Attachment 14
Monroe ITS SOW from DB RFP

INTELLIGENT TRANSPORTATION SYSTEM (ITS) SCOPE OF WORK (09-24-2010)

1. GENERAL REQUIREMENTS

1.2 DESCRIPTION

(A) Summary of Work

This section of the RFP will provide the NCTA Monroe Connector/Bypass with intelligent transportation system (ITS) devices and fiber-optic communications.

This ITS subsystem includes, but is not limited to:

- Closed circuit television (CCTV) cameras,
- Color, full-matrix dynamic message signs (DMS),
- Microwave vehicle detection systems (MVDS),
- Road weather information system (RWIS),
- Equipment installation and software integration in the new Joint Forces STOC facility on District Drive in Raleigh,
- NCTA TMC software to configure, control, and monitor ITS field devices and communications hardware, if current software cannot control,
- A multiple path Ethernet-based fiber-optic communications system comprised of approximately 20 cable miles of fiber-optic cable and associated conduit along Monroe Connector/Bypass for the toll collection and ITS systems.

The Design-Build Team shall be responsible for designing, furnishing, and installing the CCTVs, MVDS, and RWIS with metal poles and foundations. The Design-Build Team shall furnish and install the DMS signs on structures described elsewhere in this RFP.

The communications infrastructure will consist of underground conduit system including conduit, tracer wire, junction boxes, heavy-duty junction boxes, splice enclosures, and single-mode fiber-optic cable.

The Design-Build Team is to design and install the complete conduit system to service all ITS devices and toll facilties. Although the trunk line conduit system will run down only one side of the freeway, a fully redundant communications system will be provided by two leased circuits (by others). The Toll System Integrator will provide the leased connection to the NCTA Customer Service Center in Morrisville; this will also serve as the redundant/backup loop for the fiber-optic communications system. The interface/connection point shall be the Design-Build Team-provided routing switch located in the hub building at each end of the project. See Special Details in the ITS Concept Plans.

Two fiber-optic cables shall be installed in the conduit system; one for ITS equipment and the other for tolls equipment. Furnish and install fiber-optic splice/termination centers for both the tolls and ITS systems. The tolls equipment will be installed by others.

All communications between proposed ITS field devices and the local hub shall be Ethernet over single-mode fiber-optic cable. Design-Build Team shall furnish and install Ethernet edge switches, routing switches, and related electronics.

The Design-Build Team shall be responsible for determining the exact location of the ITS devices, conduit and junction boxes, obtaining Engineer’s approval of the locations, installing

conduit, tracer wire, junction boxes, heavy-duty junction boxes, and developing and implementing test and coordination procedures. The basis of the design shall be the ITS Concept Plans provided by the NCTA.

Upon completion of the work, the Design-Build Team shall conduct field-testing of the communications system, ITS devices, and software and maintain all hardware and software until final acceptance by the NCTA.

In order to consistently confine maintenance activities to the right shoulder, NCTA will consider median locations for devices acceptable only if there are exceptional circumstances along the right shoulder which make device locations there inadvisable. If located in the median, devices would need to be protected by guardrail, and be able to be serviced/maintained without a shoulder closure.

The Design-Build Team shall be responsible for submitting applications, including application fees associated for any permits for the conduit installation. This will include, but not limited, any pole attachment fees, railroad and other right of way encroachment permits, and utility connection fees. The Design-Build Team shall obtain railroad right of way encroachment permits if it is necessary to enter or cross the railroad right of way to install fiber-optic cable in the ITS conduit across any railroad rights of way. All fees associated with crossing the railroad rights of way shall be structured as a one-time cost with no recurring annual fees. Any permits shall be obtained in NCTA's name.

