will be progressively decommissioned as the new fiber-optic communications is progressively built-out and brought online.

Perform the following major tasks under this contract, as shown in the Plans:

- Furnish and install a new fiber-optic communications system comprised of fiber-optic cable, fiber-optic splice/termination centers, fiber-optic transceivers (video and data), video matrix switch, 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 guides, wood poles, and pole guy assemblies with guy guards;
- Furnish and install new cabinets and ancillary equipment, extending existing field wiring as and if necessary;
- Modify existing cabinet bases and install new cabinet bases;
- Furnish and install new traffic signal controllers;
- Upgrade existing traffic signal displays;
- Remove existing control equipment and cabinets;
- Furnish and install detector loops, junction boxes, lead-in cables and digital detector units;
- Furnish and install signal cable and lead-in cable;
- Furnish and install CCTV camera assemblies and cabinets;
- Modify existing electrical services and install new electrical services;
- Integrate all components into a fully-functioning fiber-optic and wireless communications system.

The Department will stagger the start of each construction phase from the start of construction on this Phase 1 project, but there will be concurrent construction on one or more of the subsequent phases while Phase 1 is being constructed. In addition, Phase 1 construction work may overlap construction work in other phases where the geographic boundaries of phases meet. In some cases, the work on adjoining phases may be interrelated to the Phase 1 work. For example, an adjacent phase's fiber-optic communications cable may be required to splice into fiber-optic cable being installed in Phase 1 or terminate at a communications hub being installed in Phase 1. Contractors for different phases 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.

The City of Wilmington has joint use permits for the proposed new attachments of aerial fiber-optic communications cable. Joint use permits issued by the utility pole owners expire 120 days from the date of issuance. The Contactor shall commence installation of messenger cables and guy assemblies at the outset of construction and work continuously and expeditiously to complete this work prior to the joint use permit expiration date. In the event that this work cannot be completed within 120 days, notify the Engineer 20 calendar days in advance to allow the City to request an extension of the permit.

(B) Standard Specifications

Conform to these Project Special Provisions and the North Carolina Department of Transportation (NCDOT) *Standard Specifications for Roads and Structures*, July 2006, herein after 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 (NCDOT), and the "City" refers to the City of Wilmington, Development Services Department, Traffic Engineering Division.

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

1.2. MATERIAL

(A) Qualified Products

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

Signal Equipment Qualified Products List (QPL) is available on the Department's Web site. 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 web site 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 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

Warrant workmanship and Contractor-furnished equipment for a thirty (30) Day Observation Period.

The thirty (30) Day Observation Period is considered to be a part of work included in the total contract time and must be completed prior to acceptance of the Project.

Final acceptance will occur at the successful completion of the thirty (30) Day Observation Period and after all documentation requirements have been fully satisfied.

(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 successful completion of the 30-day observation period. Include unconditional coverage for all parts and labor necessary or incidental to repair of defective equipment or workmanship and malfunctions that arise during warranty period.

Ensure all Contractor-furnished equipment, including pieces and components of equipment, hardware, firmware, software, middleware, internal components, and subroutines which perform any date or time data recognition function, calculation, or sequencing will support a four digit year format for a period of at least 50 years and will support user-definable parameters for setting the start and end dates for daylight savings time.

Upon successful completion of the 30-day observation period, transfer manufacturer's warranties with proper validation by the manufacturer to the Department of its designated maintaining agency.

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

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

1.3. CONSTRUCTION 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. Deviations from this sequence must be approved by the Engineer. The City of Wilmington will furnish and install the computer equipment, workstations, equipment rack, servers, port server and Ethernet switches for the signal system portions of the project. The equipment provided by the City of Wilmington will be installed prior to the Contractor commencing work. The Contractor will furnish and install all CCTV equipment.

The first item of work on this project shall be the installation of messenger cable and guy assemblies. Commence installation of guys and messenger cable immediately to secure attachment locations joint use poles. Permits for attachment to joint use poles expire 120 days after issuance. In the event that this work cannot be completed within 120 days, notify the Engineer at 20 calendar days in advance to allow the City to request an extension of the permit.

(B) TMC Migration

The central block diagram for the new signal system is shown in the Plans as Sheet 7. It depicts the existing equipment to be retained and the new equipment to be installed. The block diagram depicts equipment to be furnished and installed by the City of Wilmington. Some key components must be upgraded early in the project so the migration can proceed. The proposed sequence is described below.

(1) Step 1

Install the video cabling in the TMC and all cabling in the Signal Shop as well as the DVR while maintaining the existing equipment. Install the fiber-optic cable between the TMC and the Signal Shop

Install the replacement analog video matrix switch, additional video distribution amplifier, video multiplexer and video server while maintaining the existing video

monitoring system. Do not connect the existing monitors to the new analog video matrix switch until the existing cameras are migrated to the new video switch.

(2) Step 2

Install and update the Protronix video management software database and maps with information regarding the new camera locations on the new analog video matrix switch. Complete migration of the CCTV system control equipment before adding any new cameras.

Continue the existing signal system operations by maintaining dial-up communications to the on-street masters for each closed loop control section.

(3) Step 3

Construct the field communications as described in the plan set and move traffic signals from the closed loop signal systems and various isolated signals to the new communications system.

Coordinate with the City of Wilmington for the City to modify the communications addresses and other communications parameters in the new ATMS database to migrate from the existing closed loop system and isolated traffic signal operations over twisted-pair copper communications to the new ATMS software over fiber communications.

Add or relocate CCTV cameras to the GUI and database as shown in the Plans.

(4) Step 4

Upon transferring signals to the new fiber-optic cable, disconnect the dial-up modems to the closed-loop masters.

(5) Step 5

After completing the field integration complete the removal of the TMC equipment shown in the Plans to be removed.

(C) Field Infrastructure

The approach to maximizing communications to all signals throughout the long construction process requires that a new fiber communication route be established separate from the existing twisted-pair network, allowing both to function simultaneously. This network is comprised of:

1) New aerial cable over-lashed to existing twisted-pair copper cable while the copper cable remains in use. This means that the abandoned copper cable remains in place after construction. Certain aerial routes are on new pole lines or deviate from the course of the existed twisted-pair.
2) New underground cable in a new trenched, drilled or bored conduit. In certain situations, as shown in the Plans, the fiber cable will be run through the existing conduit with the existing twisted-pair cable.

(D) Field Migration

Follow the outline of construction described below. Deviations from this sequence must be approved by the Engineer.

(1) Step 1

Install new messenger cable and new guy assemblies within 120 days of notice to proceed.

(2) Step 2

Extend new communications cable to the major arterials (i.e., NC 132, US 421, Shipyard Boulevard) with 96-fiber and 24-fiber cables as shown on the Plans. For this Phase, all fiber can be installed while maintaining communications to these signals via the copper cable network. If necessary, establish new temporary on-street masters to allow central monitoring within each of the signal control channels. Coordinate closely with the City Traffic Engineer to ensure a smooth transition during this process.

During this process, remove the copper communications cable from the conduit along:

- 17th St. from Shipyard Blvd. to Independence Blvd.
- 17th St. from S. College Rd. to John D. Barry Rd.

Extend new communications cable to these two signals via 24-fiber cables. These two signals (only) may be on time-base coordination (TBC) for up to 30 days.

(1) Step 3

Once the communications in Steps 1 and 2 are established and successfully tested, and continuous communications paths are established with outlying signals, begin the process of transferring communications from the old twisted-pair copper network to the new fiber network. Start at the outer edge of the local signal channels and work in the direction toward the TMC. Make every effort to group the work by the existing copper communications channel configurations, allowing channels to be taken offline and disconnected in discrete packages. When the existing copper communications are disconnected, complete the work at the intersection and initiate the fiber communications in a time period no greater than two days per traffic signal in that channel. Exceptions to this requirement must be approved by the Engineer. Notify the City of Wilmington Traffic Engineer at (910) 341-4696 at least two weeks prior to the commencement of work on a particular communications channel to ensure that TBC will be operating and effective during the time of communications interruption. As each signal channel is completed and lit, test intersection communications as per the requirements of "Testing and Acceptance" section of these special provisions.

In one instance, the new fiber network will be connected to a newly-installed NCDOT closed-loop signal system. This location is:

1) US 421 / NC 132 Closed-Loop System (i.e., the Monkey Junction CLS)

The existing splicing and terminations are reused to the greatest extent possible. However, some modifications to the terminations and jumpers are required, as noted in the Plans. In addition, the transceivers will be replaced. Notify the NCDOT Division 3 Traffic Engineer at (910) 251-2693 at least two weeks prior to the commencement of connecting into this network, to ensure that time-base coordination will be operating and effective during the time of interruption of communications. Complete the work at these

intersections and initiate the modified fiber communications in a time period no greater than 72 hours.

(E) Intersection Parameters and Database

The City will provide, both in paper and electronic format, all intersection parameters, database and timing plans in OASIS™ format. The Contractor shall be responsible for loading OASIS™-formatted data into the Model 2070L controllers. The City shall be responsible for graphics for these new intersections.

1.4. CONSTRUCTION METHODS

(A) General

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

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

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

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

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

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

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

(B) Regulations and Codes

Furnish material and workmanship conforming to the *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.

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.

(C) Utility Services

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

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

(D) 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 tropical storm or hurricane.

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

Perform yearly maintenance on all traffic signal conflict monitors. The year shall be defined 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 until the completion of the 30-day Observation Period and the receipt of written notification from the Engineer of final acceptance of the project.

(E) Inspections

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.

(F) 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 unless the Plans indicate otherwise. 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; poles; splice cabinets; cabinet foundations; messenger cable; communications cable; and guy assemblies. Assume ownership of removed poles, messenger cable, interconnect cable, communications cable, and supporting hardware. Return all other Department-owned equipment and material, except for CCTV equipment and material, between 8:00 a.m. and 12:00 p.m., Monday through Thursday, to the Division 3 Traffic Services Office located at 5504 Barbados Boulevard in Castle Hayne, North Carolina, 28429. Return all City-owned equipment and material as well as all CCTV equipment and materials between 8:00 a.m. and 12:00 p.m., Monday through Thursday, to the City Signal Shop located at 206 Operation Center Drive off of River Road in southwest Wilmington (28412). The Department will deduct the cost of Department-owned and City-owned equipment damaged by the Contractor from money due to the Contractor.

(G) Vehicle Preemption Systems

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

(H) 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.

(I) 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 at recessed-screw, barrier type terminal blocks, in junction boxes, in cabinets or in condulets. Unless specifically allowed, connect no more than two conductors to the same terminal screw.

Maintain color coding of wires through splices.

Protect ends of wire and cable from water and moisture.

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

(J) Grounding

Provide a grounding system at all new and revised electrical service points unless otherwise specified. Where existing cabinet foundations are to be reused, existing ground rods installed through the foundations are to be disconnected and cut off flush with the foundation surface. Install new ground rod(s) and grounding conductor(s) according to the Department's *Roadway Standard Drawings*.

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

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

(K) 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.

(L) Traffic Signal Activation

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

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 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 withholding of payments until the as-built documentation is brought current. The submitted as-built may be field-checked by the Engineer at his discretion. If the as-built documentation is found to have an unacceptable number of inaccuracies, the Engineer may withhold payment until the as-built plans are corrected. Include all field installation including the SMFO cable network installed on the drawings.

Store documentation for signal installations in a manila envelope placed in a weatherproof holder mounted within each cabinet or housing for easy access.

Provide a manual, electrical schematic diagram, and cabinet wiring diagram for each control equipment cabinet and piece of equipment in each cabinet. Place a marked-up "redline" copy of the cabinet wiring diagram inside the cabinet immediately upon installation of the cabinet and provide an electronic copy upon final acceptance. Place all manuals and cabinet prints in a weatherproof holder. For any wiring diagrams and electrical schematic diagrams not bound into printed manuals, provide copies in a reproducible format 22"x 34" in size.

Provide at least five hard copies along with one electronic copy (on CD or DVD) of Operator's Manuals containing detailed operating instructions for each different type of model of equipment. Ensue manuals contain instructions for possible modification to equipment.

Provide at least five hard copies along with one electronic copy (on CD or DVD) of maintenance procedures manuals containing detailed preventative and corrective maintenance procedures for each different type of model of equipment.

The Department will provide the Contractor one reproducible and 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.

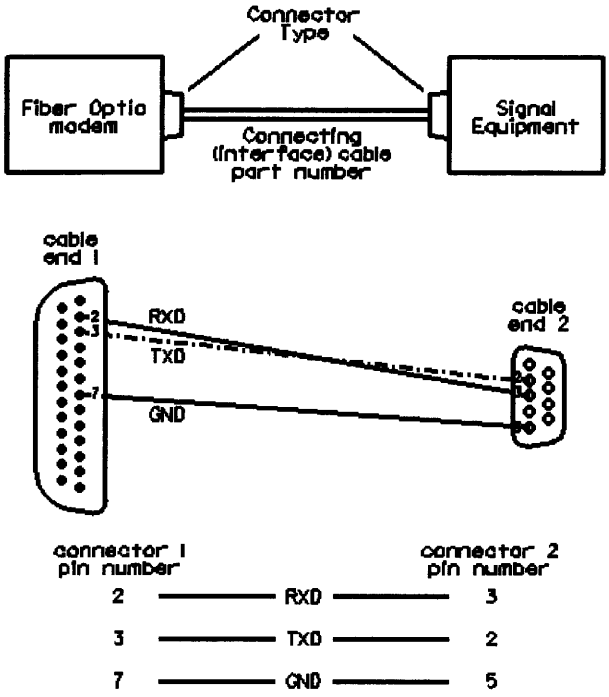
Within 10 days after the observation period begins, furnish one reproducible copy of the draft as-built plans in hard copy format for review. Provide draft hard copy as-built drawings on 22"x 34" bond plan sheets.

Upon receipt of review comments from the Engineer, correct any errors on 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.

(C) 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:



(D) 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 fiber spliced 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 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.

50

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, less than the retainage provided in Article 109-4 of the *Standard Specifications*, 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. All such payments will be made less the retainage provided in Article 109-4 of the *Standard Specifications*.

Payment will be made under:

Pay Item	**Pay Unit**
Mobilization	Lump Sum

3. TEMPORARY TRAFFIC CONTROL

3.1. DESCRIPTION

Furnish, install, maintain, relocate, and remove traffic control devices in accordance with these Project Special Provisions, the Temporary Traffic Control Plan, the MUTCD, and Roadway Standard Drawings to maintain and control vehicular and pedestrian traffic in a safe and efficient manner during signal system construction. Traffic control devices required for this project include work zones signs, flashing arrow panels, changeable message signs, drums, cones, barricades, use of flaggers, truck mounted impact attenuators (TMIA), skinny drums and the use of police.

3.2. GENERAL REQUIREMENTS

(A) Maintenance of Traffic

The Contractor will be required to maintain traffic, both vehicular and pedestrian, within the limits of the project, including roadways that cross or intersect the project, unless otherwise provided for in the contract or approved by the Engineer.

(B) Temporary Traffic Control Plan

(1) General

Maintain vehicular and pedestrian traffic through work zones in accordance with these Project Special Provisions, the Temporary Traffic Control Plan, the MUTCD, and Roadway Standard Drawings.

If a conflict arises, Phasing and Drawings govern over project notes, and local notes govern over general notes.

(2) Phasing

Complete the requirements of each Step before proceeding to the next Step, unless the Plans permit work to be performed concurrently.

(3) Project Notes

General Notes included in the Traffic Control Plan apply at all times during the project.

(4) Alternate to Traffic Control Plan

If desired, submit an alternate traffic control plan a minimum of 30 calendar days in advance of the anticipated implementation to allow for adequate review time. Do not implement alternate plans for traffic control until approved in writing and properly sealed. No adjustment in compensation or extension of the completion date(s) will be allowed due to the review time of the alternate. If an alternate traffic control plan is implemented, the Contractor shall be responsible for any unanticipated changes to subsequent Steps.

(5) Traffic Control Plan not fully covered in the Contract

When the Traffic Control Plan does not cover a particular work function, notify the Engineer to allow for the development or modification of a sealed set of the Traffic Control Plans.

(C) Temporary Lane Closures

(1) General

Operate all equipment and personnel within the designated work area during lane closures. Do not impede or stop traffic for the purpose of performing construction related work on the traffic side of the lane closure, except when called for in the Temporary Traffic Control Plan.

Install lane closures with the traffic flow, beginning with devices on the upstream side of traffic. Remove lane closures against the traffic flow, beginning with devices on the downstream side of traffic.

Vehicles used to install or remove lane closures shall have flashing or rotating beacons.

(2) Intersections

When construction proceeds through an intersection, provide flagger(s) and all other necessary Traffic Control as required by the Plans to direct the traffic through the intersection. When an intersection is signalized, have authorized personnel place the signal in flash mode prior to beginning work in the intersection.

When it is necessary to close a lane of traffic for construction on the departure (downstream) side of an intersection, implement the lane closure on the approach (upstream) side of the intersection. Close the appropriate lane of dual turn lanes that would otherwise turn into the lane that is closed on the departure side of the intersection.

(D) Temporary Road Closures

(1) Traffic Pattern Alterations

Notify the Engineer 21 calendar days, or as specified, prior to altering the existing traffic pattern.

Pre-plan all traffic pattern alterations. Meet with the Engineer to discuss the implementation strategy before altering traffic. The Engineer will then notify the proper authorities and other affected parties as necessary.

(2) Traffic Stoppage

Limit the stoppage of traffic to times specified in the Plans. Provide enough time between consecutive stoppages to allow the traffic queue to deplete.

(E) Traffic Control Supervision

Designate a Traffic Control Supervisor for the project who is knowledgeable of Temporary Traffic Control Plan design, devices and application, and has full authority to ensure traffic is maintained in accordance with the contract. Coordinate with Department's project traffic control representative on all details concerning the Contractor's traffic control program.

Provide a Traffic Control Supervisor or designated representative to be on call at all times to make any necessary changes in the traffic control operations in a timely manner.

Coordinate with and cooperate with traffic control supervisors of adjacent or overlapping construction projects to insure safe and adequate traffic control is maintained throughout the projects at all times including periods of construction inactivity.

(F) Vehicular Access

Maintain continuous and safe vehicular access, including but not limited to, all residences, businesses, schools, police and fire stations, hydrants, other emergency services, hospitals and mailboxes. Conduct operations in such a manner as to limit the inconvenience to property owners.

(G) Pedestrian Access

Maintain continuous and safe pedestrian access, including but not limited to, all residences, businesses, schools and mailboxes. Conduct operations in such a manner as to limit the inconvenience to pedestrians. Pay special attention to pedestrian areas used by visually-impaired pedestrians. Coordinate with local Orientation and Mobility Specialists to make appropriate provisions for visually impaired pedestrians when construction activities will disrupt pedestrian paths that they normally use.

Protect open excavations within or adjacent to areas subject to pedestrian traffic from pedestrian intrusion by surrounding the excavation/hazard with orange plastic mesh construction fencing (also referred to as safety fence, tree protection barricade, warning fence, etc.) or other method approved by the Engineer. Do not use tape, flagging, rope or plastic chain strung between barricades, cones or stakes.

3.3. WORK ZONE TRAFFIC CONTROL DEVICES

(A) General

Furnish, install, maintain, relocate, and remove traffic control devices in accordance with the Plans and Project Special Provisions. All traffic control devices furnished by the Contractor will remain the property of the Contractor, unless otherwise specified in the contract.

(B) Work Zone Signs

Furnish, install, maintain, temporarily cover and uncover signs, relocate and remove work zone signs (barricade mounted) in accordance with the contract.

Furnish, install, maintain and relocate portable work zone signs and portable work zone sign stands in accordance with the contract. When portable work zone signs and portable work zone sign stands are not in use for periods longer than 30 minutes, collapse or remove sign stands and reinstall once work begins again.

Use portable work zone signs only with portable work zone sign stands specifically designed for one another. Portable work zone signs may be roll up or approved composite signs.

(C) Flashing Arrow Panels, Type C

Furnish, install, place, operate, maintain, relocate, and remove flashing arrow panels in accordance with the contract.