(B) Standard Specifications

Conform to this Scope of Work and the North Carolina Department of Transportation (NCDOT) *Standard Specifications for Roads and Structures*, dated July 2006, herein after referred to as the "*Standard Specifications*", the NCDOT *Roadway Standard Drawings*, dated 2006 and the ITS Concept Plans. Conform also to *Typical Open Road Tolling (ORT) Facility Guidelines*. Conform to the regulations and codes described in Section 1700 of the *Standard Specifications*.

In the event of conflict between this Scope of Work and the *Standard Specifications*, this Scope of Work shall govern.

The 2006 *Standard Specifications* are revised as follows:

General Requirements (1098-1), Page 10-268, Subarticle 1098-1(h) - In the second paragraph, add, "use 200 amp meter base for underground electrical service".

Underground Conduit Construction Methods (1715-3), Page 17-10, Subarticle 1715-3(b) section (1), revise first paragraph, second sentence to "install rigid metallic conduit for all underground runs located inside railroad right-of-way."

Reference is made to the "Project Special Provisions for Signals and Intelligent Transportation Systems". The document can be found at the following link:

http://www.ncdot.org/doh/preconstruct/traffic/ITSS/ws/PSP.doc

This document is continually updated. The version that governs the Design-Build Team is the version in effect on the date of advertisement.

(C) Systems Engineering

The development of the plans, specifications, and estimates shall adhere to NCTA and NCDOT standards, specifications, and the requirements of the Metrolina Regional ITS

Architecture as defined in the North Carolina Statewide ITS Strategic Deployment Plan. Develop a systems engineering document that defines the physical and functional requirements of the system to ensure consistency with the Metrolina Regional ITS Architecture and to ensure conformance with the requirements of 23 CFR 940.11.

(D) Other Codes and Standards

All communication conduit system materials must conform to the latest version of the applicable standards of the National Electric Manufacturer's Association (NEMA), the Underwriters' Laboratories, Inc. (UL), the Electronic Industries Association (EIA), the National Electric Code (NEC), the International Municipal Signal Association (IMSA), and the National Electrical Safety Code (NESC). All materials and workmanship must conform to the standards of the American Society for Testing and Materials (ASTM) and American National Standards Institute (ANSI).

1.3 MATERIALS

(A) Qualified Products

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

Certain categories of signal and communications equipment, material, and hardware shall be pre-approved on the latest version of the QPL by the date of installation. These categories are defined in this Scope of Work.

(B) Observation Period

Warrant workmanship and Design-Build Team-furnished equipment for a 60-day observation period under the payment and performance bond from date of acceptance.

(C) Wire and Cable

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

1.4 CONSTRUCTION COORDINATION

(A) Introduction

This section addresses coordination issues that may affect this project.

(B) Toll System Integrator

The Design-Build Team shall coordinate with the Toll System Integrator for design and construction issues and to schedule training.

(C) Integration

NCTA ultimately will use and support the Smartlink statewide ITS software (by others). Others shall deploy that software in the STOC facility. This software package will control and manage all ITS field devices described herein. The software will integrate with NCDOT’s statewide Traveler Information Management System (TIMS). The package will also facilitate center-to-center (C2C) communications between NCDOT’s regional TMCs. Existing software packages used by the equipment at the current TMCs will be maintained for maintenance and troubleshooting. Smartlink will communicate with the devices using NTCIP drivers or via “black box” converters. The Design-Build Team shall closely coordinate with NCDOT’s

Metrolina and Triangle Regional ITS Engineers regarding all matters of NCDOT's local computing networking and ITS device operations and control.

It is anticipated the Smartlink will not be deployed by the time of the startup of the Monroe Connector/Bypass operations, therefore, Design-Build Team shall purchase, deploy and integrate the necessary software to operate the ITS devices from the NCTA TMC at the STOC during the interim period of operation until Smartlink is ready. NCDOT owns licenses at the STOC for Daktronics *Vanguard 3.8*, Protronix *VideoPro*, and EIS WATER that the Design-Build Team may utilize if they wish. NCDOT expects to upgrade to *Vanguard 4.0* by December 2010. The Design-Build Team shall confirm what software and versions are in use. For other devices supplied, the Design-Build Team shall supply vendor software for testing, operation, and maintenance. NCDOT will not provide the software for the Design-Build Team for testing and MIB development. The Design-Build Team shall also be responsible for any MIB development and configuration if the NCDOT STOC does not already have MIBs for the device in question.