(D) Changeable Message Signs

Furnish, install, maintain, relocate and remove changeable message signs in accordance with the contract.

(E) Drums

Furnish, install, maintain, relocate and remove drums with ballast in accordance with the contract.

(F) Cones

Furnish, install, relocate, maintain, and remove cones and reflective cone collars in accordance with the contract.

(G) Barricades

Furnish, erect, maintain, relocate, ballast, and remove barricades in accordance with the contract.

(H) Flaggers

Furnish, relocate, and maintain the flaggers, hats, vests and STOP/SLOW Paddles and any other incidentals necessary to complete the work in accordance with the contract.

(I) Truck Mounted Impact Attenuators

Furnish, install, operate, maintain, and relocate truck mounted impact attenuators (TMIA) in accordance with the contract.

(J) Skinny Drums

Furnish, install, maintain, relocate, and remove Skinny Drums with ballast in accordance with the contract.

(K) Police

Furnish Police Officers and marked Police Vehicles to direct traffic in accordance with the contract.

3.4. MATERIALS

(A) Work Zone Traffic Control Devices

Refer to Division 10 of the *Standard Specifications*.

Supply certifications that meet the requirements of *Standard Specifications* Article 106-3, at least 72 hours prior to use for all used traffic control devices.

Provide traffic control devices that are listed on the Department's Approved Product List or accepted as traffic-qualified by the Work Zone Traffic Control Unit.

(B) Work Zone Signs

(1) General:

Refer to Division 10 of the *Standard Specifications*:

Item	Section
Work Zone Signs	1089-1

Work Zone Sign Supports	1089-2
Barricade Mounted Signs	1089-3

(2) Material Qualifications

Provide portable work zone sign stands, portable signs and sheeting that meet the requirements of NCHRP 350 for Category II traffic control devices and are listed on the Department's Approved Products List and accepted as traffic-qualified by the Work Zone Traffic Control Unit.

Provide portable work zone signs and stands that are crash tested by the manufacturer. The portable work zone sign and the portable work zone sign stand shall be crash tested together as a system.

(C) Flashing Arrow Panels, Type C

(1) General:

Refer to Division 10 of the *Standard Specifications*:

Item	Section
Flashing Arrow Panels	1089-6

(2) Material Qualifications:

Use Flashing Arrow Panels that have been evaluated by NTPEP.

Use Flashing Arrow Panels that are on the Department's Approved Products List and are traffic-qualified by the Work Zone Traffic Control Unit.

(D) Changeable Message Signs

(1) General:

Refer to Division 10 of the *Standard Specifications*:

Item	Section
Changeable Message Signs	1089-7

(2) Material Qualifications:

Use Changeable Message Signs that have been evaluated by NTPEP.

Use Changeable Message Signs that are on the Department's Approved Products List and are traffic-qualified by the Work Zone Traffic Control Unit.

(E) Drums

Refer to Division 10 of the *Standard Specifications*:

Item	Section
Drums	1089-5

Provide drums that are on the Department's Approved Products List or are traffic-qualified by the Work Zone Traffic Control Unit.

(F) Cones

Refer to Division 10 of the *Standard Specifications*:

Item	Section
Cones	1089-5

Provide cones that are on the Department's Approved Products List or are traffic-qualified by the Work Zone Traffic Control Unit.

(G) Barricades

Refer to Division 10 of the *Standard Specifications*:

Item	Section
Barricades	1089-3

Provide barricades that meet the requirements of NCHRP 350 for Category II traffic control devices and are on the Department's Approved Products List and are traffic-qualified by the Work Zone Traffic Control Unit.

(H) Flaggers

Refer to Division 10 of the *Standard Specifications*:

Item	Section
Flaggers	1089-12

(I) Truck Mounted Impact Attenuators

(1) General:

Refer to Division 10 of the *Standard Specifications*:

Item	Section
Truck Mounted Impact Attenuators	1089-9

(2) Material Qualifications:

Use TMIAs that meet the requirements of NCHRP 350 Test Level II or III for work zone traffic control devices and are on the Department's Approved Products List and are traffic-qualified by the Work Zone Traffic Control Unit.

(J) Skinny Drums

Refer to Division 10 of the *Standard Specifications*:

Item	Section
Skinny Drums	1089-5

Provide Skinny Drums that are on the Department's Approved Products List and are traffic-qualified by the Work Zone Traffic Control Unit.

3.5. CONSTRUCTION METHODS

(A) Work Zone Traffic Control Devices

Have all traffic control devices inspected and approved prior to using them on the project.

Install traffic control devices before construction operations begin and during the proper phase of construction. Maintain and relocate traffic control devices during the time they are in use. Keep these devices in place as long as they are needed and immediately remove thereafter. When operations are performed in stages, install only those devices that apply to the present conditions.

(B) Work Zone Signs

(1) Work Zone Signs (Barricade Mounted)

Mount approved composite or roll up signs to barricade rails so that the signs do not cover more than 50 percent of the top two rails or 33 percent of the total area of the three rails. Signs shall be mounted a minimum of 1 foot from the ground to the bottom of the sign.

(2) Work Zone Signs (Portable)

Install the portable work zone sign and sign stand to stand plumb within 10° left and right, within 20° front and back and be capable of standing erect in windy conditions.

When not in use for periods longer than 30 minutes, lay the portable work zone sign flat on the ground and collapse the sign stand and lay it flat on the ground.

Clean the sign face prior to use.

Install portable work zone sign stands to carry roll up or approved composite signs at a minimum height of 1 foot from the bottom of the sign to the edge of pavement elevation on two-lane two-way roadways and at least 5 feet from the bottom of the sign to the edge of pavement elevation on multi-lane roadways.

(C) Flashing Arrow Panels, Type C

Use arrow panels that have the capability to display mode selections.

Do not use straight-line caution or chevron displays.

Mount flashing arrow panels on trucks, trailers, or other mobile units.

(D) Changeable Message Signs

Mount all changeable message signs on a trailer, or truck, as specified in the Plans, designed to adequately support the message board in a level position. Align and sight the changeable message sign to provide optimal driver visibility. Sign operator will adjust flash rate so that no more than two messages will be displayed and be legible to a driver when approaching the sign at the posted speed.

Relocate the units for the various stages of construction as shown in the Plans or as needed to adequately inform the motorists.

Provide an experienced operator for the changeable message sign during periods of operation to ensure that the messages displayed on the sign panel are in accordance with the Plans and in accordance with message content guidelines. Ensure that the message sign is illuminated properly to meet the existing light conditions, and that all adjustments for operation of the sign are made as needed to properly guide motorists.

Expedite repairs due to failure, malfunction, or damage to a changeable message sign. Furnish another changeable message sign (approved by the Engineer and at no additional cost) during the repair time. Repair and/or replace changeable message sign immediately; otherwise, suspend all construction activities requiring the use of the sign until the sign is restored to operation.

(E) Drums

Use the same type of reflective sheeting on all drums installed at any one time during the life of the project.

Use a ballasting method in accordance with the manufacturer's specification. When using tire ballasting method, use approved manufacturer's tires and place the tires flush with the ground.

(F) Cones

Use reflective collars on all cones used between dusk and dawn. Use the same type of reflective sheeting on all cone collars installed at any one time during the life of the project. Do not use cones in the upstream taper of lane or shoulder closures for multilane roadways and for no longer than 3 consecutive days.

(G) Barricades

At the end of the workday, properly close the road where construction equipment accesses a road closure through Type III barricades.

Use sandbags or other approved ballasting methods to prevent overturning of barricades by the wind. If needed, place sandbags or other acceptable ballasting on the feet of the frame. Do not ballast barricades with objects such as rocks or chunks of concrete.

Do not anchor barricades to any pavement surfaces unless such anchoring method has passed the crash test requirement of NCHRP 350 for work zone category II devices.

Point the striped diagonals on the barricade rails in the direction traffic is being directed.

(H) Flaggers

Provide the services of competent and properly equipped flagger(s) (see *Roadway Standard Drawing* No. 1150.01) at locations and times for such periods as necessary for the control and protection of vehicular and pedestrian traffic. Use flagging methods that comply with the guidelines in the MUTCD.

(I) Truck Mounted Impact Attenuator

Prior to use, furnish the Engineer detailed brochures, specifications, and other manufacturer's data that completely describes the performance criteria, installation, and instructions for the TMIA.

Use only TMIAs that meet the crash test requirements of Standard Specifications Article 1089-9(A).

Do not park TMIAs against rigid objects (i.e. bridge piers or portable concrete barrier) except as a temporary safety measure and in no case for longer than 72 hours. Install the TMIA on a truck that is fully operational, in good running order, and in accordance with the manufacturer's specifications.

Use the appropriate lighting and delineation on the truck and TMIAs as shown in the contract.

(J) Skinny Drums

Use the same type of reflective sheeting (minimum of Type III) on all skinny drums installed at any one time during the life of the project.

Use ballasting methods in accordance with the manufacturer's specification.

Use skinny drums as follows:

Skinny drums may be used in lieu of cones.

Space skinny drums equal in feet to the posted speed limit, not to exceed 50 foot spacing in the tangent sections on multilane roadways.

Do not use skinny drums as follows:

Do not use skinny drums for tapers on multilane roadways.

Do not substitute skinny drums for normal drums or intermix with drums unless directed buy the Engineer or the Traffic Control Plans.

Do not use skinny drums to separate two directions of travel that have been shifted on a multilane roadway unless directed by the Engineer or Traffic Control Plans.

Do not use skinny drums for lane closures on multilane roadways for longer than 3 consecutive days.

(K) Police

Use uniformed police officers and marked police vehicles equipped with police lights mounted on top of the vehicle and police vehicle emblems to direct or control traffic as required by the Plans or by the Engineer.

Use a police officer(s) when an existing traffic signal must me taken out of operation in order to remove and replace the existing cabinet and controller. Use a police officer(s) when a traffic signal must be deactivated while constructing a conduit entrance into an existing cabinet foundation (subject to the Engineer's prior approval), while overlaying an existing cabinet foundation with a new preformed foundation and while removing and replacing an existing foundation with a new preformed foundation in the same location.

(L) Pedestrian Safety

Install measures for separating pedestrian traffic from the work area and from adjacent vehicular traffic where pedestrian paths are evident or sidewalks are present. Use protective barricades, warning and guidance devices and signs to provide a safe, well-defined passageway for pedestrians. When a sidewalk must be closed temporarily to perform construction work, refer to Chapter 6D, "Pedestrian and Worker Safety," and Typical Applications 28 and 29 (TA-28 and TA-29) of the 2003 Edition of the *Manual on Uniform Traffic Control Devices* (MUTCD 2003) for appropriate pedestrian traffic control measures. The MUTCD 2003 is available for downloading via the Internet from the following web address: http://mutcd.fhwa.dot.gov

3.6. MAINTENANCE AND INSPECTION

(A) Work Zone Traffic Control Devices

Submit a proposed traffic control device maintenance schedule and checklist for approval prior to construction. Perform continuous maintenance and scheduled inspections of traffic control devices. Review and maintain all traffic handling measures to ensure that adequate provisions are in place for the safety of the public and workers.

Maintenance activities include cleaning of dirty devices or repair or replacement of traffic control devices that are damaged (torn, crushed, discolored), displaced by traffic or other means, or deteriorated beyond effectiveness.

If there are traffic control devices in use, perform inspection on a daily basis.

The name and telephone number of the agency, contractor or supplier may be shown on the non-retroreflective surface of all channelizing devices. Use letters and numbers that are a non-reflective color and not over 2 inches in height.

(B) Changeable Message Signs

Perform all maintenance operations recommended by the manufacturer of the sign. Include the periodic cleaning of the sign face and associated solar panels in maintenance operations.

(C) Drums

At no cost to the Department, immediately replace any drum, ballast or reflective sheeting that is torn, crushed, discolored, or otherwise damaged.

(D) Cones

At no cost to the Department, immediately replace any cone or reflective collar that is torn, crushed, discolored, or otherwise damaged.

(E) Barricades

At no cost to the Department, periodically inspect barricades and ballast. Replace any ballast as needed, including sandbags that have loose sand outside the bag.

(F) Truck Mounted Impact Attenuators

Repair or replace within 24 hours any truck mounted impact attenuator that becomes crushed or otherwise damaged so that it will perform its intended purpose. Suspend all construction activities until the attenuator is repaired or replaced. Provide safe control of traffic until the attenuator has been repaired by using approved methods.

(G) Skinny Drums

At no cost to the Department, immediately replace any Skinny Drum, ballast, or reflective sheeting that are torn, crushed, discolored, or otherwise damaged.

3.7. FAILURE TO MAINTAIN TRAFFIC CONTROL

Failure to maintain temporary traffic control measures and traffic control devices in accordance with this Special Provision may result in formal notification of noncompliance. Implement remedial action immediately for imminent danger situations as directed. Implement remedial action within 48 hours after notification of a safety issue that is not an imminent danger situation.

Failure to comply may result in having the work performed with available forces and equipment. The Contractor is held responsible for this work, and the actual cost of performing said work will be deducted from the moneys due the Contractor on the contract. In cases of willful disregard for the safety of the public, the Engineer may proceed immediately to implement the measures necessary to provide the appropriate level of traffic control to ensure that the safety of all concerned parties is maintained.

3.8. MEASUREMENT AND PAYMENT

Payment at the contract unit prices for the various items in the contract will be full compensation for all work covered by this Special Provision.

Work zone signs (barricade mounted) will be measured and paid for as the actual number of square feet that have been satisfactorily installed on barricades and accepted by the Engineer. Payment will be made for the initial installation only. Relocation of signs will be considered incidental to the measurement of the quantity of signs.

Work zone signs (portable) will be measured and paid for as the actual number of square feet that have been satisfactorily installed and accepted by the Engineer. Payment will be made for the initial installation only. Relocation of signs will be considered incidental to the measurement of the quantity of signs.

No direct payment will be made for stationary work zone sign supports or portable work zone sign stands. All stationary work zone sign supports or portable work zone sign stands are considered incidental to the work of providing work zone signs.

Flashing arrow panels, Type C will be measured and paid for as the maximum number of panels that have been satisfactorily placed and accepted by the Engineer in use at any one time during the life of the project as required by the contract.

Changeable message signs will be measured and paid for as the maximum number of changeable message signs acceptably placed and in operation, at any one time during the life of the project. Payment for changeable message signs will be made according to the following schedule:

70% of the unit bid upon placing the unit in service.
20% of the unit bid when the project is 50% complete.
10% of the unit bid when the project is 100% complete.

Drums will be measured and paid for as the maximum number of drums acceptably placed and in use at any one time during the life of the project. Relocation of drums is considered incidental to the measurement of the quantity of drums and no separate payment will be made.

Cones will be measured and paid for as the maximum number of cones acceptably placed and in use at any one time during the life of the project. Relocation of cones is considered incidental to the measurement of the quantity of cones and no separate payment will be made.

Barricades (Type III) will be measured and paid for as the maximum number of linear feet of barricades acceptably placed and in use at any one time during the life of the project. Measurement will be made of the total length of each barricade along one rail. Relocation of barricades is considered incidental to the measurement of the quantity of barricades.

Flaggers (hour) will be measured and paid for as the actual number of hours that each flagger is satisfactorily provided and accepted by the Engineer during the life of the project. The Department will pay for all flaggers that are used in conjunction with a lane closure. Flaggers used for operations not involving a lane closure will be considered incidental to that operation and no payment will be made.

TMIA will be measured and paid for as the maximum number of TMIAs acceptably placed and in use at any one time during the life of the project for all operations other than Moving and Mobile Operations. TMIAs are considered incidental to all moving and mobile operations. In the case of emergency situations, TMIAs will not be paid for when payment has already been made for a stationary unit. Relocation of TMIAs are considered incidental to the measurement of the quantities of TMIAs and no separate payment will be made.

Skinny drums will be measured and paid for as the actual number of skinny drums satisfactorily placed, accepted by the Engineer and in use at any one time during the life of the project. Relocation of skinny drums is considered incidental to the measurement of the quantity of skinny drums and no separate payment will be made.

Police will be measured and paid for as the actual number of hours that each police officer is provided during the life of the project as approved by the Engineer and subject to the following conditions:

- Measurement and payment will not exceed 3 hours per police officer provided to direct traffic at a given signalized intersection during the removal and replacement of a controller cabinet.
- Measurement and payment will not exceed 1 hour per police officer provided to direct traffic at a given signalized intersection while constructing a new conduit entrance into an existing cabinet foundation, overlaying an existing

cabinet foundation with a new preformed foundation or replacing an existing foundation with a new preformed foundation in the same location.

There will be no direct payment for marked police vehicles as they are considered incidental to the pay item.

No measurement will be made of orange plastic mesh construction fencing or other approved methods of protecting open excavations/hazards from pedestrian intrusion as such measures will be considered incidental to the excavation work.

Payment will be made under:

Pay Item	Pay Unit
Work Zones Signs (Barricade Mounted)	Square Foot
Work Zones Signs (Portable)	Square Foot
Flashing Arrow Panel, Type C	Each
Changeable Message Sign	Each
Drums	Each
Cones	Each
Barricades (Type III)	Linear Foot
Flaggers	Hour
TMIA	Each
Skinny Drums	Each
Police	Hour

4. SIGNAL HEADS

4.1. DESCRIPTION

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

4.2. MATERIALS

(A) General

Fabricate vehicle 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 from sheet aluminum.

Paint all surfaces inside and outside of signal housings and doors. Paint outside surfaces of tunnel and traditional visors, messenger cable mounting assemblies as well as pole and pedestal mounting assemblies. Have electrostatically-applied, fused-polyester paint in highway yellow (Federal Standard 595A, Color Chip Number 13538) 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.

Have the interior surfaces of tunnel and traditional visors painted an alkyd urea black synthetic baking enamel with a minimum gloss reflectance and meeting 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.

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.

(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 light emitting diode (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.

The City of Wilmington and NCDOT will modify all existing vehicle signal heads on this project to include LEDs. The Contractor is not responsible for modifying existing vehicle signal heads to include LEDs. The Contractor is responsible for installing all new vehicle signal heads on this project in accordance with the Plans.

(C) **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 Traffic Signal 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 Qualified Products 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 "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 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 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.

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 within 45 days of receipt of modules that have failed at no cost to the Department. Provide manufacturer's warranty documentation to the Department during evaluation of product for inclusion on Qualified Products List (QPL).

Inclusion of the LED traffic signal modules on the Department's Qualified Products List for traffic signal equipment requires:

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 the VTCSH Circular Supplement. (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 will 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.

(D) LED Arrow Signal Modules

Ensure arrow modules meet or exceed the electrical and environmental operating requirements of sections 3 and 5 of the Interim Purchase Specification of the ITE VTCSH part 2 Light Emitting Diode (LED) Vehicular Traffic Signal Modules (hereafter referred to as VTCSH-2), the chromaticity requirements of Section 4.2, and the requirements of Sections 6.3 (except 6.3.2) and 6.4 (except 6.4.2).

Provide modules that meet the requirements of Table 5-1. Ensure that fluctuations of line voltage have no visible effect on the luminous intensity of the indications. Design the module to have a normal operating voltage of 120 VAC rms, and measure all parameters at this voltage.

Table 5-1

Maximum Power Consumption (in Watts) at 77°F

	Red	Yellow	Green
12-inch arrow	9	10	11

Certify that the module meets the requirements of VTCSH-2, Section 5.7. Ensure all wiring meets the requirements of Section 5.1 of the VTCSH-2. In addition, spade terminals appropriate to the lead wires and sized for a #10 screw connection to the existing terminal block in a standard signal head.

Ensure that the module is compatible with signal load switches and conflict monitors. Design the module to provide sufficient current draw to ensure proper load switch operation while the voltage is varied from a regulated 80 Vrms to 135 Vrms. Design off-state for green and yellow modules to be 30Vrms or less, and on-state to be 40 Vrms or greater. Design the voltage to decay to 10 Vrms or less in 100 milliseconds. Ensure that the control circuitry prevents current flow through the LEDs in the off state to avoid a false indication.