(D) Regulations and Codes

Furnish material and workmanship conforming to the *National Electric Code* (NEC), *National Electric Safety Code* (NESC), Underwriters Laboratories (UL), or other listing agencies approved by the North Carolina Department of Insurance, and all local safety codes in effect on the date of advertisement. Comply with Article 4, Chapter 87 of the *North Carolina General Statutes* (Licensing of Electrical Contractors). Comply with 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 will neither eliminate nor take the place of the inspections by the Engineer. Upon the Engineer's receipt of written certification and the Design-Build Team's written request for a final inspection of the installations, the Engineer will perform a final inspection.

Where required, conform to 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.

(E) Utility Services

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

The Design-Build Team shall provide electrical and telecommunication service as described in this Scope of Work, contact the utility company and make application to ensure all work can

be completed. Obtain authorization for service in NCTA's name for NCTA-owned locations. Make application for service in NCTA's name for NCTA-owned locations.

The Design-Build Team will be responsible for all expenses associated with utility installation costs, hookups, etc. Once installed, NCTA will be responsible for monthly utility company usage charges prior to final acceptance.

(F) Maintenance and Repair of Material

Ensure that an IMSA certified, or equivalent, Level II traffic qualified technician is standing by to provide emergency maintenance services whenever any electrical work is performed. Standby status is defined as being able to arrive, fully equipped, at the work site within two hours 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 ITS devices and communications related equipment within the project construction limits until completion of the observation period and receipt of written notification of final acceptance of the project.

For all failures, malfunctions, or damages to equipment, begin necessary repairs within four hours of notification. Complete repairs within eight hours of notification. The inability to contact the supervisory employee or prearranged alternate will not extend repair time requirements.

Remove and replace all ITS devices and communications related equipment that fails.

Except for damages and malfunctions caused by the Design-Build Team's work activities, the Design-Build Team will not be held responsible for pre-existing conditions reported to the Engineer before starting any work at the specific location. The Design-Build Team shall assume responsibility for all maintenance and emergency services necessary once work has begun at an existing device location and for all damages and malfunctions caused either directly or indirectly by the Design-Build Team's work activities.

In the event the Design-Build Team fails to perform in accordance with the Plans and Scope of Work within the time frame specified, NCTA reserves the right to perform maintenance and emergency service necessary to ensure continuous operation. Further, all expenses incurred by NCTA in implementing this option will be deducted from payment due the Design-Build Team, plus $2,500 liquidated damage per occasion, per day, or any portion thereof, until corrected.

Maintain system equipment until the completion of the 60-day observation period and the receipt of written notification from the Engineer of final acceptance of the project.

(G) Wire and Cable

Comply with Section 1700-3 (J) of the *Standard Specifications*.

(H) Grounding

Comply with Section 1700-3 (K) of the *Standard Specifications*.

(I) Electrical Bonding

Comply with Section 1700-3 (L) of the *Standard Specifications*.

2. UNDERGROUND CONDUIT

2.1 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.

Provide conduit as needed to interconnect the ITS devices and toll facilities.

2.2 MATERIAL

(A) General

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL, however, for HDPE and accessories, adhere to "Submittal 'Requirements" in Section 20.2.

Comply with Section 1098-4 of the *Standard Specifications*.

(B) Conduit Types

Comply with Section 1098-4 of the *Standard Specifications*. Provide fiberglass (UL 1684) or rigid galvanized steel outerducts for bridge-mounted conduit. The fiberglass conduit must be rated for above-ground use (XW type). Provide expansion fittings for bridge-mounted conduit.