Design all modules to meet existing NCDOT monitor specifications for each of the following types of signal monitors: NEMA TS-1 conflict monitors (including so-called NEMA plus features such as dual indication detection and short yellow time detection); NEMA TS-2 Malfunction Management Units (MMU); and 170 cabinet Type 210ECL and 2010ECL conflict monitors (including red monitoring and so-called plus features such as dual indication detection and short yellow time detection).

Ensure that the modules and associated onboard circuitry meet Class A emission limits referred to in Federal Communications Commission (FCC) Title 47, Subpart B, Section 15 regulations concerning the emission of electronic noise.

Provide modules that meet the requirements of Table 5-2. Design and certify the modules to meet or exceed the maintained minimum luminous intensity values throughout the warranty period based on normal use in a traffic signal operation over the operating temperature range. Test the Red and Green arrow modules for maintained luminous intensity at 165°F (ITE 6.4.2.2). Use LEDs that conform to the chromaticity requirements of VTCSH-2, Section 2 throughout the warranty period over the operating temperature range. Make chromaticity coordinate compliance measurements at 77°F.

Table 5-2
Minimum Initial and Maintained Luminance for Arrow Indications (in cd/ft^2)

	Red	Yellow	Green
Arrow Indication	511	1022	1022

Design the modules as retrofit replacements for installation into standard incandescent traffic sections that do not contain the incandescent lens, reflector assembly, lamp socket and lens gasket. Ensure that installation does not require special tools or physical modification for the existing fixture other than the removal of the incandescent lens, reflector assembly, lamp socket, and lens gasket.

Provide modules that are rated for use in the operating temperature range of -40°F to +165°F. Ensure that the modules (except yellow) meet all specifications throughout this range. Fabricate the module to protect the onboard circuitry against dust and moisture intrusion per the requirements of NEMA Standard 250-1991 for Type 4 enclosures to protect all internal components.

Design the module to be a single, self-contained device with the circuit board and power supply for the module inside and integral to the unit.

Design the assembly and manufacturing process for the module to ensure all internal components are adequately supported to withstand mechanical shock and vibration from high winds and other sources. Group the individual LEDs such that a catastrophic loss or the failure of one LED will result in the loss of not more than 20 percent of the signal module light output. Solder the LEDs to the circuit board.

Fabricate the lens and signal module from material that conforms to ASTM specifications. Ensure enclosures containing either the power supply or electronic components of the module are made of UL94VO flame retardant materials. The lens of the signal module is excluded from this requirement.

Permanently mark the manufacturer's name, trademark, model number, serial number, date of manufacture (month & year), and lot number as identification on the back of the module.

Permanently mark the following operating characteristics on the back of the module: rated voltage and rated power in watts and volt-amperes.

If a specific mounting orientation is required, provide permanent markings consisting of an up arrow, or the word "UP" or "TOP" for correct indexing and orientation within the signal housing.

Provide a lens that is integral to the unit with a smooth outer surface and UV stabilized to withstand ultraviolet exposure for a minimum period of 60 months without exhibiting evidence of deterioration. Coat the front of a polycarbonate lens to make it more abrasion resistant. Seal the lens to the module to prevent moisture and dust from entering the module.

Tint the red, yellow, and green lens to match the wavelength (chromaticity) of the LED.

Ensure that the module meets specifications stated in Chapter 2, Section 9.01 of the ITE Equipment and Materials Standards for arrow indications. Design arrow displays to be solid LEDs (spread evenly across the illuminated portion of the arrow or other designs), not outlines. **Determine the luminous intensity using the CALTRANS 606 method or similar procedure.**

Burn In - Energize the sample module(s) for a minimum of 24 hours, at 100 percent on-time duty cycle, at a temperature of +165°F before performing any qualification testing. Any failure of the module, which renders the unit non-compliant with the specification after burn-in, is cause for rejection. All specifications will be measured including, but not limited to:

(a) **Photometric (Rated Initial Luminous Intensity)** - Measure at +77°F. Measure luminous intensity for red and green modules upon the completion of a 30 minute 100 percent on-time duty cycle at the rated voltage**. Measure luminous intensity for yellow modules immediately upon energizing at the rated voltage**.

(b) **Chromaticity (Color) -** Measure at +77°F. Measure chromaticity for red and green modules upon the completion of a 30 minute 100 percent on-time duty cycle at the rated voltage. **Measure chromaticity for yellow modules immediately upon energizing at the rated voltage**.

(c) **Electrical -** Measure all specified parameters for quality comparison of production quality assurance on production modules. (rated power, etc)

NCDOT evaluates and approves all LED Traffic Signal modules for the QPL by a standard visual inspection and blind operational survey, a compatibility test, current flow, and other random tests, in addition to reviewing the lab reports and documentation from the manufacturer. The tests are conducted at the Traffic Electronics Center in Raleigh. Ensure each 12-inch arrow module is visible at 300 feet during sway conditions (extended view) until obscured by the visor. Sufficient luminance during the extended views will be determined during this blind survey evaluation.

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 within 45 days of receipt of modules that have failed at no cost to the Department. Provide manufacturer's warranty documentation to the Department during evaluation of product for inclusion on Qualified Products List (QPL).

(E) 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 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. 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) Relocate Existing Vehicle Signal Heads

Relocate existing vehicle signal heads by placing an existing vehicle signal head at a different location, and running and attaching new signal cable to the vehicle signal head at the new location. Complete signal cable runs before disconnecting service to the existing vehicle signal heads. Do not disconnect existing vehicle signal heads until the new signal cable runs are wired into the controller cabinet and ready to be connected for immediate reactivation of vehicle signal heads. Disconnect, immediately relocate, and reactivate the existing vehicle signal heads. Instead of relocating existing vehicle signal heads and at the Contractor's option, install new vehicle signal heads of the same arrangement, display, and size at no additional cost to the Department.

4.4. MEASUREMENT AND PAYMENT

*Vehicle signal head (_____)*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, and mounting assemblies as these will be considered incidental to furnishing and installing 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.

Relocate existing vehicle signal head will be measured and paid for as the actual number of existing vehicle signal heads of each type relocated, rewired, and accepted.

Payment will be made under:

Pay Item	Pay Unit
Vehicle Signal Head (12", 3 Section)	Each
Vehicle Signal Head (12", 4 Section)	Each
Vehicle Signal Head (12", 5 Section)	Each
Signal Cable	Linear Foot

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. MATERIAL

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 new messenger cable and new guy assemblies within 120 days of notice to proceed. Refer to Section 1, "General Requirements", of these Project Special Provisions for additional requirements.

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 dead-end 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 attachment messenger cable. Do not attach messenger cable to metal or concrete 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.

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 Burndy clamps (UCG25RS) at each end. If existing poles do not have a grounding system, install new grounding system that complies with the Construction Methods in the "Wood Poles" section of these Project Special Provisions for bonding messenger cable. Bond messenger cable that supports communications cable to pole ground at 1300-foot intervals.

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

On joint use poles at signal and ITS equipment installations (i.e., controller cabinets, CCTV cabinets, DMS cabinets, etc.), do not use existing utility company grounds. Install a grounding 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.

6.2. MATERIAL

(A) General

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

Provide conduit that meets the following: ASTM D 638 Tensile Strength – 3,000 psi, min; Elongation – 400 percent, min ASTM D 1238 Melt Index – 0.4 maximum 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 a smooth outer wall and either a smooth or ribbed inner wall. Ensure conduit is capable of being coiled on reels in continuous lengths, transported, stored outdoors, and subsequently uncoiled for installation without affecting its properties or performance.

(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:

- Comply with Subarticle 1400-2(H) Duct and Conduit Sealer of the *Standard Specifications.*
- Contains no asbestos;
- Designed for use with electrical and telecommunications cables housed in conduits
- 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.

6.3. CONSTRUCTION METHODS

(D) 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.

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

Where cable is not immediately installed and 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.

Where the Plans call for installation of 1.25" HDPE conduit, the Contractor may substitute 2" HDPE conduits in the same quantity at no additional cost to the Department. However, 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 for all underground communications cable routes unless shown otherwise on the Plans.

Install a minimum of two conduits for all directional drill installations beneath roadways, railroad rights-of-way or streams or which run longitudinally beneath a sidewalk.

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 with 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. Pull tracer wire simultaneously in a continuous length with the fiber-optic cable. Where multiple pulls of fiber-optic cable are required and conduit is placed in the same trench, only one tracer wire is required. Where multiple pulls of fiber-optic cable are required and conduits may separate into individual trenches, install a tracer wire in each conduit run. Provide

waterproof butt splices where tracer wire is spliced. Splicing is allowed only in cabinets and junction boxes. Label all tracer wires entering the equipment cabinet.

(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. For unpaved areas, backfill excavations with removed material, tamp the backfilled material and rake smooth the top 1-1/2 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.

(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.

(E) 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. 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" 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. Finish unpaved areas flush with surrounding natural ground.

(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.

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 the following structures, the minimum clearance requirements are:

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

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

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

(2) Directional Drill Operations

Provide grounding for the drill rig in accordance with the manufacturer's recommendations. Place excavated material near the top of the working pit and dispose of properly. Backfill pits and trenches to facilitate drilling operations immediately after drilling is completed.

Use drill head suitable for type of material being drilled and sized no more than 2 inches larger than the outer diameter of the conduit. Direct drill to obtain proper depth and desired destination. Pressure grout with an approved bentonite/polymer slurry mixture to fill all voids. Do not jet alone or wet bore with water.

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

Once drill head has reached final location, remove head, and install back reamer of appropriate size (no more than 2 inches larger than outer diameter of conduits) to simultaneously facilitate back reaming of drill hole and installation of conduit. Back reamer is sized larger than actual conduits to ensure conduits are not adversely subjected

to deviations caused by the original drill operation and are as straight as practical in their final position.

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

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

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

(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.

(E) Maximum Length of Directional Drill

The length of a directional drill shall not exceed 1000 feet measured horizontally along the route of the directionally drilled conduit(s), unless otherwise approved by the Engineer. On or before the 1000-foot mark, transition from directional drill to trenching to continue the route up to the maximum spacing of 1500 feet between junction boxes. Alternatively, continue the route by begin a successive directional drill and installing an oversized heavy-duty junction box where the two directional drilled conduit runs meet.

(F) Splicing and Coupling of HDPE Conduit

Install HDPE in continuous lengths. Splicing or joining of HDPE conduits is prohibited. If unforeseen problems are encountered at a specific location during installation necessitate the splicing or coupling of HDPE conduits, obtain the Engineer's prior approval to install a junction box and splice or join the conduits in the junction box using an Engineer-approved splicing or coupling method. Approval of splicing/coupling at one location does not constitute approval for splicing/coupling conduits at any other location on the project.

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 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 as Underground Conduit .

No measurement will be made of vertical segments, non-metallic conduit, metallic conduit, sealing devices, pull lines and miscellaneous fittings as these will be considered incidental to conduit installation. No measurement will be made of restoration of paved and unpaved ground surfaces with like materials, including but not limited to backfill, graded stone, paved materials, seeding and mulching, as this work will also be considered incidental to conduit installation.

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 near edge of the cabinet foundation as these will be considered incidental to riser installation.

Conduit will be paid for per linear foot based on quantity and size of conduits. As examples, an installation of a single 1.25" HDPE conduit would be paid as:

Directional Drill (1)(1.25") Linear Foot

An installation of two 1.25" and four 2" HDPE conduits would be paid as:

Directional Drill (2)(1.25")&(4)(2") Linear Foot

Payment will be made under:

Pay Item	**Pay Unit**
Tracer Wire	Linear Foot
Underground Conduit (2)(1.25")	Linear Foot
Underground Conduit (1)(2")	Linear Foot
Directional Drill (1)(1.25")	Linear Foot
Directional Drill (2)(1.25")	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. MATERIAL

(A) General

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

Provide junction box covers with standard *Traffic Signal* or *NCDOT 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 *NCDOT 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.

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

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.

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 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.

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, graded stone, and grounding systems as these 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 (Oversized, Heavy-Duty)	Each
Junction Box (Special-Sized, Heavy-Duty)	Each

8. EXTENSION OF EXISTING FIELD WIRING

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 (2) 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 twenty (20) terminals with each terminal having two (2) 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 be 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.

The front door of the enclosure shall be equipped with a Corbin No. 2 lock and latch.

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 than 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-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 Cabinet Where Existing Cabinet is Pole-Mounted

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. Do not bond 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 bond 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 using gel-filled butt splice connectors 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.* Engineer-approved replacement of loop lead-ins will be paid as provided for under *Lead-In Cable.*

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 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

Unless otherwise specified in the Plans, furnish Class 3 or better wood poles to mount CCTV cameras and cabinets that are a minimum of 60 feet long to permit the CCTV camera to be mounted 45 feet above the ground at the pole.

(D) Service Pole

Furnish Class 4 or better wood poles for mounting aerial electrical service assemblies (i.e., service riser with disconnect and meter base) and attaching aerial service drops. Provide poles of sufficient length to attain the vertical clearance beneath the service drop required by the NESC and power company but no less than 25 feet in length.

9.3. CONSTRUCTION METHODS

Install poles at location 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 ft.	14 ft.
45-50 mph	16 ft.	18 ft.
≥ 55 mph	22 ft.	22 ft.

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 pole at manufacturer's recommended depth or at a depth equal to 10% of the pole length plus two feet, whichever is greater, but in no case less than of 5 feet deep. Ensure the pole is within two degrees of vertical when fully loaded.

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

On new Department-owned or City-owned poles, install a grounding system consisting of number 4 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 furnished, installed, and accepted.

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

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

Payment will be made under:

Pay Item	Pay Unit
Wood Pole	Each
CCTV Wood Pole	Each
Service Pole	Each

10. GUY ASSEMBLIES

10.1. DESCRIPTION

Furnish and install guy assemblies with all necessary hardware.

10.2. MATERIAL

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:

(A) Expanding anchor - provide steel construction with protective paint or heat shrink of 6 mil plastic to protect metal during shipping and storage.

(B) Screw anchor - provide hot-dipped galvanized steel construction.

(C) 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 new pole grounding system as described below.

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

Install new guy assemblies within 120 days of notice to proceed. Refer to Section 1, "General Requirements", of these Project Special Provisions for additional requirements.

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 using Burndy Clamp (UCG25RS) or equivalent. If existing City or Department poles do not have a grounding system install a grounding system consisting of number 4 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 attach to existing guy assemblies unless specifically approved by owner.

10.4. MEASUREMENT AND PAYMENT

Down Guy Assembly will be measured and paid as the actual number of direct down guy assemblies furnished, installed, and accepted.

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

Aerial Guy Assemblies will be measured and paid as the actual number of aerial guy assemblies furnished, installed, and accepted without regard to the length of the aerial guy. Measurement and payment for aerial guy will include all horizontal components of the aerial guy assembly. The down guy or sidewalk guy that makes up the vertical component of the aerial guy assembly will be measured and paid for separately under its respective pay item.

No measurement will be made of guy cable, guy guards, anchors, clamps, strandvises, 2" galvanized pipe, pole plates, or other fittings or of 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
Down Guy Assembly	Each
Sidewalk Guy Assembly	Each
Aerial Guy Assembly	Each

11. RISER ASSEMBLIES

11.1. DESCRIPTION

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

11.2. MATERIAL

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

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

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

Provide Tyco™(Raychem™) part number 704289-000 (formerly FOSC-ACC-CABLE-SEAL-2-NW) or equivalent heat shrink tubing retrofit kits for the installation of new fiber-optic in existing risers.

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-inch riser with weatherhead for electrical service.

Use separate 2-inch riser with weatherhead for signal cables (bundled). Use separate 2-inch riser with weatherhead for the combination of all lead-in and twisted-pair communications cable. Install 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 turn into the bottom of the cabinet. Standard 90-degree elbows for 1-inch conduit have a 5.75-inch centerline 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 cable can be installed without violating its minimum bending radius. Install fiber-optic cable so it does not share a riser with any other cable.

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

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 or pole attachment hardware 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 near edge of 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.

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. MATERIAL

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

(A) Loop Sealant

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

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

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

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

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

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

(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.

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 Web site.

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.

Twist loop conductor pairs a minimum of 5 turns per foot from where conductors leave saw slot to junction box. 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. MATERIAL

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 megaohms. 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 cable assemblies with grounding systems, fiber-optic cable storage racks (snow shoes), communications cable identification markers, lashing wire, and all necessary hardware.

14.2. MATERIAL

(A) SMFO Communications Cable

Furnish single-mode fiber-optic communications cable that is pre-approved on the Department's QPL. 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* and the following requirements. Provide six fibers per buffer tube in cables containing 6, 12, 24 and 36 fibers. Provide 12 fibers per buffer tube in cables containing 48 or more fibers. 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 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 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".

(B) Drop Cable Assembly

Furnish factory-preassembled, factory-preterminated drop cable assemblies with integral pre-attached interconnect center/patch panels designed to mount inside equipment cabinets. Furnish drop cable assemblies to provide communications links between splice enclosures and fiber-optic transceivers.

Provide an assembly that is factory-assembled with the designated drop cable length as shown in the Plans. The assembly may be rail mounted or rack mounted. If the assembly is rack mounted it shall occupy only one rack unit.

Construct the drop cable assembly using single-mode, fiber-optic cable containing a minimum of six fibers. Furnish patch panel with a minimum of six ST connectors.

Furnish low bend radius single mode cable described above. A low bend radius cable is defined as a fiber-optic cable whose manufacturer-specified minimum bend radius does not exceed 5 inches when loaded and 4 inches when installed. Provide outdoor-rated, non-armored, riser rated cable. Provide UV-rated cable.

Use single mode fiber-optic cable that does not exceed attenuation of 0.30 dB/km at 1550 nm and 0.40 dB/km at 1310 nm. Ensure attenuation loss for complete drop cable assembly does not exceed a mean value of 1.5 dB.

Provide metal connector housing, ceramic ferrules and coupler inserts. Provide a connector attenuation of .20 dB and a reflectance of < -40 dB SPC/<-55 dB UPC. Use heat-cured epoxy material.

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

Furnish SMFO jumpers that are a minimum of 3 feet in length with factory-assembled ST connectors on each end for connecting fiber-optic transceivers to the fiber-optic patch panels on the drop cable assemblies. Ensure SMFO jumpers meet the operating characteristics of the SMFO cable with which they are to be coupled.

(C) Communications Cable Identification Markers

Furnish yellow communications cable identification markers that are resistant to fading when exposed to UV sources and changes in weather. Use markers designed to coil around fiber-optic cable 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 and contain the following text in black:

WARNING
CITY OF WILMINGTON FIBER-OPTIC CABLE
CONTACT TELEPHONE NO.: (910) 341-4696

WARNING
CITY OF WILMINGTON 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

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

(D) Fiber-Optic Cable Storage Guides

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

Furnish fiber-optic storage guides (snowshoes) that are non-conductive and resistant to fading when exposed to UV sources and changes in weather. Ensure snowshoes have a captive design such that fiber-optic cable will be supported when installed in the rack and 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.

(E) Aerial Cable Protectors

Furnish SquirrelGuard™ manufactured by Osmose Utility Services, Inc., or a Department-approved equivalent to protect aerial fiber-optic communications cable from damage by squirrels and from tree limb abrasion. Provide cable protectors that are designed to fit over the cable as a protective sleeve and that have a round shape. Size the cable protectors to properly fit over the cable(s) lashed to messenger cable in accordance with the manufacturer's guidelines. Provide cable protectors that are constructed of rugged, durable dielectric material that is black in color, that is formulated for outdoor use and to be UV-resistant, and that is designed for a service life of at least 10 years.

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 cabinet door.

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

Before installing cable, provide three copies of 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 or conduits. Do not share risers or conduits containing fiber-optic cable with other type cable unless the Plans specify otherwise or the Engineer directs or approves otherwise.

(B) Aerial Installation

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

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

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

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.

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

Store 100 feet of each fiber-optic cable on all cable runs that are continuous without splices as shown on the Plans. Obtain approval for spare cable storage locations. Store spare fiber-optic cable on fiber-optic cable storage racks (snow shoes). Locate spare cable storage in the middle of spans between termination points. Do not store spare fiber-optic cable over the roadway or driveways.

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

(C) Underground Installation

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

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

Use a 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.