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

Comply with Section 1098-4 of the *Standard Specifications*.

(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 installation requirements. Ensure each duct plug provides a means to secure a pull line to the end of the plug.

Comply with Section 1098-4 of the *Standard Specifications.*

Furnish moldable sealing putty that has the following characteristics:

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

Use moldable sealing putty in occupied conduit risers and cabinets.

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

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

(D) Mechanical Couplings for HDPE Conduit

Provide mechanical couplings that are both watertight and airtight for joining two segments of HDPE conduit of like diameter in trenched locations. Do not use mechanical couplings for directionally drilled installations. Provide couplings designed to accommodate pneumatic methods of cable installation. Provide couplings suitable for burial underground and which meet the following requirements:

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

2.3 CONSTRUCTION METHODS

(A) General

Provide a special detail for conduit attachment to bridge for review by NCDOT Structures unit. Show how the transition is made from bridge conduit back to underground conduit, and also show expansion fittings. Show conduit runs between girders, not exposed on outside of bridge.

Comply with Section 1715-3 of the *Standard Specifications*.

Install a minimum of two 2" conduits for all underground routes that are designated to convey a single 48-fiber communications cable. Install four 2" conduits for all underground routes that are designated to convey a pair of 48-fiber communications cables. Install a minimum of one 2" conduit for underground routes that are designated to convey 6-fiber communications cable.

Install a minimum of two 2" conduits for conveying communication cables, exclusive of conduit needed for power service, for all directional drill installations beneath roadways, railroad rights-of-way, or streams.

Do not exceed 1,500 feet between junction boxes in any underground conduit route that conveys communications cable without the prior approval of NCTA.

(B) Maximum Length of Directional Drill

The length of a directional drill shall not exceed 1,000 feet measured horizontally along the route of the directionally drilled conduit(s), unless otherwise approved by the Engineer. On or before the 1,000-foot mark, transition from directional drill to trenching to continue the route up to the maximum spacing of 1,500 feet between junction boxes. Alternatively, continue the route by beginning a successive directional drill and installing an over-sized heavy-duty junction box where the two directionally drilled conduit runs meet.

(C) Splicing and Coupling of HDPE Conduit

Install a continuous HDPE conduit free from splices or couplings between junction boxes whenever possible. However, splicing or coupling of HDPE conduit may be permitted, subject to the prior approval of NCTA, in the following situations:

- To complete an underground HDPE conduit run when the end of an HDPE reel is reached
- When transitioning from directional drill to trenching or from trenching to directional drill in an underground run while maintaining the same quantity and size of conduits in the run

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

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

(D) Bore and Jack

Comply with Section 1715-3 of the *Standard Specifications*.

3. JUNCTION BOXES

3.1 DESCRIPTION

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

3.2 MATERIALS

(A) General

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

Provide junction box covers with standard *NCTA* logos, pull slots and stainless steel pins. For standard size junction boxes, provide covers with *NCTA Electrical* logo. Provide covers with *NCTA Fiber Optic* logo on all oversized and special-sized, heavy-duty junction boxes that house fiber-optic communications cable along the project.

Do not provide sealant compound between junction boxes and covers.

Material, equipment, and hardware furnished under this section must be pre-approved on the Department's QPL by the date of equipment installation; however, for special-sized heavy-duty junction boxes, loop and custom splice boxes, adhere to "Submittal 'Requirements" in Section 20.2.

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

(B) Standard Sized Junction Boxes

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

(C) Oversized Heavy-Duty Junction Boxes

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

(D) Special-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.

(E) Loop Splice Boxes

Provide loop splice boxes and covers with minimum inside dimensions of 36"(l) x 17"(w) x 30"(d) that meet or exceed the Tier 15 requirements of ANSI/SCTE 77. Provide certification that testing methods are compliant with ANSI/SCTE 77.