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

(D) Installation of Drop Cable Assembly

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

For existing riser locations, remove the existing weatherhead. Install fiber-optic cable with heat shrink tubing.

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 50 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.

Mount drop cable assembly using screws to either the rack frame or rack mount in 19-inch communications rack in a location convenient to the fiber-optic transceiver. Mount the drop cable assembly close enough to the fiber-optic transceiver to connect them using 3-foot fiber-optic jumpers. Secure drop cable in cabinet using cable ties and wire management hardware.

Install SMFO jumpers between the appropriate connectors on the patch panel and the corresponding connectors on the fiber-optic transceiver.

Label all connectors, pigtails, and the connector panel. At the aerial splice enclosure 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.

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

(E) Aerial Cable Protectors

As directed by the Engineer, at locations where aerial fiber-optic communications cables are subject to damage by squirrels or from tree-limb abrasion, install cable protectors over the fiber-optic cable that are of sufficient length to protect the cable from the potential threat as directed by the Engineer. Do not install aerial cable protectors at any locations without the prior approval of the Engineer. Do not install cable protectors for lengths of application that are shorter or longer than approved/directed by the Engineer.

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 following conditions: 75% of the payment will be made upon acceptance of the installed cable and the remaining 25% of the payment will be made following final acceptance (including completion of the 30-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 assembly (___') will be measured and paid as the actual number of fiber-optic drop cable assemblies of each length furnished, installed, and accepted according to following conditions: 75% of the payment will be made upon acceptance of the installed cable and the remaining 25% of the payment will be made following final acceptance (including completion of the 30-day observation period).

Aerial cable protectors will be measured and paid as the actual linear feet of aerial cable protectors furnished, installed, and accepted. No measurement and payment will be made of any aerial cable protectors installed without the prior approval of the Engineer or for cable protectors installed at locations or for lengths of application other than approved or directed by the Engineer.

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

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 drop cable assemblies.

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 (96-Fiber)	Linear Foot
Drop Cable Assembly (50')	Each
Drop Cable Assembly (150')	Each
Drop Cable Assembly (200')	Each
Drop Cable Assembly (300')	Each
Drop Cable Assembly (400')	Each
Drop Cable Assembly (>400')	Each
Aerial Cable Protector	Linear Feet

15. FIBER-OPTIC SPLICE CENTERS

15.1. DESCRIPTION

Furnish and install fiber-optic interconnect centers, fiber-optic splice enclosures, and all necessary hardware. Modify existing splices in existing interconnect centers and splice enclosures.

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 for rack mounting in the Signal Shop and in the TMC server room. Design and size interconnect centers to accommodate all fibers entering cabinets. Provide interconnect centers that are a maximum of 2 rack units (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.

Furnish SMFO jumpers that are a minimum of 3 feet in length with factory-assembled PC-ST connectors on each end. 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 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.

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

15.3. CONSTRUCTION METHODS

(A) General

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

Do not exceed 0.05 dB of attenuation per splice.

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

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

(B) 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. Install one rack-mounted interconnect center in the existing communications rack in the TMC. The rack will be furnished and installed by the City. Install one interconnect center in the wall-mounted communications rack in the Signal Shop.

Terminate and 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 routing switch or the core switch.

(C) 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 over roadways or driveways.

Fusion splice all fibers including fibers designated to be coupled with fibers from a drop cable assembly. 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 cable assemblies to snowshoes.

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

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.

(D) 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 show on the Plans. Unlash existing, reroute and relash existing fiber-optic cable as required to relocate the existing aerial splice enclosure.

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: 75% of the payment will be made upon acceptance of the installed interconnect centers and the remaining 25% of the payment will be made following final acceptance (including completion of the 30-day observation period).

Splice enclosure will be measured and paid as the actual number of fiber-optic splice enclosures furnished, installed, and accepted according to following conditions: 75% of the payment will be made upon acceptance of the installed splice enclosures and the remaining 25% of the payment will be made following final acceptance (including completion of the 30-day observation period). No measurement will be made between aerial, underground, manhole, or junction box installation of the fiber-optic splice enclosure.

Modify existing splice 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 splice trays, pigtails, jumpers, connector panels and testing, as these will be considered incidental to furnishing and installing fiber-optic interconnect centers and splice enclosures and to modifying existing splices in existing splice centers.

Payment will be made under:

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

16. FIBER-OPTIC TRANSCEIVERS

16.1. DESCRIPTION

Furnish and install fiber-optic transceivers with all necessary hardware according to the Plans and specifications.

Furnish and install fiber-optic transceivers in the following configurations:

- Shelf-mount RS-232 serial data drop and repeat,
- Rack-mount RS-232 serial data drop and repeat,
- Shelf-mount video/data transmitter, and
- Rack-mount video/data receiver.

16.2. MATERIALS

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL. Furnish fiber-optic transceivers that are compatible, interoperable and completely interchangeable with the existing fiber-optic transceivers currently in use by the City.

(A) Serial Data Transceivers

(1) General

Furnish single mode fiber-optic data transceivers that transmit and receive optical signals over a fiber-optic communications medium of two fibers and interface with traffic signal controllers and cabinets. Ensure the transceivers are asynchronous in operation. Ensure transceivers are capable of operating up to 20 miles without boosting signal and without distortion. Ensure transceivers are switch selectable for either local or master operation.

Do not provide transceivers internal to system equipment. Provide identical transceivers at all locations capable of being interchanged throughout system.

Provide LEDs on the front panel of transceivers for power, and transmitting and receiving indications. Comply with the following:

- Input Power: 115 VAC,
- Minimum Loss Budget: 12 dB with corresponding receiver,
- Operating Wavelength: 1310 or 1550 nm,
- Bit Error Rate < 1 in 10^{-9} @ maximum optical loss budget,
- Data Rate DC – 100kbps
- Operating Mode Asynchronous, Simplex or Full Duplex,
- Optical Connector: ST,
- Data Connector: DB-25S,
- Signal Connector: Female Plug Type,
- Temperature Range: 0 to 150 degrees F,
- Humidity 0-95% (non-condensing),
- Certifications, Compliance and Compatibility
  - RS-232C/D (Simplex or Duplex)
  - Supports Request to Send (RTS) and Clear to Send (CTS)

- NTCIP
- UL
- FCC Part 15

Furnish transceivers that transmit and receive data in drop-and-repeat poll-response data network mode with EIA/TIA-232, EIA/TIA-422, and EIA/TIA-485 protocols.

Provide transceivers that meet or exceed NEMA TS-1/TS-2 and Caltrans Specifications.

(2) Shelf-Mounted Drop and Repeat Data Transceivers

Provide modular, standalone transceivers that can be shelf-mounted (i.e., surface-mounted) for use in traffic signal cabinets. Furnish transceivers with an aluminum housing that are environmentally-hardened units designed for unconditioned roadside installation inside signal controller cabinets.

(3) Rack-Mounted Drop and Repeat Data Transceivers

Provide rack-mounted transceiver cards for use in the TMC. Provide rack-mounted transceiver cards for installation in a rack-mounted card chassis to be mounted in a 19-inch equipment rack inside the City's TMC. Provide transceiver cards with all hardware and fasteners required to securely install the cards in the card chassis.

(B) Video/Data Transceivers

(1) General

The fiber-optic video transceivers (w/ data) must meet the following minimum functional requirements:

• Video:	10-bit digitally encoded video transmission
• Input:	1 volt pk-pk (75 ohms)
• Connector:	BNC (gold plated center pin)
• Bandwidth:	5Hz – 10MHz
• Diff. Gain:	< 2%
• Diff. Phase:	< 1%
• Signal / Noise:	>67dB @ maximum optical loss budget
• Frame Rate:	Broadcast quality (30fps)
• Data Connector:	Terminal Block with Screw Clamps or DB-9
• Data Interface:	RS-232, RS-422 / RS-485
• Data Format:	NRZ, RZI, Manchester, Bi-phase
• Data Rate:	DC to 512 kbps
• Bit Error Rate:	< 1 in 10^{-9} @ maximum optical loss budget
• Operating Mode:	Simplex or Full Duplex
• Optical Connector:	ST
• Wavelength:	1310 / 1550 nm, single mode
• Optical Budget:	23 dB
• Max Distance:	43 miles
• Operating Temp:	-40 to +74 degrees Celsius
• Humidity:	0-95% (non-condensing)

- Certifications, Compliance and Compatibility:
  - RS-250C Medium Haul Transmission
  - NTSC / PAL / SECAM / Full Color
  - UL
  - CE
  - FCC Part 15

Provide transceivers that meet or exceed NEMA TS-1/TS-2 and Caltrans Specifications.

(2) Shelf-Mounted Video/Data Transmitters

Provide modular, standalone video/data transmitters that can be shelf-mounted (i.e., surface-mounted) for use in CCTV cabinets. Furnish transmitters with an aluminum housing that are environmentally-hardened units designed for unconditioned roadside installation inside CCTV cabinets. Provide video/data transmitters that are fully compatible with existing (relocated) video/data cards and the two relocated card cages.

(3) Rack-Mounted Video/Data Receivers

Provide rack-mounted video/data receiver cards for installation in a rack-mounted card chassis to be mounted in a 19-inch equipment rack inside the City's TMC. Provide receiver cards with all hardware and fasteners required to securely install the cards in the card chassis. Provide video/data receivers that are fully compatible with existing (relocated) video/data cards and the two relocated card cages.

(C) Card Chassis

Provide a card chassis (i.e., card cage, subrack, rack chassis, etc.) equipped with a power supply unit and AC power cord for rack-mounting fiber-optic data transceiver cards (provide 2 units) and fiber-optic video/data receiver cards (provide 2 units) in a 19-inch EIA communications rack housed in the City's TMC. Provide a chassis constructed of aluminum and designed to house the power supply unit plus a minimum of 14 single-slot (1-inch) or 7 dual-slot (2-inch) cards. Provide all hardware and fasteners required to mount the chassis in the equipment rack. Provide card cages that are from the same manufacturer as and compatible with the data transceiver cards furnished on the project. Provide card cages for the video/data receiver cards that are fully compatible with the existing (relocated) video/data receiver cards and the two relocated card cages. Provide separate chassis for the serial data transceiver cards and for the video/data receiver cards.

16.3. CONSTRUCTION METHODS

(A) Shelf-Mounted Drop and Repeat Data Transceivers

Install the shelf-mount fiber-optic transceivers in each traffic signal cabinet as shown in the Plans and comply with manufacturer's installation instructions. Connect the optical port of the transceiver to fiber-optic drop cable as shown in the splice details. Connect the serial data port with the serial data port of the 2070L controller.

(B) Rack-Mounted Drop and Repeat Data Transceivers

Install the rack-mount fiber-optic transceiver cards in the card chassis mounted in the communications rack inside TMC as shown in the Plans. Comply with the

manufacturer's installation instructions. Install fiber-optic jumpers between the optical ports of the transceiver and the appropriate connectors on the fiber-optic patch panel to connect the transceiver with the appropriate fibers of the incoming communications cable as shown in the splice details. Connect the transceiver cards with the terminal server.

(C) Shelf-Mounted Video/Data Transmitters

The fiber-optic video/data transmitters will transmit CCTV video and bi-directional PTZ data over a single fiber. Install the shelf-mount fiber-optic video/data transceivers in each CCTV cabinet as shown in the Plans and comply with manufacturer's installation instructions. Connect the optical port of the transceiver to fiber-optic drop cable as shown in the splice details. Connect the analog video input to the coaxial cable from the CCTV camera. Connect the serial data port to the serial data cable from the CCTV camera.

(D) Rack-Mounted Video/Data Receivers

The fiber-optic video/data receivers will receive CCTV video and transmit bi-directional PTZ data over a single fiber. Install the rack-mount video/data receiver cards in the card chassis mounted in the communications rack inside the TMC as shown in the Plans. Comply with manufacturer's installation instructions. Install fiber-optic jumpers between the optical ports of the receiver and the appropriate connectors on the fiber-optic patch panel to connect the receiver with the appropriate fibers of the incoming communications cable as shown in the splice details. Connect the receiver cards with the terminal server.

(E) Card Chassis

In the position shown in the Plans and according to the manufacturer's instructions, mount the new card chassis in the new communications rack being installed in the TMC under this project. Plug the AC power cord from the power supply into the rack-mounted UPS in the communications rack.

Relocate the existing card chassis housing the existing video/data receivers from the existing rack to the new communications rack as shown in the Plans.

16.4. MEASUREMENT AND PAYMENT

Fiber-optic transceiver – drop and repeat will be measured and paid as the actual number of fiber-optic transceivers – drop and repeat furnished, installed, and accepted according to following conditions: 75% of the payment will be made upon acceptance of the installed fiber-optic transceiver and the remaining 25% of the payment will be made following final acceptance (including completion of the 30-day observation period).

Furnish fiber-optic transceiver – drop and repeat will be measured and paid as the actual number of fiber-optic transceivers – drop and repeat furnished and accepted.

Fiber-optic video/data transmitter will be measured and paid as the actual number of fiber-optic video/data transmitters furnished, installed, and accepted according to following conditions: 75% of the payment will be made upon acceptance of the installed video/data transmitter and the remaining 25% of the payment will be made following final acceptance (including completion of the 30-day observation period).

Furnish fiber-optic video/data transmitter will be measured and paid as the actual number of fiber-optic video/data transmitters furnished and accepted.

Fiber-optic video/data receiver will be measured and paid as the actual number of fiber-optic video/data receivers furnished, installed, and accepted according to following conditions: 75% of the payment will be made upon acceptance of the installed video/data receiver and the remaining 25% of the payment will be made following final acceptance (including completion of the 30-day observation period).

Furnish fiber-optic video/data receiver will be measured and paid as the actual number of fiber-optic video/data receivers furnished and accepted.

No measurement will be made of fiber-optic card chassis, jumpers or RS-232 cables as they will be considered incidental to furnishing and installing the drop and repeat fiber-optic transceivers and the video/data fiber-optic transmitters/receivers.

No measurement will be made of relocating existing fiber-optic card chassis from the existing communications rack to the new communications rack in the TMC as shown in the Plans as such work will be considered incidental to furnishing and installing the new communications rack.

Removal of the existing video/data transceivers that are replaced with new units will be measured and paid for separately in accordance with the "CCTV Field Equipment" section of these Project Special Provisions.

Payment will be made under:

Pay Item	**Pay Unit**
Fiber-Optic Transceiver – Drop and Repeat	Each
Furnish Fiber-Optic Transceiver – Drop and Repeat	Each
Fiber-Optic Video/Data Transmitter	Each
Furnish Fiber-Optic Video/Data Transmitter	Each
Fiber-Optic Video/Data Receiver	Each
Furnish Fiber-Optic Video/Data Receiver	Each

17. UNDERGROUND CABLE MARKERS

17.1. DESCRIPTION

Furnish and install 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.

17.2. MATERIAL

(A) 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 811*
1/4" for all other

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

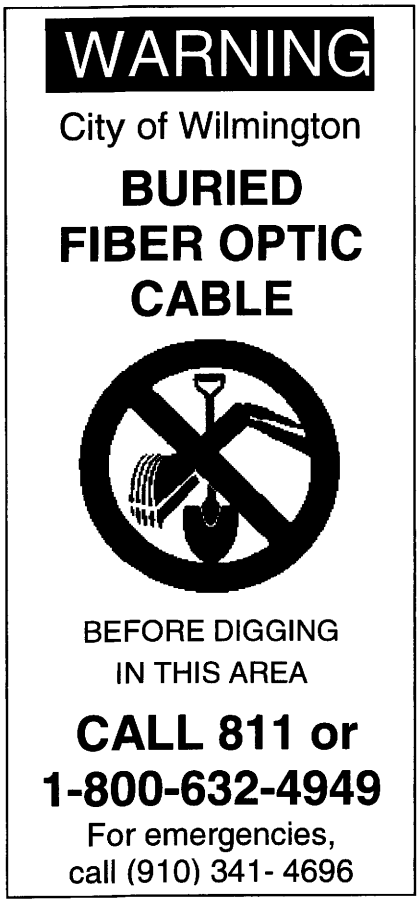
Submit sample of proposed cabinet decals to the Engineer for approval before installation. In lieu of designing a custom decal, the contractor may submit for the Engineer's approval a stock/standard decal format (i.e., off-the-shelf format) from the decal manufacturer that differs from the example format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

(B) 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 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 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 811 or 1-800-632-4949*;
1/4" for all other

Text Color: Black
Background Color: Yellow
Symbol Color: Black
Symbol Size: 2" Diameter

Submit sample of proposed pole sign to the Engineer for approval before installation. In lieu 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.

(C) 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.

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 Color: Black
Background Color: Orange

Submit sample of proposed curb marker to the Engineer for approval before installation. In lieu 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.

17.3. CONSTRUCTION METHODS

(A) 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 an aerial drop cable.

(B) Pole Signs

Using the hot-dipped, galvanized 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 at the pole. 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.

(C) Curb Markers

Install curb markers along 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 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.

17.4. MEASUREMENT AND PAYMENT

No measurement will be made of utility pole signs, cabinet decals and curb markers as they will be considered incidental to furnishing and installing fiber-optic communications cable.

18. REMOVE EXISTING COMMUNICATIONS CABLE

18.1. DESCRIPTION

Remove existing fiber-optic and copper communications cable.

18.2. 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 splice cabinets includes the removal of cabinet base if base mounted. 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.

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 Engineer, it will be so noted on the Plans.

Remove all existing twisted-pair communications cable splice boxes and cabinets and associated risers and in-ground junction boxes as shown in 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).

At several locations, fiber-optic cable owned by New Hanover County is overlashed to the City's existing aerial communications cable. Unless directed otherwise by the Engineer, do not remove the existing City communications cable and supporting messenger cable when the County fiber-optic cable is lashed to them. Cut the City cable but not the supporting messenger at the end of the coincident route instead and abandon the overlashed City cable in place. Do not disturb, unlash or damage the New Hanover County fiber-optic cable.

18.3. MEASUREMENT AND PAYMENT

Remove existing communications cable will be measured in horizontal linear feet of existing communications cable removed. Payment will be in linear feet. Sag, vertical segments, or spare segments of communications cable will not be paid for, as these distances will be considered incidental to the removal of existing communications cable.

Remove splice cabinet will be measured as the actual existing twisted-pair communications cable splice boxes/cabinets successfully removed without regard to the size or type of cabinet, mounting location or mounting method.

No additional measurement will be made for multiple cables being removed from the same conduit or same pole. Where multiple adjacent conduits exist (each containing multiple cables), each conduit will be considered separately for purposes of payment. No payment will be made for 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, vacated wood poles, risers and in-ground junction boxes, foundations for base-mounted splice cabinets, as these will be considered incidental to removing existing communications cable and splice cabinets.

Payment will be made under:

Pay Item	Pay Unit
Remove Existing Communications Cable	Linear Foot
Remove Splice Cabinet	Each

19. CABLE TRANSFERS

19.1. DESCRIPTION

Remove and reinstall existing communications cable for pole relocations.

19.2. 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.

19.3. 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

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. MATERIAL

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

Use Type III retroreflective sheeting, except for black sheeting. Use non-reflective for black sheeting.

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. RELOCATE EXISTING SIGN

21.1. DESCRIPTION

Relocate existing signs for signals.

21.2. CONSTRUCTION METHODS

As directed by the plans, relocate existing signs. Comply with the "Signs Installed for Signals" section of these Project Special Provisions.

21.3. MEASUREMENT AND PAYMENT

Relocate existing sign will be measured and paid for as the actual number of existing signs, regardless of mounting method, relocated and accepted.

Payment will be made under:

Pay Item	Pay Unit
Relocate Existing Sign	Each

22. SIGNAL CABINET FOUNDATIONS

22.1. 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.

22.2. MATERIAL

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

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

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

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

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

22.3. 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.

Do not install foundations over uncompacted fill or muck.

When installing a new foundation to replace an existing foundation, remove the existing cabinet foundation following completion of the new foundation and installation of the controller cabinet on the new foundation unless the Plans or the Engineer direct otherwise.

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. Install minimum 4 inches above and 4 inches below finished grade. 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.

22.4. MEASUREMENT AND PAYMENT

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

No measurement will be made of the removal of existing foundations as these will be considered incidental to furnishing and installing the new foundation.

Payment will be made under:

Pay Item	Pay Unit
Signal Cabinet Foundation	Each

23. MODIFY CABINET FOUNDATIONS

23.1. DESCRIPTION

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

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

23.2. MATERIALS

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

23.3. CONSTRUCTION METHODS

(A) General

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 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.

(B) Install Conduit Entrance into Existing Foundation

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. If it is not possible to maintain traffic signal operations while constructing new conduit entrance and as approved by the Engineer, provide a police officer to direct traffic through the intersection while the signal is inoperable. Complete drilling and restore signal operations within one hour of deactivation of the signal.

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.

(C) 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. 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.

Enlarge the foundation to the distance specified for new cabinet foundations. Provide a 1-inch chamfer on all new outside edges.

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

(D) Alternate Methods of Modifying Foundations

Where the Plans call for a new conduit entrance to be installed into an existing cabinet foundation or for the existing foundation to be modified by expanding it, the Contractor may, subject to the approval of the Engineer and at no additional cost to the Department, use one of the following methods in lieu of core-drilling and/or expanding the existing base:

- Remove the existing cabinet foundation and replace it with a new preformed cabinet pad in the same location.
- Overlay the existing cabinet foundation with a new preformed cabinet pad.
- Install a new cabinet foundation adjacent to the existing foundation.

Comply with the construction methods for each method described below.

(1) In Situ Replacement

Carefully remove the existing concrete from around the existing conduit spread, taking care not to damage the conduit stubs or the existing field wiring. Construct additional conduit stub-out(s) where the Plans call for a new conduit entrance in the existing foundation. Once existing concrete has been completely removed and new stub-out(s) has been constructed, immediately set a preformed cabinet pad over the existing conduit spread and new stubout(s). Install preformed cabinet pad in accordance with the manufacturer's instructions. Reinstall existing controller and cabinet or install new

controller and cabinet on the new preformed pad. Provide preformed cabinet pads that are listed on the Department's QPL.

(2) Overlay Existing Foundation

Where the top of the existing cabinet foundation is no more than 2 inches above the surrounding ground, overlay the existing foundation by setting a preformed cabinet pad over the existing conduit spread and existing foundation. Level and hand tamp the ground around the existing foundation and install the preformed pad in accordance with the manufacturer's instructions. Furnish and install couplings, nipples, and bushings to extend the existing conduit stub-outs so that the tops of the conduits are 2-3 inches above the top of the preformed pad. Use existing field wiring, splicing and extending the field wiring inside the controller cabinet as needed (refer to Extension of Existing Field Wiring section of these Project Special Provisions). Install new conduit entrance(s) into the existing foundation if necessary.

Immediately reinstall the existing controller and cabinet or install the new controller and cabinet once the preformed pad is set in place.

Backfill around the perimeter of the new pad with topsoil to a point 4 inches below the top surface of the new pad. Gently slope the backfill to tie into the existing ground line with a gradual slope no steeper than 4:1; do not create an abrupt or unsightly mound. Ensure the preformed pad and backfill does not block the flow of runoff or impound water. Hand tamp the new soil and apply grass seed and mulch.

Do not use this method where the top of the existing cabinet foundation is more than 2 inches higher than the surrounding ground, unless the Engineer approves otherwise.

(3) Construct New Foundation Adjacent to Existing Foundation

Construct a new cabinet foundation with all necessary hardware adjacent to the existing foundation and rewire the cabinet using one of the following methods:

- Install new risers on adjacent cabinet pole, "pull back" existing field wiring to the top of the existing risers, reinstall existing wiring through the new risers to the new foundation and splice and extend field wiring with gel-filled butt splice connectors in base of new cabinet if necessary.
- Install new risers with terminal splice cabinet on adjacent cabinet pole, "pull back" existing field wiring to the top of the existing risers, and reinstall existing wiring through the new risers to the terminal splice cabinet. Inside the terminal splice cabinet, splice the existing wiring to new conductors from the new base-mounted controller cabinet.

Comply with the "Signal Cabinet Foundations" section and the "Extension of Existing Field Wiring" section of these Project Special Provisions.

23.4. MEASUREMENT AND PAYMENT

Conduit entrance into existing foundation will be measured and paid for the actual number of conduit entrances drilled into existing cabinet foundations furnished, installed and accepted. As approved by the Engineer, police provided for directing traffic while a signal is inoperable during construction of conduit entrance into existing foundation will

be measured and paid for separately in accordance with the "Temporary Traffic Control" section of these Project Special Provisions.

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

Alternate methods for adding conduit entrances to and modifying existing cabinet foundations will be measured and paid as *conduit entrance into existing foundation* and/or *modify foundation for controller cabinet*, as specified in the Plans for the given location. Such payment will be full compensation for all work required to add the conduit entrance and/or modify the cabinet foundation using one of the alternate methods described above. No separate measurement will be made of preformed cabinet pads, removal of existing foundations or splicing and extending existing field wiring required due to the use of an alternate method for adding a conduit entrance or for modifying an existing cabinet foundation.

Payment will be made under:

Pay Item	**Pay Unit**
Conduit Entrance into Existing Foundation	Each
Modify Foundation for Controller Cabinet	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. Install Department-furnished local controller software on existing controllers where required. Install updates of local controller and operating system software.

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) (11-19-99) 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 will be 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.

Furnish one additional MODEL 2070-7A, Async Serial Com Module (9-pin RS-232) for all master controller locations.

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

For locations with flashing yellow arrow (FYA) left-turn signals, furnish cabinets with auxiliary file pre-wired into the cabinet. FYA(s) are proposed at the following locations.

- Cascade Road at College Road (03-0361)
- College Road at Holly Tree (03-0362)
- College Road at Shipyard Boulevard (03-0067)

Furnish cabinets with auxiliary file pre-wired into the cabinet for future implementation of FYA left-turn signals at the following locations.

- 17th Street at Glen Meade Road (03-0204)
- 17th Street at Medical Center Drive (03-0206)
- 17th Street at Wellington Street (03-0432)
- Bragg Drive at College Road (03-0924)
- Burnette Boulevard at Carolina Beach Road (03-0019)
- Carolina Beach Road at Echo Farms Boulevard/G. Anderson Drive (03-0524)
- Carolina Beach Road at Halyburton Parkway (03-0911)
- Carolina Beach Road at Independence Boulevard (03-0601)
- Carolina Beach Road at Medical Center (03-0996)

- Carolina Beach Road at Raleigh Street (03-0313)
- College Road Cape Fear Academy/Pinecliff Drive (03-0726)
- College Road at Pine Valley Drive (03-0365)
- Longstreet Drive at Shipyard Boulevard (03-0068)

Where auxiliary output files have been installed and wired into traffic signal cabinets for future use, no field wiring is required to the output terminals of the auxiliary output file.

(B) 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 2010ECL-NC 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 2010ECL-NC 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.

(C) 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.

(D) Model 2010ECL-NC Enhanced Conflict Monitor

Furnish Model 2010ECL-NC Enhanced Conflict Monitors with 16 channels. Ensure that the conflict monitor is designed to monitor an intersection with up to four approaches using the four-section flashing yellow arrow (FYA) movement outlined by the NCHRP Research Project 3-54 on Protected/Permissive signal displays with Flashing Yellow Arrows. Two cabinet configurations should be available: the basic FYA mode and the compact FYAc mode. Ensure that the conflict monitor can be changed from/to Normal mode, to/from standard FYA, and to/from the compact FYAc mode via an external switch. Follow the following charts for each FYA mode:

Flashing Yellow Arrow (FYA) Conflict Monitor Chart				
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

Flashing Yellow Arrow Compact (FYAc) Conflict Monitor Chart				
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 monitor has the Configuration Change Fault option and that the Configuration Change Fault select jumper is installed to ensure that the unit will set the fault mode upon any change in the configuration parameters.

In addition to CALTRANS requirements, ensure the conflict monitor monitors for the absence of a valid voltage level on at least one channel output of each load switch. Ensure that the absence of the programming card will cause the conflict monitor to trigger, and remain in the triggered state until reset.

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

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

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

1. **Red Monitoring or Absence of Any Indication (Red Failure):** A condition in which no "on" voltage signal is detected on any of the green, yellow, or red inputs to a given monitor channel. If a signal is not detected on at least one input (R, Y, or G) of a conflict monitor channel for a period greater than 1000 ms when used with a 170 controller and 1500 ms when used with a 2070L controller, ensure monitor will trigger and put the intersection into flash. If the absence of any indication condition lasts less 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 the P20 Connector is installed and both the following input conditions are in effect: a) Red Enable input to monitor is active (Red Enable voltages are "on" at greater than 70 Vrms, off at less than 50 Vrms, undefined between 50 and 70 Vrms), and b) neither Special Function 1 nor Special Function 2 inputs are active.
2. **Yellow Indication Sequence Error:** Yellow indication following a green is missing or shorter than 2.7 seconds (with ± 0.1-second accuracy). If a channel

fails to detect an "on" signal at the Yellow input following the detection of an "on" signal at a Green input for that channel, ensure that the monitor triggers and generates a sequence error fault indication.

3. **Dual Indications on the Same Channel:** In this condition, more than one indication (R,Y,G) is detected as "on" at the same time on the same channel. If dual indications are detected for a period greater than 500 ms, ensure that the conflict monitor triggers and displays the proper failure indication (Dual Ind fault). If this condition is detected for less than 250 ms, ensure that the monitor does not trigger.

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

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

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

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

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

Provide communications from the monitor to the 170/2070L controller via an RS-232C/D port on the monitor in order to upload all event log information from the monitor to the controller or to a Department-furnished system computer via the controller. Ensure that the controller can receive the data through a controller Asynchronous Communications Interface Adapter (Type 170E) or Async Serial Comm Module (2070L) determined by the controller software. Provide software capable of communicating directly through the same monitor RS-232C/D to retrieve all event log information to a Department-furnished laptop computer.

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

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

Provide a DB-9 female connector for the purpose of data communication with the controller. Electrically isolate the port interface electronics from all monitor electronics, excluding Chassis Ground. Furnish a communications connecting cable with pin connections as follows:

170		Conflict Monitor DB-9
RX pin L	Connect to	TX pin 2
TX pin K	Connect to	RX pin 3
+5 pin D	Connect to	DTR pin 4
GND pin N	Connect to	GND pin 5

2070L		Conflict Monitor DB-9
DCD pin 1	Connect to	DCD pin 1
RX pin 2	Connect to	TX pin 2
TX pin 3	Connect to	RX pin 3
GND pin 5	Connect to	GND pin 5
RTS pin 7	Connect to	CTS pin 7
CTS pin 8	Connect to	RTS pin 8

24.6. MATERIALS – 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 and Model 224 loop detector sensor cards.

24.7. CONSTRUCTION METHODS

(A) General

Remove existing controllers and cabinets where required. Remove maintenance diary from cabinet and place in new cabinet or deliver to the Engineer. Take existing equipment out of service only at the time directed. Provide a police 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.

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 cabinet side facing roadway. Use 3-inch black characters. For City-owned signals, apply the city intersection number to all sides of cabinet on sides of the cabinet visible from the street using 3-inch high, pre-cut vinyl numerals.

Provide external electrical service disconnect 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.

Activate controllers with proposed phasing and timing.

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 Wilmington Signal System.

(B) System Interconnection

When interconnection of signals is required, install interface equipment and hardware for signals. Demonstrate proper operation of interconnection using manual commands after interconnection is complete.

Program telemetry command sequences and enable devices necessary for testing of communication between local controllers and field master controllers, and between field master controllers and City-furnished central computer.

(C) Workshop

Provide enclosed workshop to set up and test new controllers and cabinets before installation. Locate workshop within the City Limits of Wilmington. Ensure workshop provides protection from weather and sufficient space to house two test observers, all necessary test equipment and material, controllers and cabinets.

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 or malfunction management unit 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.

24.8. MEASUREMENT AND PAYMENT

Controllers with cabinets (____) will be measured and paid as the actual number of each type of controllers with cabinets 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 30-day observation period).

Police provided for directing traffic while a signal is inoperable during removal of the and replacement of cabinet and controller (i.e., cabinet change-out) will be measured and paid for separately in accordance with the "Temporary Traffic Control" section of these Project Special Provisions.

Detector cards (Type 2070L) will be measured and paid as the actual number of Type 2070L detector cards furnished, installed, and accepted.

Auxiliary files will be measured and paid as the actual number of auxiliary files furnished, installed, and accepted.

No measurement will be made of conflict monitors, grounding systems, modems, workshop and installing Department-furnished local controller software on existing

controllers as these will be considered incidental to furnishing and installing controllers with cabinets.

Furnish detector card (Type 2070) will be measured and paid as the actual number of Type 2070L 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 2010ECL-NC enhanced conflict monitor will be measured and paid as the actual number of model 2010ECL-NC enhanced conflict monitors furnished and accepted.

Payment will be made under:

Pay Item	**Pay Unit**
Controller with Cabinet (2070L, Pole Mounted)	Each
Controller with Cabinet (2070L, Base Mounted)	Each
Detector Card (Type 2070L)	Each
Auxiliary File	Each
Furnish Detector Card (Type 2070L)	Each
Furnish 2070L Controller	Each
Furnish 336S Cabinet	Each
Furnish 332 Cabinet	Each
Furnish 2010ECL-NC 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 170 Cabinets.

25.2. MATERIAL

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

25.3. CONSTRUCTION METHODS

Unless otherwise shown in the Plans, install a cabinet base extender at locations requiring new Model 332A cabinet on an existing/modified or new foundation and where an existing base-mounted Model 332A cabinet that is being retained does not have a cabinet base extender.

Install a cabinet base adapter at locations requiring a new Model 332A 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 Model 336 cabinet is used as base mount cabinet, install adapter or extender, as required.

Use permanent, flexible waterproof sealing material to:

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

25.4. MEASUREMENT AND PAYMENT

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

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

Payment will be made under:

Pay Item	Pay Unit
Cabinet Base Adapter	Each
Cabinet Base Extender	Each

26. ELECTRICAL SERVICE

26.1. DESCRIPTION

At locations called out in the Plans, install a new electrical service for a CCTV camera assembly and modify an existing traffic signal controller cabinet electrical service to add a meter base.

26.2. 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, revise and/or upgrade all materials necessary to form a complete electrical service assembly as shown in NCDOT Roadway Standard Drawing No. 1700.01. Furnish new external electrical service disconnects, meter bases, 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. 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 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
- 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.

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.

For all new ground-mounted electrical service assemblies for underground electrical service, provide a combination panel with pedestal extension as shown in the Plans. 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.

26.3. 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.

(B) 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 camera pole as shown in the Plans. 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 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 the combination panel, even where source power lines are overhead. Except at locations where the Plans specifically call for use of a wood service pole, do not set a wood service pole with an overhead feed from the power company without the prior approval of the Engineer.

Where the Plans specifically call for installation of a service pole to facilitate an overhead feed, install a wood service pole in accordance with the "Wood Poles" section of these Project Special Provisions. Install the service pole at a location approved by the Engineer and the local power company. Install a 1-inch rigid galvanized riser with weatherhead and a meter base/disconnect combination panel on the service pole such that the disconnect can be seen be personnel standing at the nearby CCTV controller cabinet. Install a 1-inch rigid galvanized conduit containing new service wires (conductors) underground between the disconnect and the pole-mounted CCTV cabinet, including the short risers at each end of the run to connect the underground conduit to the cabinet and disconnect on their respective poles. After installation of the meter base, the local power company will install a new meter and make any necessary connections to the power lines.

(C) Modify Existing Electrical Service for Traffic Signal

At locations identified in the Plans, modify an existing electrical service assembly for a traffic signal to add a new meter base where none presently exists. Comply with NCDOT Roadway Standard Drawing No. 1700.01.

Extend or replace electrical service conductors and conduits between the disconnect and the controller cabinet as required. Modify existing risers as needed to add the meter base to the existing electrical service assembly. After installation of the meter base, the local power company will install a new meter.

26.4. MEASUREMENT AND PAYMENT

New electrical service for CCTV (_____) will be measured and paid for as the actual number of complete, functional electrical service of each type for CCTV locations furnished, installed and tested.

No measurement will be made of short risers (i.e., from disconnect to underground conduit), meter bases, service disconnects, underground conduit runs between ground-mounted combination pedestals and CCTV or signal cabinets, underground conduits between traffic signal controller cabinets and a service disconnect mounted on a nearby pole, 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.

Risers with weatherheads will be measured and paid for separately in accordance with the "Riser Assemblies" section of these Project Special Provisions. Underground conduit runs between a new service pole and an adjacent CCTV camera pole will be measured and paid for separately in accordance with the "Underground Conduit" section of these Project Special Provisions.

Wood service poles for new overhead electrical service, where required, will be measured and paid for separately in accordance with the "Wood Poles" section of these Project Special Provisions.

Modify existing electrical service for traffic signal will be measured and paid for as the actual number of electrical service locations that have been modified to add a meter base.

No measurement will be made of the following as they are considered incidental to modifying an existing electrical service for traffic signal: electrical service conductors; conduit and hardware required to connect the electrical service to the cabinet; and upgrading existing grounding systems, where required.

Payment will be made under:

Pay Item	Pay Unit
New Electrical Service for CCTV (Overhead)	Each
New Electrical Service for CCTV (Underground)	Each
Modify Existing Electrical Service for Traffic Signal	Each

27. SPREAD SPECTRUM RADIO

27.1. DESCRIPTION

Furnish and install a spread spectrum radio system with all necessary hardware in accordance with the Plans and specifications to provide a data link between field devices (i.e., traffic signal controllers and dynamic message signs). 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.

27.2. MATERIALS

(A) General

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

(B) 900 MHz Radios

Furnish license free 902 – 928 MHz radio modems with antennas, coaxial cable and mounting hardware, and configuration software. Design radio modems to work in "point-to-point", "point-to-multipoint", "multipoint-to-point", and "multipoint-to-multipoint" configurations. Provide radios that can operate as repeaters. Ensure the spread spectrum radio meets the following minimum requirements:

- License free (ISM) spread spectrum radio band (902 – 928 MHz),
- Frequency hopping technology (direct sequence spread spectrum technology is not acceptable),
- Bi-directional, full duplex,
- Programmable radio frequency (RF) output levels of 1mW, 10mW, 100mW, or 1 Watt,
- A minimum of 139 user-selectable radio frequency channels, with 62 available hopping sequences (2 non-overlapping),
- Serial interface capable of operating at 1200 bps to115 Kbps sustained data throughput,
- 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, 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, and
  - Typical current draw of no greater than 600 mA when powered with 12 VDC input, and transmitting 1 Watt of RF output power.
- 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 jumpers in 6-foot lengths.

Furnish an RS-232 data interface cable to be installed between the radio modem and the field device's RS-232 interface. Ensure cable is a minimum of 6 feet long.

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

(C) Software

Furnish units with a Windows® based 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 wireless radio. Provide configuration software that can be upgraded in the future at no additional charge.

Ensure the radio modem is configurable from a single location (i.e. master radio location) via supplied software (no extra cost). Furnish software supplied with drivers to allow easy set-up with all industry standard traffic signal 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 and dynamic message sign (DMS) controllers.

(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) @ 900MHz	3.9 dB
Power Rating @ 900MHz	0.58 kW
Center Conductor	0.108" copper clad aluminum
Dielectric: Cellular PE	0.285"
Shield	Aluminum tape – 0.291" Tinned copper braid – 0.320"
Jacket	Black UV protected polyethylene
Bend Radius	1" with less than 1 ohm impedance change at bend
Impedance	50 ohms
Capacitance per foot	23.9 pf/ft
End Connectors	Standard N-Type male connectors on both ends

(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 Beam Width (at half power points)	40 degree
Vertical Beam Width (at half power points)	35 degree
Power Rating, UHF Frequency	200 Watts
Lightning Protection	DC ground
Termination	Coaxial pigtail with a standard N-Type female connector
Impedance	50 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, wood pole or DMS sign structure, 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 specifications:

- Center Contact: Gold plated beryllium copper (spring loaded, not soldered),
- Outer Contact: Silver plated brass,
- Body: Silver Plated brass,
- Crimp Sleeve: Silver plated copper,
- Dielectric: Teflon PTFE,
- Water Proofing Sleeve: Adhesive lined polyolefin heat shrink, 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: 3/4 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 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. See the special details shown in the Plans.