(F) Custom Splice Boxes

Provide larger boxes for specialized use near ORT Toll Zones that meet or exceed the Tier 15 requirements of ANSI/SCTE 77. Provide certification that testing methods are compliant with ANSI/SCTE 77.

3.3 CONSTRUCTION METHODS

Comply with Section 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 electrical 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 for boxes containing fiber-optic cable except those with splice enclosures.

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

Install loop splice boxes in ORT Toll Zones as shown in the ORT Project Specific Drawings.

4. WOOD POLES

4.1 DESCRIPTION

Furnish and install wood poles with grounding systems and all necessary hardware. Wood poles are for the sole purpose of bringing electric service just inside the right of way where it shall transition to underground conduit. The Design-Build team shall not use wood poles for mounting any ITS devices.

4.2 MATERIAL

(A) General

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

Comply with Section 1082-4(G) of the *Standard Specifications*.

(B) Service Pole

Furnish Class 4 or better wood poles for bringing cable onto right of way from overhead source. 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. All electrical service assemblies shall be pedestal mounted as described in this Scope of Work.

4.3 CONSTRUCTION METHODS

Mark final pole locations and receive approval from the Engineer before installing poles. Unless otherwise required, 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.

Comply with Section 1720-3 of the *Standard Specifications*.

On new NCTA-owned poles, install a grounding system consisting of # 4 AWG solid bare copper wire that is exothermically welded to a ground rod. Install ground wire up pole to a point adjacent to the uppermost span. Use wire staples to secure ground wire to pole. Install ground rod at base of pole.

5. FIBER-OPTIC CABLE

5.1 DESCRIPTION

Furnish and install single-mode fiber-optic (SMFO) communications cable and drop cable assemblies with grounding systems, communications cable identification markers, and all necessary hardware. Provide two 48-strand single-mode fiber-optic cables in separate conduits, one for ITS and one for toll operations.

The exact location of conduit and junction boxes shall be determined by the Design-Build Team. Route the ITS and toll operations fiber-optic cables through each ORT (Open Road Tolling) mainline building and/or gantry facility. Route toll operations cable thru each ORT ramp building/facility/cabinet as well. All fiber strands of these cables shall terminate on separate patch panels provided by the Design-Build Team.

The toll operations cable shall extend no further than the last ORT building in each direction of the project. The ITS cable shall extend to the outer limits of the roadway project, or the outermost ITS device, whichever is furthest from the center of the project; however, DMS A1 and A2 are not required to be connected by fiber-optic cable.

In the ITS trunk fiber-optic cable, reserve one tube of 12 strands for future use by NCDOT and one tube of 12 strands for future use by NCTA.

The Design-Build Team shall conduct OTDR tests on both the ITS and toll operations fiber-optic cable and correct any defects revealed by the testing. The Toll System Integrator shall energize the Tolls designated cable and connect equipment to it after acceptance.

5.2 MATERIALS

(A) SMFO Communications Cable

Furnish single-mode fiber-optic communications cable that is pre-approved on the Department's QPL.

Comply with Section 1098-10 of the *Standard Specifications*.

(B) Drop Cable Assembly

Furnish drop cable assemblies to provide communications links between splice enclosures and Ethernet edge switches mounted in cabinets. Provide an assembly that is factory pre-assembled and factory pre-tested with the necessary drop cable length. Furnish a drop a cable assembly comprised of the designated length of fiber-optic cable that has been factory pre-terminated on a factory pre-connectorized patch panel with six connectors matching the Ethernet edge and routing switches to form an integral pre-assembled unit. Furnish a drop-cable assembly that requires no field assembly, connectorization, or termination other than splicing the free end of the drop cable into the fiber-optic trunk cable in a splice enclosure external to the cabinet.