(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,
  18kA, 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.

27.3. CONSTRUCTION METHODS

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
S. 17th Street at Independence Boulevard	Receiver	South	1- Yagi (13 dB)
S. 17th Street at George Anderson Drive	Transmitter	North	1- Yagi (13 dB)
Carolina Beach Road at Sanders Road	Receiver (DMS)	South	1- Yagi (8.5 dB)
	Receiver (Signals)	South	1- Yagi (13 dB)
Carolina Beach Road at DMS	Transmitter	North	1- Yagi (8.5 dB)
Carolina Beach Road at Cathay Road	Transmitter / Repeater	North	1- Yagi (13 dB)
		South	1- Yagi (8.5 dB)
Carolina Beach Road at Halyburton Memorial Parkway	Transmitter	North	1- Yagi (8.5 dB)

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.

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

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

Install the coaxial cable shield grounding system by carefully removing the outer jacket of the coaxial cable without damaging the cable shield. Install the shield grounding system following the cable manufacturer's recommendations. Install and weatherproof the connection using the appropriate weatherproofing materials and following the manufacturer's recommendations. On wood poles, secure the #6 AWG grounding lead cable to the pole ground using split bolt or compression type fitting or an Engineer

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

Do not exceed the 1-inch bend radius of the coaxial cable as it traverses from the cabinet to the antenna assembly. Connect the lightning arrestor to the coaxial cable in the equipment cabinet. Properly ground and secure the arrestor in the cabinet. Permanently label all cables entering the cabinet. Ensure the power supply for the radio system is **NOT** connected to the GFCI receptacle circuit located in the cabinet. Place a copy of all manufacturer equipment specifications and instruction and maintenance manuals in the equipment cabinet.

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

27.4. WARRANTY

Provide a warranty for a minimum of one year or the manufacturer's customary warranty period, whichever is greater, with each radio and antenna assembly to ensure that the products are free of manufacturing defects in material and workmanship. The warranty commences on the date the radio system is accepted by the Engineer.

27.5. MEASUREMENT AND PAYMENT

900MHz Radio will be measured and paid as the actual number of 900MHz radios furnished 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 30-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, any integration between the radio system and a fiber-optic network (if necessary) and warranties.

Furnish 900MHz Radio will be measured and paid as the actual number of 900MHz radios furnished and accepted. This item includes one spare antenna, lightning arrestor, power supply and power cord per radio.

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 Radio	Each
Furnish 900MHz Radio	Each

28. SYSTEM SUPPORT AND TEST EQUIPMENT

28.1. DESCRIPTION

Furnish communications and signal system support and test equipment with all necessary hardware.

28.2. 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 communications and signal system support 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,
- Screw driver set,
- 48 alcohol wipes,
- Fiber-optic cleaver with diamond blade and average cut less than 0.5 degrees from perpendicular,
- 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 (e.g., Kimwipes®),
- Metal ruler,
- Tweezers,
- Crimping pliers,
- CamSplice™ assembly manual,
- CamSplice™ assembly fixture,
- 12 non-adhesive, mechanical CamSplice™ splices,
- Scissors,
- Hard-sided, padded storage case,
- 20 3-foot single circuit, ST-ST, single mode fiber-optic jumpers, and
- 2 mechanical splice trays, 12 CamSplice™ capacity, compatible with the interconnect centers being installed in the racks in the TMC and the Signal Shop.

(C) 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 degrees F,
  - Storage ..... 0 to 150 degrees F,
- Relative humidity ..... 5 to 95 percent, non-condensing,
- Battery power Alkaline: 28 hours; NiCad: 8 hours (recharger and NiCad batteries provided), and
- Carrying case.

(D) 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 (-10° to 50° C),
- 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.

(E) 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)

(F) Video Monitor:

Furnish one portable color CCTV monitor for field-testing of CCTV installations.

- Display: 4-inch 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: Backlit and built-in,
- Controls: Color, brightness, power on/off, tint, red and blue drive,
- Power: 12 VDC, 500 mA,
- Cables: 6-foot power and video cables each,
- Connectors: Video – BNC, Power – DC jack, and
- Operating Temperature: 32° F to 104° F.

Furnish portable power supply to operate test monitor with 120 VAC.

28.3. TESTING

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.

28.4. DOCUMENTATION

Provide training and operating/user manuals and any other documentation required by the Department for each unit of test equipment provided.

28.5. WARRANTY

Provide a warranty for a minimum of one year or the manufacturer's customary warranty period, whichever is greater, with each electronic unit to ensure that the products are free of manufacturing defects in material and workmanship. The warranty commences on the date the electronic unit is accepted by the Engineer.

28.6. MEASUREMENT AND PAYMENT

Furnish fiber-optic restoration kits will be measured and paid as the actual number of fiber-optic restoration kits furnished and accepted.

Furnish fiber-optic power meters 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 monitors will be measured and paid as the actual number of video test monitors furnished and accepted.

Payment will be made under:

Pay Item	Pay Unit
Furnish Fiber-Optic Restoration Kit	Each
Furnish Fiber-Optic Power Meter	Each
Furnish Optical Light Generator	Each
Furnish Visual Fault Locator	Each
Furnish Video Monitor	Each

29. CCTV FIELD EQUIPMENT

29.1. DESCRIPTION

Furnish and install CCTV field equipment, cabinets and local camera control software described in this Section. Furnish equipment that is compatible and interoperable with the existing SpectraDome IV cameras using the Pelco protocol and the existing and proposed Pelco video switches currently in use by the City of Wilmington. Ensure that the equipment is fully compatible with all features of the video matrix switch and the CCTV control software. Remove and dispose of CCTV field equipment and cabinets as described in this Section 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 transient voltage and surge suppression (TVSS) technology and standards.

29.2. MATERIALS

(A) General

Furnish new CCTV camera assemblies, CCTV cabinets, and CCTV wood poles.

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;
- Pole-mount camera attachment hardware;
- All necessary cable, connectors and incidental hardware to make a complete and operable system,
- Furnish a NEMA Type 4, IP 66 enclosure constructed of aluminum with a clear acrylic dome or approved equal camera unit housing; and
- Transient voltage surge suppressors.

(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,
- NTCIP 1201,
- NTCIP 1205 v01.08,
- NTCIP 1208,
- NTCIP 2104,
- NTCIP 2202,
- NTCIP 2301,
- NTSC, and
- UL Listed.

Provide UL listed TVSS devices according to the *UL 1449, 2nd edition* standard and shall comply with the NEMA requirements as detailed in the *NEMA LS 1 (1992)* standard.

Provide UL listed air terminal according to the *UL 96A* standard and be suitable for use in a UL master label lightning protection system.

(C) Camera and Lens

(1) Cameras

Furnish new ¼-inch charged-coupled device (CCD) color cameras. Furnish 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,
- Image sensor resolution: 470 horizontal by 350 vertical TVL,
- Image resolution: 724 horizontal pixels by 494 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 1/30,000th of a second,
- 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,
- Sensitivity: 1.5 lux at 90% scene reflectance,
- Signal to noise ratio: Greater than 50 dB,
- Video output connection: 1-volt peak to peak, 75 ohms terminated, BNC connector, and
- Primary power: 120 VAC, and
- Power: 24 VAC or less.

(2) Zoom Lens

Furnish each camera with a motorized zoom lens with automatic iris control with manual override and neutral density spot filter. Furnish lenses that meet the following optical specifications:

- 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: 0.14" – 3.25", 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: .08 lux at ½ color, .3 lux at 1/60 black and white, .013 lux at ½ black and white,
- Preset positioning: Minimum of 64 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. Mechanical or electrical means must be provided 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.

(D) Camera Housing

Furnish new dome style enclosure for assemblies with a high performance integrated dome system or approved equal. Equip each housing with mounting assembly for attachment to the CCTV camera pole. The enclosures must be equipped with a strip heater and a sunshield and be 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.

A dome-type environmental housing shall have a sustained ambient operating temperature of -50° F to 122° 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.

(E) Pan and Tilt Unit

Each new dome style assembly must be equipped 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. The pan and tilt units must meet or exceed the following specifications:

- Pan: Continuous 360 degrees,
- Tilt: Up/down 180 degrees minimum,
- Presets: Minimum of 64presets,
- Pan speed: .1 degrees/second to 150 degrees/second,
- Tilt speed: .1 degrees/second to 200 degrees/second,

- Input voltage: 24 VAC 50/60Hz, and
- Motors: Two-phase induction type, continuous duty, instantaneous reversing.

(F) Control Receiver/Driver

Each new camera unit must contain 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 64 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.

(G) Software:

Furnish vendor-supplied software to program and configure the cameras in the field. This software shall include features to set communications addresses and protocols, define presets, tours, privacy zones and camera ID. 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 cable.

(H) CCTV Camera Attachment to Pole

At locations shown in the Plans where new CCTV cameras are to be installed on new CCTV poles, design, fabricate, and furnish an attachment assembly for the CCTV camera unit. Use stainless steel banding approved by the Engineer. Submit shop drawings for review and approval by the Engineer prior to installation.

Furnish CCTV attachment that allows for the removal and replacement of the CCTV enclosure as well as providing a weatherproof, weather-tight, seal that does not allow moisture to enter the enclosure.

Furnish CCTV camera attachment assembly that is able to withstand 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, Luminares and Traffic Signals* and can support a minimum camera unit dead load of 45 pounds.

(I) Surge Suppression

Provide a maximum 20 Ω ground impedance measurement, and the placement of transient voltage protection both ahead of and behind the ITS device electronics for CCTV installations. All TVSS devices shall have an ambient operating temperature of -40° F to 165° F with 95 percent non-condensing relative humidity.

(1) Grounding

Furnish a grounding system as shown in the Plans. Provide all connections to the grounding electrode with an exothermic weld. 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.

Furnish an air terminal and ensure it extends at least five feet above the CCTV camera, as shown in the Plans.

(2) CCTV Power Source Supply Side

Power source supply side protection is designed to restrict surge current transients from entering the power source from the CCTV device and/or site. The TVSS 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 TVSS 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 TVSS 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.

(3) CCTV Power Line Side

The TVSS 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 TVSS shall be rated at a minimum of 150,000 amps per phase, and have minimum clamping voltage ratings of 293 volts at 500 amps, 350 volts at 3,000 amps, and 446 volts at 10,000 amps. The TVSS for the power source shall also be UL listed for a minimum suppressed voltage of 400 volts per line to the neutral/ground. The suppression device shall be an MOV type.

(4) CCTV Data/Video Supply and Line Side

The TVSS shall have an operating voltage to match the characteristics of the CCTV, such as 24 volts of direct current (VDC) and less than 5 VDC for data and video functions. These specialized TVSS units shall be UL listed according to the *UL 497A* standard. The minimum surge current rating for the TVSS 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).

(J) CCTV Cabinet

Furnish and install cabinets to house CCTV related equipment described herein. Provide the cabinets with 19-inch communications rack for all equipment. It is the

Contractor's responsibility to size the cabinet appropriate to fit all the equipment installed within the cabinet at the particular location.

Furnish Type 336 CCTV cabinets meeting the following minimum requirements:

- Video/data transceiver (furnished and paid for separately),
- Termination of the composite cable to the camera; and
- Maintenance access points for data and video connections to observe camera images and program/monitor camera status.
- Fiber-optic interconnect center(furnished and paid for separately),
- Grounding busbar,
- 19-inch rack system for mounting of all devices in the cabinet,
- Pull-out shelf for laptop and maintenance use,
- Fluorescent lighting,
- Ventilation fans,
- Thermostats,
- 120 VAC power supply,
- 120 VAC GFCI-protected duplex outlets for tools,
- 120 VAC TVSS-protected duplex outlets for equipment,
- TVSS lightning and surge protection on incoming and outgoing electrical lines (power and data), 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.

Construct the cabinets using unpainted sheet aluminum with a minimum thickness of 0.125 inch.

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 storage space for cabinet documentation and other miscellaneous items. The storage compartment shall be of adequate construction to support a weight of 20 pounds when extended without sagging. The top of the storage compartment shall be hinged aluminum. Provide at least one removable metal shelf with each cabinet.

Provide all cabinets and door exterior seams with continuously welded and all exterior welds shall be smooth. Provide all cabinets with two (2) full-size doors. 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.

Ventilation: Provide all cabinets with a 100 CFM, minimum, cooling fan capacity. Provide a thermostat incorporated into the ventilation system. Provide dual fans.

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 shall be covered 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.

Electrical: 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.

29.3. 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 the CCTV cabinet on the pole in a manner approved by the Engineer. The air terminal ground wire must not pass through this cabinet.

(B) CCTV Camera

Mount CCTV camera units at a height of 45 feet above ground level measured from the base of the pole as approved by the Engineer. Mount cameras on existing poles as shown on the Plans.

Install CCTV assemblies at the locations shown on the Plans.

Mount CCTV camera on the side of pole nearest intended field of view and that avoids occluding the view with the pole. Obtain approval of camera orientation from the Engineer.

Use the vendor-supplied software to configure the cameras.

(C) Power Service

Provide 120VAC power from existing or proposed electrical service assemblies as shown on the Plans. Install new electrical service for CCTV in accordance with the "Electrical Service" section of these Project Special Provisions.

(D) Surge Suppression

(1) Grounding

Connect all grounding points related to the CCTV camera assembly and its subsystems to a single point main grounding electrode as shown in the Plans. A 10-foot grounding electrode shall be installed a minimum of 20 feet away from any additional grounding electrodes and/or ground-mounted devices.

This grounding radiant shall consist of one main 10-foot grounding rod located at the structural base of the CCTV camera pole and attached to three additional 10-foot radiant grounding rod placed a minimum of 20 feet away from the main grounding rod. 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.

(2) Device Power Source Supply Side

Install a transient voltage surge suppressor (TVSS) at the CCTV power source on the supply side. This device shall provide protection between line-to-neutral, line-to-ground, line-to-line and neutral-to-ground.

(3) Device Power Line Side

Install a TVSS 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.

(4) Device Data/Video Supply and Line Side

Install specialized TVSS 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.

(E) CCTV Cabinet

Mount the CCTV cabinet on the wood or metal pole using stainless steel bands as shown in the Plans. Attach all risers to the base of pole-mounted cabinet as shown in the Plans.

Ground all cabinets in accordance with the requirements of these Project Special Provisions. Keep the ground wire from the cabinet ground busbar 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 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, busbar, device clamp, lug; or connector, do not splice any wiring. Label all wiring, cables, terminal strips, and distribution blocks. Provide strain relief for all cabling with connectors, all cabling entering knockouts or ports at the equipment, and where appropriate.

Fasten all components of the cabinet assembly 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; busbars, panel and socket mounted TVSS, circuit breakers, accessory and equipment outlets, and DC power supply chassis.

Fasten all other cabinet components with hex-head or Phillips-head machine screws installed with nuts (with locking washer or insert) or into tapped and threaded holes. Fasten stud-mounted components to a mounting bracket providing complete access to the studs and mounting nuts. All fastener heads and nuts (when used) shall be fully accessible within a complete cabinet assembly, and any component shall be removable without requiring removal of other components, panels or mounting rails. Do not use self-tapping or self-threading fasteners.

The CCTV camera cabinet will be interconnected to CCTV camera assembly using a composite cable carrying the video, serial data and power. Terminal strips shall be provided to support 4-wire EIA 422 communications and the 24 VAC power as will be required for power and data. The terminal strips shall be accessible such that it shall not be necessary to remove any other components to gain access. The terminal shall secure conductors by means of nickel or cadmium plated brass binder head screws.

Configure the cabinets to allow maintenance access for both video and data channels. This access should provide a means to connect video feed and control data channels to a laptop computer. The connection of the laptop computer to video and data feeds shall not require disassembly or removal of any of the equipment or other components located inside the cabinet with the exception of patch cords for the data and video feeds. Provide a communication cable for connection to a typical laptop and video board or monitor for future maintenance activities. The data cable shall consist of an integral RS-232 to RS-

422 converter as required to support the CCTV camera protocol and shall be compatible with the CCTV camera assembly. The data cable shall plug into the test point connector as provided in the cabinet and into a typical laptop RS-232 serial port. The video cables shall interface with the CCTV camera cabinet test point connection and be prepped for interconnection to a BNC receptacle. Two sets of cables shall be provided, two for data and two for video

Each cabinet shall be ISO 9001 certified at the time of bid letting.

Equip the cabinets with TVSS lightning and surge protection described separately in these Project Special Provisions.

(F) Removal of Existing Equipment

Upon completion of replacement cameras remove the old equipment. Deliver the following removed equipment to the City's Signal Shop: cameras, camera mounting brackets, composite camera lead-in cable, cabinets, video/data transceivers and other electronic components. Dispose of all other removed CCTV related hardware, conduit, pole and wire.

29.4. DOCUMENTATION

Furnish to the Department two copies of the following materials prior to acceptance: installation, operation, training and troubleshooting manual, wiring diagrams, including cable pinouts, parts lists, warranty materials, and serial and model numbers of all equipment furnished. The manual shall include weight and dimension information, the operating temperature and relative humidity requirements and the system's general maintenance procedures. The manual shall also include:

- Signal-to-noise ratios (see note below);
- Resolution;
- Sensitivity;
- Power consumption;
- Optical zoom range;
- Digital zoom range;
- Zoom and focus presets;
- Pan and tilt presets;
- Ethernet connection specifications; and
- EIA 232/422/485 camera control interface.

Note: Include a factory test procedure sheet for all cameras used on the project and the camera manufacturer's qualified products list for each test that included cameras used on the project.

All equipment and appurtenances shall be furnished and identified by name, model number, serial number, technical support and warranty telephone numbers, and any other pertinent information required to facilitate equipment maintenance.

Include a factory test procedure sheet for each type cabinet used on a project.

29.5. WARRANTY

Provide a warranty for a minimum of one year or the manufacturer's customary warranty period, whichever is greater, with each CCTV assembly and CCTV cabinet to ensure that the products are free of manufacturing defects in material and workmanship. The warranty commences on the date the CCTV assembly and CCTV cabinet is accepted by the Engineer.

The TVSS components shall carry a manufacturer's warranty of ten (10) years from the date of final Department acceptance.

29.6. 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 30-day observation period).

No separate measurement will be made for cabling, connectors, CCTV camera attachment assemblies, software, grounding equipment, surge protectors, 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.

Fiber-optic video/data transceivers and fiber-optic interconnect centers/patch panels will be measured and paid for separately in accordance with the "Fiber-Optic Transceivers" and "Fiber-Optic Cable" sections of these Project Special Provisions.

CCTV cabinets will be measured and paid as the actual number of CCTV cabinets 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 30-day observation period).

Remove CCTV equipment will be measured and paid at the contract lump sum price. The price and payment will be full compensation for all work required for the removal of the existing field and TMC CCTV equipment (i.e., camera and its mounting brackets, cabling, cabinet, fiber-optic transceiver and pole), delivery of equipment designated to be retained to the City's Signal Shop, and disposal of all other removed CCTV related hardware.

Payment will be made under:

Pay Item	Pay Unit
CCTV Camera Assembly	Each
CCTV Cabinet	Each
Remove CCTV Equipment	Lump Sum

30. CCTV INTEGRATION AND SOFTWARE MODIFICATION

30.1. DESCRIPTION

The CCTV integration and software modification work includes:

- Installing and configuring the replacement video switch software and configuring its database;
- Installing and configuring the replacement video server software and configuring its database; and
- Installing and configuring the frame grabbing software and configuring its database.

30.2. FUNCTIONAL REQUIREMENTS

(A) Graphical User Interface (GUI) Software

The graphical user interface software includes a zoomable static display map that indicates the 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.

Edit the existing unified device database to add the new CCTV devices with icons. The unified device database contains the coordinates of each device in individual records and contains a maximum of fifty fields. 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.