Provide a drop cable assembly with a patch panel in a compact, modular housing or a patch panel housed in low profile, rack-mountable interconnect center. The compact modular patch panel shall have a rugged, durable, non-metallic housing that can be surface-mounted vertically to the face of the 19-inch equipment rack rail inside a cabinet or mounted horizontally within the equipment rack occupying no more than one standard rack unit (1 RU) of space. The dimensions of the patch panel shall not exceed 1.75" (h) x 16.5" (w) x 13.5" (d). The low-profile interconnect center that houses the patch panel shall be a powder-coated aluminum enclosure

designed for mounting horizontally in the 19-inch equipment rack inside a device cabinet and shall occupy no more than one standard rack unit (1 RU) of space.

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 /<-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 connectors matching the Ethernet edge and routing switches on each end for connecting Ethernet edge and routing switches to the fiber-optic patch panels on the drop cable assemblies. The Design-Build Team shall provide SMFO jumpers of sufficient length to not strain the fibers within when installed in the final position. The minimum length for all jumpers shall be 3 feet in field cabinets and 6 feet in the STOC and ORT Buildings. Ensure SMFO jumpers meet the operating characteristics of the SMFO cable with which they are to be coupled.

(C) Communications Cable Identification Markers

Comply with Section 1098-10(C) of the *Standard Specifications*, with the exception of replacing “NCDOT” on the cable marker with “NCTA"

5.3 CONSTRUCTION METHODS

(A) General

Comply with Section 1730-3(A) of the *Standard Specifications*.

(B) Underground Installation

Comply with Section 1730-3(C) of the *Standard Specifications*.

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.

Store 50 feet of each fiber-optic cable in oversized heavy-duty junction boxes on all cable runs that are continuous without splices. Obtain approval for spare cable storage locations.

(C) Installation of Drop Cable Assembly

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

At below ground splice enclosures, coil at least 50 feet of slack cable for each cable entering and exiting the splice enclosure in the 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, however store no more than 100 feet of extra cable.

Mount the patch panel of the drop cable assembly vertically to the surface the rack frame or horizontally within 19-inch equipment rack using the screws, mounting brackets and hardware provided with the drop cable assembly. Mount the patch panel in a location convenient to the

Ethernet switch and/or video encoder to facilitate installation of SMFO jumpers between them. Secure drop cable in cabinet using cable ties and cable management hardware.

Install SMFO jumpers between the appropriate connectors on the patch panel of the drop cable assembly and the Ethernet edge switch.

Label all connectors, pigtails, and the connector panel.

Using an OTDR, test the end-to-end connectivity of the drop cable assembly from patch panel installed inside the ITS cabinet to its respective communications hub. Comply with the OTDR testing and reporting requirements of the "Testing and Acceptance" section of this Scope of Work when testing drop cable.

6. FIBER-OPTIC SPLICE CENTERS

6.1 DESCRIPTION

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

6.2 MATERIALS

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL. Ensure patch panel connectors match connectors for associated switches.

(A) Interconnect Center

Furnish compact, modular interconnect centers designed for rack mounting in open road tolling (ORT) buildings. Design and size interconnect centers to accommodate all fibers (used and unused) entering the ORT buildings.

Comply with Section 1098-11 of the *Standard Specifications*.

(B) Splice Enclosure

Comply with Section 1098-11 of the *Standard Specifications*.

6.3 CONSTRUCTION METHODS

(A) General

Comply with Section 1731-3 of the *Standard Specifications*.

(B) Termination and Splicing within 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 for each trunk cable entering an ORT building in 19-inch communications racks in each ORT building. Coordinate with the Tolls Integrator on the placement of the racks.

Fiber strands shall be either expressed through an interconnect center or terminated on patch panels. For all fibers designated to pass through an interconnect center, neatly coil and express the fibers without cutting. Neatly coil excess tubing inside interconnect center.

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

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.

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

(C) Splice Enclosure

Develop a cable-splicing plan to maximize cable performance and minimize the quantity of cable.

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.