(B) Central CCTV Software

The existing CCTV central software that controls the existing video matrix switch at the TMC is Protronix's VideoPro. It also interfaces with a DVR. This software includes on screen pan-tilt-zoom controls of each camera in the system.

Install the graphical user interface and Protronix central CCTV software controlling the video matrix switch on the replacement video server. Copy the database to the new video server. Edit the database of the existing graphical user interface and Protronix central CCTV software to add the existing, relocated and additional CCTV devices and update the map coverage. Modify the Protronix CCTV central software configuration so that the CCTV video can be displayed on the existing monitors and display devices at the TMC, the Signal Shop and the Department's EIC. Coordinate with the City of Wilmington's IT Department for Internet access.

(C) Frame Grabbing Software

Install and configure the existing video frame grabbing software on the two frame grabbers. Configure each frame grabber for sequencing through each active input to produce jpeg images for transfer to the Department. Coordinate with the City of Wilmington's IT Department for Internet access.

(D) Video Switch Configuration

Copy the video switch database in the Wilmington Traffic Management Center (TMC) to the new video switch. Edit the configuration setup after transferring from the existing video switch to incorporate the new CCTV analog and serial data ports, DVR and communications hardware. Extend the same priorities and lockout privileges to the TMC users, as they currently exist for other City-owned CCTV devices within the City of Wilmington.

30.3. DOCUMENTATION

Provide updated installation, operations and training manuals for the software. Provide printed copies of the updated database.

30.4. MEASUREMENT AND PAYMENT

CCTV software integration for the editing of the databases and integrating of the new CCTV devices will be measured and paid for at the contract lump sum price. The price and payment will be full compensation for all work required by this section, including the furnishing, testing and all materials, equipment labor, tools, storage, shipping and incidentals necessary to edit the existing system configuration to add the new CCTV devices.

Payment will be made under:

Pay Item	Pay Unit
CCTV Software Integration	Lump Sum

31. UNINTERRUPTIBLE POWER SUPPLY

31.1. DESCRIPTION

Furnish and install rack mounted uninterruptible power supply (UPS) units for the CCTV equipment in the TMC and free-standing (i.e. floor model) UPS units for the CCTV equipment in the Signal Shop. Each UPS shall also include any ancillary equipment or incidental items, such as required mounting hardware and cabling

Furnish, assemble, fabricate, or install new products obtained from the manufacturer or reseller. Provide commercial off-the-shelf materials, equipment, and components.

31.2. MATERIALS

Supply UPS units 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;
- Manage all network UPS units;
- Operating system shutdown;
- Power event summary;
- Recommended actions;
- Risk assessment summary;
- Run command file; and
- System event log integration.

31.3. CONSTRUCTION METHODS

(A) General

For the UPS in the TMC, provide power conditioning and uninterrupted power to the video servers and video switch. For the UPS in the Signal Shop, provide power conditioning and uninterrupted power to the Ethernet switch installed by others and to the video equipment. Size each unit to provide 20-30 minutes of backup power operation to provide an orderly shutdown or transfer to generator power for the building. Provide remote monitoring through the Ethernet network that a UPS has transferred to battery operation.

(B) Mechanical Specifications

Ensure that all wiring complies with NEC requirements and standards. Furnish and identify all equipment and appurtenances by name, model number, serial number, technical support and warranty telephone numbers, and any other pertinent information required to facilitate equipment maintenance. Ensure that every conductive contact surface or pin is gold-plated or made of a noncorrosive, nonrusting, conductive metal. Ensure that all external screws, nuts, and locking washers are stainless steel. Do not use self-tapping screws unless the Engineer provides prior approval. Supply parts made of

corrosion-resistant materials, such as plastic, stainless steel, anodized aluminum, brass, or gold-plated metal.

Supply each UPS unit with fifty (50) percent spare outlets. Ensure that the UPS meets the following material requirements:

- For the UPS in the TMC, rack-mount in 19-inch EIA rack; for the UPS in the Signal Shop, floor mount.
- Sealed AGM type, maintenance free batteries;
- USB and DB-9, RS-232 interface port;
- Status Lights: power on, power source and overload;
- Alarms: audible and remote notification; and
- Manual power on/off switch.

(C) Electrical Specifications

Provide the UPS meeting the following electrical 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;
- Noise filtering: Full time multi-pole noise filtering shall meet 0.3% IEEE surge let-through; zero clamping response time shall meet UL 1449.

(D) 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: 0-104° F;
- Operating relative humidity: 95 percent;
- Storage temperature: 5-113° F;
- Storage relative humidity: 95 percent.

(E) Installation Requirements

Install the TMC UPS unit in the 19-inch communications racks within the TMC and the Signal Shop UPS unit on the floor adjacent to the workstation in the bench repair area of the Signal Shop.

Connect the UPS units to power outlet. Connect the UPS monitoring port to the respective Ethernet switch.

Install the UPS monitoring software on a workstation in the TMC for remote monitoring of both units. Run the UPS diagnostics.

For the UPS in the TMC, plug the power strip mounted on the rack frame into the UPS. Plug all communications hardware into the TMC UPS or the power strip. Plug the communications hardware in Signal Shop into the Signal Shop UPS.

31.4. 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 Wilmington.

Provide technical support and warranty telephone numbers, and any other pertinent information required to facilitate equipment maintenance.

31.5. WARRANTY

Provide a warranty for a minimum of one year or the manufacturer's customary warranty period, whichever is greater, with each UPS to ensure that the products are free of manufacturing defects in material and workmanship. The warranty commences on the date the UPS is accepted by the Engineer.

31.6. MEASUREMENT AND PAYMENT

UPS will be measured and paid as the actual number of UPS furnished, installed, and accepted according to following conditions: 75% of the payment will be made upon acceptance of the installed UPS and the remaining 25% of the payment will be made following final acceptance (including completion of the 30-day observation period)...

No measurement will be made of power cords, adapters, mounting hardware, connectors, serial cables, installation materials and configuration software necessary to complete this work described in this section as such work will be considered incidental to furnishing and installing the UPS.

Payment will be made under:

Pay Item	Pay Unit
UPS	Each

32. CENTRAL VIDEO EQUIPMENT

32.1. DESCRIPTION

The central video equipment scope of work shall include a replacement video switch, a DVR, additional video distribution amplifier, replace the existing frame grabber, replace the existing video server, an additional frame grabber and provisions for viewing and controlling video at the City Signal Shop. Note the existing video server is labeled as "EIC Server" on that unit. Note the existing frame grabber is labeled as "EIC Transmitter" on that unit. Provide joystick/keyboards for selecting and controlling cameras and monitors.

32.2. MATERIALS

(A) Video Matrix Switch

Provide a replacement analog video matrix switch compatible with existing Pelco SpectraDome III and IV cameras in use by the City of Wilmington. The switch shall utilize camera control protocols compatible with the Pelco cameras. If the Contractor desires to use any protocols other than that used in the existing cameras he will be responsible for adapting all cameras to the same protocols.

The replacement video matrix switch shall consist of the following components:

- Central microprocessor unit (CPU)/controller,
- Input and output bays,
- Video and keyboard cables to connect the video matrix CPU to the City's KVM switch,
- Administrative keyboard for accessing the CPU,
- Operator joystick/keyboards (3),
- Primary and backup power supplies,
- Color quad video processor,
- VCR/DVR control interface/software,
- Character generator for displaying date, time and text on each analog output,
- Alarm interface unit,
- Control software, and
- Cabling.

The video matrix switch shall be expandable within the chassis up to 256 inputs and 32 outputs by adding additional video input and/or output cards.

Furnish video input cards and connector panels for at least 48 camera inputs. Furnish video output cards and connector panels for at least 32 camera outputs.

Provide the video input and out cards meeting the following requirements:

- Video Input Level: .5 to 2V p-p, RS-170 composite video,
- Impedance: 75 ohms unbalanced-to-ground, terminating, and
- Connectors: BNC.

Furnish RS-422 serial communications ports to provide PTZ control for at least 48 cameras and four joystick/keyboards.

Provide the following features in the Windows-based system software:

- Windows® XP compatible,
- Remote programming of switch,
- External storage of all configuration data,
- Logging of system activity, including events and alarms, and
- Password protection for control of system operations and programming.

Provide the following features in the CPU:

- Macro and scheduler to activate tours, etc. (macros can also be activated manually by keyboard),
- VGA monitor port, parallel printer, and two PC_AT keyboard ports,
- 32 macros with up to 72 steps per macro,
- 256 camera presets, and
- Alarm inputs and outputs to detect faults at camera site and provide external notification in ASCII format.

Provide the following features in the video matrix switch:

- Video Bandwidth: 15MHz,
- Frequency Response: Flat to 8MHz; +/- 1dB to 13MHz,
- S/N Ratio: -70.5dB,
- Adjacent Channel Crosstalk: -60.9dB typical at 3.58MHz,
- Switching Time: Less than 16 ms,
- Differential Gain: 0.51%, and
- Differential Phase: 0.38°.

Provide the following features in the character generator. Each feature can be individually programmed per camera:

- Time in 24-hour or AM/PM format,
- Date in four different modes,
- Camera number, and
- 24-character on the video screen.

Provide four joystick/keyboards for selecting and controlling cameras and monitors. Provide the following features in the joystick/keyboards:

- RS-422 or RS-485 protocol,
- Camera and monitoring switching,
- Preset selection,
- Full three-axis pan-tilt-zoom control through joystick,
- Digital LED display, and
- Programmable keys.

Provide the video matrix switch, video switching bay and character generator with the following electrical requirements:

- Input Voltage: 120VAC and
- Frequency: 50/60 Hz.

Verify that the video matrix switch, video switching bay and character generator are capable of performing all of its functions during and after being subjected to:

- Operating temperature: 20-120° F, and
- Operating relative humidity: 10-90%.

Provide the color quad video processor with following the following requirements:

- Video Bandwidth: 15MHz,
- Frequency Response: Flat to 8MHz; +/- 1dB to 13MHz,
- S/N Ratio: -70.5dB,
- Adjacent Channel Crosstalk: -60.9dB typical at 3.58MHz,
- Switching Time: Less than 16 ms,
- Differential Gain: 0.51%,
- Differential Phase: 0.38°,
- Resolution: 1024 horizontal x 512 vertical pixels,
- Camera Inputs: 4,
- Looping Outputs: 1,
- Alarm Inputs: 5,
- Alarm Outputs: 1,
- Automatic time based correction,
- Full screen or quad sequencing,
- Full screen, quad image viewing, and
- Rack-mounted, one rack unit high.

(B) Digital Video Recorder (DVR)

Furnish a digital video recorder (DVR) with an integrated DVD/CD writer in the TMC Server Room. Provide an integrated DVR capable of reading and writing DVDs (digital video discs) and CDs (compact discs) and meeting the following minimum requirements:

- 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,

- Media Supported: DVD+r, CD-Rom, CD-R, CD-RW, DVD-ROM, DVD-R, DVD-RW, DVD+RW, DVD+R,
- Video Upconversion Resolution: 720p, 1080i and 1080p,
- Connectors: 1 coaxial in, 1 coaxial out, 2 S-video in, 1 S-video out, component video/audio in and out,
- Metal chassis,
- Remote control,
- Progressive scan,
- NTSC playback format, and
- Complete set of AV and power cables.

The DVR shall interface to a desktop computer (i.e., workstation) and be able to record video images from cable TV, and the CCTV camera video images.

(C) Video Distribution Amplifier

The video distribution amplifier shall receive the video signals from the video/data transceivers and provide video output of those signals to both the media and the video matrix switch. Provide the video distribution amplifier meeting the following minimum requirements:

Performance:

- Gain Range: -3dB to +3dB,
- Frequency Response: <±0.05dB to 10MHz; +/- .2dB to 20MHz; -3dB bandwidth >50MHz,
- Line Tilt: <0.20%,
- Field Tilt: <0.20%,
- Differential Gain: <0.15%,
- Differential Phase: <0.15°,
- S/N Ratio: >70dB,
- Hum: 1mVp-p, and
- Propagation Delay: 140 ± 1ns.

Inputs:

- Input Connectors: BNC, (16 minimum),
- Video Input Level: 1Vp-p nominal,
- Subcarrier Input Level: 2.5Vp-p,
- Input Impedance: 75 ohms looping or internal terminating, user selectable,
- Input Return Loss: >45dB to 50MHz, >40dB to 10MHz,
- Coupling: D.C.,
- CMRR: >65 @1 kHz, and
- CM Range: >28Vp-p.

Outputs:

- Number of Outputs: 4 per input,
- Output Connectors: BNC,

- Output Impedance: 75 ohms,
- Output Return Loss: >45dB to 5MHz, >40dB to 10MHz,
- Output Isolation: >40dB @ 10MHz,
- Response Variation: <0.1dB, @ 10 MHz, an
- Phase Match: < ±.2°.

Electrical

- Input Voltage: 90-135VAC,
- Frequency: 50/60 Hz,
- Power: 50 VA, and
- Power Supply: Redundant and switchable.

(D) Video Multiplexer

The video multiplexer shall receive the video signals from the video distribution amplifier and provide a multiplexed video output to the existing frame grabbers for distribution to the Department over the Internet. Synchronize the video input signals to the internal clock signal of the multiplexer. Digitally multiplex into a single NTSC video output signal all video inputs. Provide the video multiplexer meeting the following minimum requirements:

Performance:

- Gain Range: -3dB to +3dB,
- Frequency Response: <±0.05dB to 10MHz; +/- .2dB to 20MHz; -3dB bandwidth >50MHz,
- Differential Gain: <0.15%,
- Differential Phase: <0.15°, and
- S/N Ratio: >70dB.

Video Inputs:

- Input Connectors: BNC,
- Video Input Level: 1Vp-p nominal,
- Subcarrier Input Level: 2.5Vp-p,
- Input Impedance: 75 ohms looping or internal terminating, user selectable, and
- Input Return Loss: >45dB to 50MHz, >40dB to 10MHz.

Video Outputs:

- Number of Outputs: 1 BNC, and
- Output Impedance: 75 ohms.

Data Ports:

- RS-232 port for programming and control from external computer,
- Ethernet port for LAN connection and management.

Electrical

- Input Voltage: 90-135VAC,
- Frequency: 50/60 Hz..

Software

- Operating System: Microsoft® Windows® compatible.

(E) Video Monitors

Provide video monitors meeting the following requirements:

(1) TMC Video Wall:

- Size: 23-inch, digital flat panel display
- Mounting: Wall-mount,
- Pitch: 27 dpi, SXGA,
- Resolution: 1,920 x 1,080 dpi,
- Colors: 16.7 million colors,
- Horizontal Scanning Frequency: 24-82kHz
- Vertical Scanning Rate: 1080 lines,
- Contrast Ratio: 1000:1,
- Viewing Angle (Horizontal): 170 degrees,
- Viewing Angle (Vertical): 170 degrees,
- Brightness: 450 cd/m^2,
- Inputs: NTSC RGB ports, HDMI (2), RGB, S-Video (2), Composite video (2).

(2) Signal Shop:

- Size: 42-inch, digital flat panel display,
- Mounting: Wall-mount,
- Pitch: 27 dpi, SXGA,
- Resolution: 1,920 x 1,080 dpi,
- Colors: 16.7 million colors,
- Horizontal Scanning Frequency: 24-82kHz,
- Vertical Scanning Rate: 1080 lines,
- Contrast Ratio: 1000:1,
- Viewing Angle (Horizontal): 170 degrees,
- Viewing Angle (Vertical): 170 degrees,
- Brightness: 4500 cd/m^2,
- Infrared Remote Control: Included,
- Inputs: NTSC RGB ports, HDMI (2), RGB, S-Video (2), Composite video (2).

Provide mounting brackets specifically designed for mounting the size of LCD monitors described above on both metal and wood stud walls. Provide brackets that allow vertical and horizontal tilt to optimize viewing angles. Provide brackets with locking set screws to prevent the monitor from falling or sliding off the bracket.

Provide RG-59 coaxial video cables for the TMC monitors to reach from the video switch output to the wall monitors.

(F) Frame Grabber and Video Server

Provide two frame grabbers and a video server meeting the following requirements:

- Intel® Zeon™ processor with a minimum clock speed of 2400 MHz,
- Rack mounted, one rack unit high,
- 512KB of level 2 ECC cache,
- RAM memory 4 DIMM sockets of DDR2 800/667 MHz unbuffered, ECC SDRAM, 2 GB of RAM, expandable to 8GB,
- Single 3.5" internal drive bay,
- 160GB internal hard drive,
- 1.44MB, 90mm internal floppy disk drive,
- 4x DVD+R/+RW and 24xCD-ROM combo drive,
- Two Gigabit PCI-Express Ethernet controllers,
- Support for Intelligent Platform Management Interface v.2.0 with virtual media over LAN & optional KVM-over-LAN support,
- Universal (x8) PCI-E or 1 64 bit PCI-X 133 MHz slot,
- One EIDE channel supports up to two UDMA IDE devices with UDMA Mode 5, PIO Mode 4, and ATA/100,
- Six Serial ATA ports and expansion slots, supporting Raid 0, 1, 6 and 10,
- Minimum of two (2) front side and 2 rear USB ports,
- PS/2 keyboard and mouse ports,
- Microsoft® Windows® server per the City of Wilmington IT Standards,
- Ethernet Network Interface with autoselect 10BaseTX/100BaseTX (10, 100 or 1000 Mb per second),
- SVGA video card with 64 MB of memory, 64-bit graphics chip with a display resolution of 1600 x1280, and
- 200 watt power supply.

In addition, for frame grabbers provide video capture card capable of capturing full motion composite (NTSC/PAL) video at 30 frames per second with a resolution of 640 x 480 NTSC or 704 x 476 PAL.

32.3. CONSTRUCTION METHODS

(A) Video Matrix Switch

Install a video matrix switch with a minimum of 48 inputs and 32 outputs expandable to 256 inputs and 32 outputs.

Install the video matrix switch in an existing 19-inch communications rack provided by the City in the TMC as shown in the Plans. Terminate and install the video input cards in the video matrix switch. Connect the analog outputs from the video distribution amplifier to individual inputs of the video matrix switch.

A KVM switch is being furnished and installed by the City. Connect a video cable between the video monitor port of the CPU to a video input of the KVM switch. Connect

a keyboard cable between the keyboard port of the CPU to the respective keyboard port of the KVM switch.

Connect the video matrix switch monitor outputs to the TMC monitors, the frame grabbers and the TMC workstations as shown in the Plans.

Connect the RS-422 PTZ data lines from each camera to individual communications ports of the video matrix switch.

Run data cables under the raised floor from the video switch to the three new joysticks in the TMC. Reuse the existing Pelco KBD 300 keyboard and its cabling. Reuse the existing cabling to existing keyboard on the center console. Install three new joysticks in cubicle offices and center console as shown in the Plans. Install one new joystick on the desk in the traffic signal controller test bench area of the Signal Shop as shown in the Plans and connect it to the video/data transceiver in the Signal Shop. Coordinate exact locations with the City Traffic Engineer. Connect the PTZ joysticks to individual communications ports of the video matrix switch.

Neatly secure cabling using cable management hardware.

Program the CPU to control the new DVR remotely. Program the video switch and CPU per these Project Special Provisions.

(B) Digital Video Recorder (DVR)

Install the DVR in an existing 19-inch communications rack in the TMC and connect to a video output and inputs of the video matrix switch. Configure the DVR for remote control and scheduled recording. Configure the DVR so it can both record video off the video switch and play back recorded video to the video matrix switch.

(C) Video Distribution Amplifier

Provide a video distribution amplifier that has a minimum of 16 input ports and 4 outputs per input. Provide a chassis that is a maximum of 2 RU (3.5" high)

Install the video distribution amplifier in 19-inch communications rack in the TMC. Connect the inputs of the video distribution amplifier to the video outputs of the fiber-optic video/data transceivers. Connect one set of the video outputs of the video distribution amplifier to the input side of the video matrix switch. Connect one set of outputs to the input side of the proposed frame grabber.

(D) Video Multiplexer

Provide a video multiplexer that has a minimum of 16 input ports and one output port. Provide a chassis that is a maximum of 2 RU (3.5" high).

Install the video multiplexer in 19-inch communications rack in the TMC. Connect one set of the video outputs of the video distribution amplifier to the input side of the video multiplexer. Connect the output of the video multiplexer to the input side of the proposed frame grabber.

(E) Video Monitors

Mount the 42-inch LCD Monitor on the wall in the Signal Shop bench repair area as directed by the City Traffic Engineer. Use a mounting bracket specifically designed

for wall mounting of LCD monitors. Ensure the mounting bracket is secured to wall studs according to the manufacturer's recommendations. If the wall studs do not align with the mounting brackets, install a ½" plywood panel large enough to connect to two vertical studs then mount the monitor bracket to the plywood. Paint the plywood to match existing wall color and sheen. Connect the video output of the video data transceiver with the appropriate video input of the monitor.

Mount the eight 23-inch LCD Monitors on the TMC video wall in as directed by the City Traffic Engineer. The monitors shall align vertically and horizontally with the existing monitors. Use a mounting bracket specifically designed for wall mounting of LCD monitors. Mount the monitors in line vertically and horizontally with the existing monitors. Connect a video output of video matrix switch with the appropriate video input of the monitor.

(F) Frame Grabber and EIC Servers

Install the new and replacement frame grabbers and video server in 19-inch communications rack in the TMC as shown in the Plans. Connect the output of the video distribution amplifiers to the input of the respective frame grabbers. Install and configure the existing frame grabbing software on the new and replacement frame grabbers.

Connect the replacement video server to the Ethernet switch and configure for access through the firewall to NCDOT. Coordinate Internet access through the firewall with the City of Wilmington IT Department. Install and configure the existing video control software on the replacement video server.

32.4. TESTING

(A) General

Perform factory and field tests of furnished and installed equipment. Test a minimum of one and at least 10% of the equipment to ensure the equipment meets the requirements of the Project Special Provisions. Develop a test plan that demonstrates the equipment operates properly within the specified environmental conditions for temperature and humidity and the use of NTCIP objects. Submit for approval before conducting tests. Tests may be conducted by a certified independent test facility. The Department reserves the right to observe and monitor any and all tests.

(B) Field Test

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 shall have the right to witness such tests, or to designate an individual or entity to witness such tests.

Repair or replace defective or failed equipment and retest.

Upon satisfactory completion of operational test, begin an observation period prior to system acceptance.

32.5. DOCUMENTATION

Furnish to 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 Wilmington.

Provide technical support and warranty telephone numbers, and any other pertinent information required to facilitate equipment maintenance.

32.6. WARRANTY

Provide a warranty for a minimum of one year or the manufacturer's customary warranty period, whichever is greater, with unit of each central video equipment to ensure that the products are free of manufacturing defects in material and workmanship. The warranty commences on the date the unit of equipment is accepted by the Engineer.

32.7. MEASUREMENT AND PAYMENT

Video matrix switch will be measured and paid as the actual number of video matrix switches furnished, installed, and accepted, subject to the following conditions: 75% of the payment will be made upon acceptance of the unit; 25% of the payment will be made following final acceptance of the integrated system (including completion of the 30-day observation period). This work shall include at no additional compensation the central microprocessor unit (CPU)/controller, input and output bays, operator joystick/keyboards (4), all joystick cabling, primary and backup power supplies, VCR/DVR control interface/software, character generator for displaying text on each analog output, alarm interface unit, control software, and cabling.

Digital video recorder will be measured and paid as the actual number of digital video recorders furnished, installed, and accepted, subject to the following conditions: 75% of the payment will be made upon acceptance of the unit; 25% of the payment will be made following final acceptance of the integrated system (including completion of the 30-day observation period).

Video distribution amplifier will be measured and paid as the actual number of video distribution amplifiers furnished, installed, and accepted, subject to the following conditions: 75% of the payment will be made upon acceptance of the unit; 25% of the payment will be made following final acceptance of the integrated system (including completion of the 30-day observation period).

Video multiplexer will be measured and paid as the actual number of video multiplexers furnished, installed, and accepted, subject to the following conditions: 75% of the payment will be made upon acceptance of the unit; 25% of the payment will be made following final acceptance of the integrated system (including completion of the 30-day observation period).

Video monitor (23") will be measured and paid as the actual number of 23" video monitors furnished, installed, and accepted, subject to the following conditions: 75% of the payment will be made upon acceptance of the unit; 25% of the payment will be made following final acceptance of the integrated system (including completion of the 30-day observation period).

Video monitor (42") will be measured and paid as the actual number of 42" video monitors furnished, installed, and accepted, subject to the following conditions: 75% of the payment will be made upon acceptance of the unit; 25% of the payment will be made following final acceptance of the integrated system (including completion of the 30-day observation period).

Video server will be measured and paid as the actual number of video servers (frame grabbers and video server) furnished, installed, and accepted, subject to the following conditions: 75% of the payment will be made upon acceptance of the unit; 25% of the payment will be made following final acceptance of the integrated system (including completion of the 30-day observation period).

No separate measurement will be made for coaxial cables, communication cables, electrical cables, mounting hardware, nuts, bolts, brackets, connectors, grounding equipment or surge suppression as these will be considered incidental to the pay items listed above.

Payment will be made under:

Pay Item	**Pay Unit**
Video Matrix Switch	Each
Digital Video Recorder	Each
Video Distribution Amplifier	Each
Video Multiplexer	Each
Video Monitor (23")	Each
Video Monitor (42")	Each
Video Server	Each

33. SIGNAL SHOP MODIFICATIONS

33.1. DESCRIPTION.

This section describes the building modifications required to provide EMT conduit, electrical junction box and a small wall-mounted equipment rack in the City of Wilmington Signal Shop housed in the Traffic Engineering building. To perform this work, contact the City Traffic Engineer at (910) 341-4696 at least 10 working days before beginning work at the Traffic Engineering building to arrange for access to that facility.

33.2. MATERIALS.

(A) General:

Furnish 2-inch EMT conduit for all conduit in the Signal Shop. Furnish all necessary conduit fittings, conduit fasteners, bushings, other attachment hardware or any other materials necessary to install conduit in the Signal Shop from the proposed junction box in the Signal Shop to the electronic equipment as shown in the Plans.

(B) 19-inch Equipment Rack:

Furnish a wall-mounted EIA 19-inch equipment rack for mounting of a fiber-optic interconnect center, fiber-optic video/data transceiver and an Ethernet switch. The unit shall be an enclosed, two-foot high rack and shall be anchored to the wall. 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 paint.

33.3. CONSTRUCTION METHODS.

(A) General:

No conduit runs shall violate the minimum bending radius of the fiber-optic cable in the conduit. Do not attach conduit to any structural members of the building by welding or drilling. Install conduit as shown in the Plans in accordance with the NEC requirements.

Install a junction box at the end of the existing 2-inch conduits above the signal test board in the Signal Shop.

Install a 2-inch EMT riser vertically to the proposed junction box at the ends of the existing 2-inch conduits. Terminate the conduit in the wall-mounted communications rack.

(B) 19-inch Equipment Rack:

Attach the 19-inch equipment rack to the wall of the Signal Shop as recommended by the manufacturer and approved by the Engineer, ensuring that the rack is anchored to the metal studs and not just the drywall. Locate an existing electrical grounding point in the Signal Shop. Ground the 19-inch equipment rack to that building ground.

33.4. MEASUREMENT AND PAYMENT

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 for the installation of EMT conduit, electrical junction box and a small wall-mounted equipment rack in the City's Signal Shop.

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.

Payment will be made under:

Pay Item	Pay Unit
Signal Shop Modifications	Lump Sum

34. SUBMITTAL DATA

34.1. DESCRIPTION

Provide project documentation as described below.

34.2. 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 proposed progress 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 his 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.

Signal Equipment Qualified Products List (QPL) is available on the Department's Web site. 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 Web site to obtain pre-approval procedures.

(D) 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 shall be returned as rejected. Additional time shall 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 Packages

Submittal Package	Description
Cabinets and Traffic Signal Controllers	Traffic Signal Cabinets, Controllers, Base Adapters, Base Extenders, Detector Amplifiers, Conflict Monitors
CCTV Equipment	CCTV Cabinets, CCTV Cameras, Composite Video Cable
Central Video Equipment	Video Switch, Video Distribution Amplifier, Video Multiplexer, Video Server, DVR, Joysticks

Submittal Package	Description
Fiber-Optic Cable	Fiber-optic Cable, Interconnect Centers, Drop Cable Assemblies, Splice Enclosures, Underground Cable Markers, Communications Cable Identification Markers
System Support Equipment	Conflict Monitor Tester, Fiber-optic Restoration Kit, Fiber-optic Power Meter, Optical Light Source, Visual Fault Locator and Video Monitor
Computer Hardware	ITS Servers, Workstations, Laptops, KVM Switch
Communications Equipment	UPS
Field Infrastructure	Conduit, Junction Boxes, Splice Boxes/Cabinets, Misc. Hardware

Submit cabinet layout and wiring diagrams for all cabinets.

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 four copies of the equipment list including four 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 or other means the specific materials for which approval is requested.

Allocate 40 days for the Department to review and respond to a submittal. Submittal approval will be granted only to specific materials; 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.

34.3. 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.

35. TRAINING

35.1. DESCRIPTION

Provide training for the installation, operation and maintenance of:

- Fiber-optic transceivers,
- Fiber-optic communications cable,
  - Fiber-optic interconnect centers,
  - Splice trays and other related fiber-optic equipment in accordance with the plans and project special provisions,
- 2070 traffic signal controllers and controller software,
- CCTV field equipment,
- CCTV central equipment,
- CCTV central software
- Controller hardware and local controller software including:
  - Controllers,
  - Cabinets,
  - Conflict monitors,
  - Detectors,
- UPS, and
- Spread spectrum radios.

35.2. 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 for approval by the Department. For exercises requiring computers, furnish enough computers to have one computer per two students.

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 audio-visual equipment, demonstration equipment, 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 12-15 students in the class. 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.

Video record the entire training on digital videodisc (DVD) and provide the DVD(s) to the Department for later use.

The training shall be conducted locally after the completion of all system integration tests. 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.

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.
- "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	Length (Days)
Fiber-Optic Communications	Lecture and Hands-on Exercises	3
2070 Traffic Signal Controllers and Controller Software	Lecture and Hands-on Exercises	2
CCTV Field Equipment	Lecture and Hands-on Exercises	1
CCTV Central Video Equipment	Lecture and Hands-on Exercises	0.5
CCTV Central Software	Lecture and Hands-on Exercises	0.5
UPS	Lecture and Demonstration	0.25
Spread Spectrum Radios	Lecture and Hands-on Exercises	1

Provide additional specific training as described below.

(B) 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)
Transceivers		.5
Safety	Lecture	
Introduction to transceivers	Lecture	
Review of Maintenance Manual	Lecture	
Review of Operations Manual	Lecture	
Question and answer session	Lecture	
Fiber-Optic Cable System		1
Safety	Lecture	

Course	Type of Training	Length (Days)
Introduction to fiber-optics, theory, and principals	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, etc.)		
Splice enclosure, splice trays, and connector panels		
Cable placement techniques		
Question and answer session		
Fiber-Optic Cable System (cont.)		1
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.		
Fiber-Optic Cable System (cont.)		1/2
Class project -- Testing and troubleshooting	Lecture, Demonstration and Hands-on	
Cable system maintenance and restoration	Lecture	
Question and answer session.		

(C) CCTV Field Equipment

Provide training for the CCTV field equipment and the local CCTV camera software as described below:

Course	Type of Training	Length (Days)
Operations	Lecture	1
Theory of operation	Lecture, Demonstration	
Local camera programming	Lecture, Demonstration and Hands-on	
Camera addresses		
Presets		
Privacy zones		
Privacy zones		

Course	Type of Training	Length (Days)
Tours		
Other features		
Maintenance	Lecture	
Routine maintenance	Lecture, Demonstration and Hands-on	
Testing	Lecture, Demonstration and Hands-on	
Troubleshooting	Lecture, Demonstration and Hands-on	

(D) CCTV Central Video Equipment

Provide training for the CCTV central equipment (video matrix switch, keyboard/joystick, DVR, video distribution amplifier, video multiplexer, proposed EIC server) as described below:

Course	Type of Training	Length (Days)
Operations	Lecture	.5
Theory of operation	Lecture, Demonstration	
Video switch programming	Lecture, Demonstration and Hands-on	
Adding and deleting devices		
Tours		
Macros		
Data backups		
Operator and access rights		
Alarms		
Maintenance	Lecture	
Routine maintenance	Lecture, Demonstration and Hands-on	
Testing	Lecture, Demonstration and Hands-on	
Troubleshooting	Lecture, Demonstration and Hands-on	

(E) CCTV Software

Provide training for the CCTV central software as described below:

Course	Type of Training	Length (Days)
Programming	Lecture, Demonstration and Hands-on	.5
Database updates		
Map updates		
Operations	Lecture	
Theory of operation	Lecture, Demonstration	
Testing	Lecture, Demonstration	

Course	Type of Training	Length (Days)
	and Hands-on	
Maintenance	Lecture	
Routine maintenance	Lecture, Demonstration and Hands-on	
Troubleshooting	Lecture, Demonstration and Hands-on	

(F) 2070 Traffic Signal Controllers and Controller Software

Provide two sessions in the basic theory and operation of the 2070 controller equipment, cabinets, conflict monitors and other related equipment. Include in this training lecture and hands-on exercise in the use of the local controller software. Assume the attendees have a good working knowledge through their use of NEMA controllers.

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- (L, D, H),	Lecture, Demonstration and Hands-on	2
Phasing,		
Timing,		
Preemption,		
Coordination,		
Data transfer		
Operations - (L),	Lecture	
Theory of operation	Lecture, Demonstration and Hands-on	
Testing	Lecture, Demonstration and Hands-on	
Maintenance- (L),	Lecture	
Routine maintenance- (L, D, H),	Lecture, Demonstration and Hands-on	
Troubleshooting- (L, D, H).	Lecture, Demonstration and Hands-on	

(G) UPS

Provide training for the UPS units that is 2 hours in length, including both classroom and "hands-on" training.

(H) Spread Spectrum Radios

Provide training for the spread spectrum 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	

35.3. 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

36. TESTING AND ACCEPTANCE

36.1. GENERAL

Conduct and complete successfully the following progressive series of tests before acceptance: factory acceptance testing, field demonstration test prior to installation, installed standalone tests, system test of the network hardware, 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. Test will be performed by the Contractor and witnessed by the Department. 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 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.

36.2. FACTORY ACCEPTANCE TESTING (FAT)

Conduct a factory acceptance test to verify to the Department that all design, materials, and performance requirements for this project are satisfactorily met. Perform the factory acceptance tests at the equipment manufacturer's facility or at an independent testing laboratory.

36.3. PRE-INSTALLATION FIELD DEMONSTRATION TESTING (FDT)

Conduct pre-installation tests on all devices at a Contractor-provided facility within New Hanover County. Perform the tests on all components including, but not limited to, traffic signal controllers, conflict monitors, supplied to verify that no damage was done to any unit during the shipment and delivery process. Notify the Engineer a minimum of 15 calendar days before the start of any tests. Conduct all tests according to the approved test procedures detailed in this section. Each device shall pass the individual tests detailed below prior to installation.

Establish a local test facility to setup, program and test the traffic signal controllers and malfunction management units before installation. Install configuration, programming and phasing, local and coordinated timing before field installation.

Confirm proper operation including color sequence, flashing, preemption and timing on a test board. Demonstrate and confirm the proper programming of the matching malfunction management unit for the same location. Test the malfunction management units by applying simultaneous input of conflicting colors. Perform an 8-hour burn-in of each controller and conflict monitor.

(A) Product Examination Test

Examine each device carefully to verify that the materials, design, construction, markings, and workmanship comply with all applicable standards, specifications, and requirements.

(B) Continuity Test Specifications

Check the wiring to determine conformance with the applicable standards, specifications, and requirements.

(C) Operational Test Specifications

Operate each device long enough to permit equipment temperature stabilization, and to check and record an adequate number of performance characteristics to ensure compliance with applicable standards, specifications, and requirements.

(D) Pre-installation Test Failure Consequence

If any unit fails to pass a FDT, the unit shall be corrected or another unit substituted in its place, and the test successfully repeated.

If a unit has been modified as a result of an FDT failure, prepare a report and deliver that report to the Engineer prior to the unit's shipment. The report shall describe the nature of the failure and the corrective action taken.

If a failure pattern develops (more than two failures), the Engineer will make a determination of the disposition of the failed equipment without additional cost to the Department or an extension of the contract period.

36.4. 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 Department will record each attempt for purposes of acceptance.

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. Label all test results (plots and discs) with the manufacturer and model number of the OTDR testing equipment.

Provide a tabular summary or spreadsheet detailing and comparing the loss budget and actual loss calculations per link. Provide test results for fiber-optic cable that demonstrates the loss budget where the fiber originates and the point where the fiber meets an electronic device.

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) 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.

(C) 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.

(D) 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 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:

- 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,
- 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 with a portable NTSC-approved monitor,
- 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.

Repair or replace defective or failed equipment and retest.

(E) 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.

(F) Spread Spectrum Radios

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 spread spectrum radios to the TMC. Run the system diagnostics from end to end.

(G) UPS

Perform the following operational tests for each UPS in accordance with the test plans. After the UPS has been installed:

- Connect TMC and Signal Shop equipment to respective UPS;
- Connect UPS monitoring cable to Ethernet switch;
- Install and configure UPS monitoring software from 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.

36.5. 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 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.

Upon satisfactory completion of the testing for the TMC equipment as installed, the City of Wilmington shall integrate the traffic signal controllers from the copper serial-based communications to the serial communications network and restore full TMC command and control.

(B) CCTV Subsystem

After completing the integration of the Phase 1 CCTV, 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 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.

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 from the TMC:

- NTCIP objects,
- Power-up self-tests,
- Iris control,
- Preset functions,
- Presence and quality of the video image with a portable NTSC-approved monitor,
- 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 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 TMC and the City's Signal Shop to ensure correct operation. Test the components of the CCTV central equipment from both the signal shop and the TMC as follows:

- Use the GUI interface to select and view each camera,
- Use each joystick/keyboard and test the ability to control the pan-tilt-zoom and iris settings of each camera,
- Use each joystick/keyboard and test the ability to select and place any camera on any monitor.

(C) Traffic Signal Subsystem

After the City of Wilmington has completed the integration of the Phase 1 traffic signal subsystem, 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 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.

36.6. OBSERVATION PERIOD

(A) General

The observation period-shall be completed by the project completion date. 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.

The observation period shall begin at least 30-days before final acceptance. A successful 30-day observation period shall consist of continuous operation with no more than a total of two calendar days of non-operation due to mechanical, electrical, or other malfunctions of either the CCTV or the traffic signal subsystems.

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, complete repairs within four hours. If any failures affect major components for more than 48 hours, the Department shall suspend the observation period beginning when the failure occurred. Resume the observation period with the approval of the Engineer after successful repair or replacement. If three or more major component failures of a like nature occur, the Department shall terminate the observation period. Begin a new 30-day observation period with the approval of the Engineer after the faulty equipment has been repaired or replaced.

(B) CCTV Subsystem

The observation period shall begin upon the successful completion of the CCTV subsystem operational test. During this period, the Department shall observe equipment and software operation according to the requirements of the Plans and these Project Special Provisions.

Major subsystem components include the video matrix switch and its peripherals, CCTV cameras, CCTV monitors, fiber-optic video/data transceivers, fiber-optic cable, and CCTV cabinets.

(C) Traffic Signal Subsystem

The observation period shall begin upon the successful completion of the traffic signal subsystem operational test. During this period, the Department shall observe equipment and software operation according to the requirements of the Plans and these project special provisions.

Major subsystem components include the traffic signal controllers and conflict monitors, controller cabinets and fiber-optic data transceivers.

36.7. 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 30 calendar day observation period.

The project will be ready for final acceptance upon the satisfactory completion of all factory acceptance, field demonstration, installed standalone, system and operational tests. In addition, final acceptance shall not occur until all punch-list discrepancies have been rectified, all documentation has been delivered and all required training has been completed.