Comply with Section 1731-3(C) of the *Standard Specifications*.

Install underground enclosures with 50 feet of slack cable from each trunk cable entering the enclosure to allow enclosure to be taken out of the special sized heavy-duty junction boxes and extended into a splicing vehicle.

For underground, special-sized heavy duty and junction box facility installations, place the enclosure along with required spare cables in the facility in a neat and workmanship like manner. Neatly coil the spare cable in the special-sized heavy-duty junction boxes. In the ORT Buildings, neatly coil the spare cable and secure with tie wraps to the communications rack or cable trays.

7. ELECTRICAL SERVICE

7.1 DESCRIPTION

Install new electrical service to new ITS cabinets and devices. For ITS devices at ORT locations, utilize electrical service in the ORT building. All new electrical services within the NCDOT or NCTA rights of way shall be underground with pedestal-mounted assemblies. Multiple devices may be fed off a common meter as described herein.

7.2 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 UL-listed 1-inch Schedule 80 conduit for underground runs.

Provide all materials necessary to form a complete electrical service assembly as shown in NCDOT *Roadway Standard Drawing* No. 1700.01, "Combination Panel".

Provide an external electrical service disconnect at each new ITS device cabinet location. For disconnects for DMS at ORT Toll Zones, place electrical panel on same concrete pad with ORT Toll Zone equipment. Furnish external electrical service disconnects with a minimum of a single pole 50 ampere circuit breaker with a minimum of 10,000 RMS symmetrical amperes short circuit current rating in a lockable NEMA 3R enclosure. Ensure service disconnects are 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 AWG through number 4 AWG.

Furnish NEMA Type 3R meter base rated 200-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 four-terminal, 600 volt, single-phase, three-wire meter bases that comply 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
- Underground service entrance

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. For all new ground-mounted electrical service assemblies for underground electrical service, provide a combination panel with pedestal extension. Ensure combination meter and disconnect mounted in a pedestal for underground service is listed as meeting UL Standard UL-231. 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.

7.3 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 above ground and Schedule 80 conduit underground. Do not allow service conductors to share conduits or junction boxes with any other conductors or cables. Do not route unfused electrical service conductors inside of metal poles.

(B) New Electrical Service for ITS Devices

Install new electrical service for a device cabinet in accordance with the details. Install a new electrical service comprised of an external service disconnect and a meter base housed in a combination panel. If more than one cabinet is fed from the same utility company service point, a common meter may be utilized with individual disconnects at each device cabinet. The cost of running electrical service to all cabinets will include any transformers.

Locate all secondary power service points outside the controlled access right of way. Locate combination panels as shown on the ITS Concept Plans. After installation of the meter base, the local power company will install a new meter and make any necessary connections to the power lines.

Have the power company route the service drop underground to the load center, even where source power lines are overhead; wood poles on NCTA right-of-way for power service are generally not permissible with the exception of bringing power just inside the right-of-way.

8. DEVICE CABINETS

8.1 GENERAL

Furnish and install ITS device cabinets to house communications hardware, fiber-optic patch panels, power supplies, cable terminations, and other equipment to support the installation of CCTV, MVDS, DMS, and RWIS devices. Install a DMS "shell cabinet" at all gantry locations that do not currently have a DMS for housing future DMS equipment. See ORT Project Specific Drawings for details of all DMS related cabinet, conduit, box, and foundation work at the ORT gantries.

8.2 MATERIALS

(A) General

Provide device cabinets as follows to house equipment specific to the site where it is installed.

Cabinet Type Designation	Purpose
A	All CCTV and MVDS sites requiring fiber-optic communications
C	Remote processing unit for RWIS site
D	All DMS signs

Type A cabinets shall be a minimum size of a Type 336 cabinet. Type D cabinets shall be a minimum size of a Type 336S cabinet.

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.

(1) Lighting

Provide two 15-watt fluorescent light strips with shields, one in the top of the cabinet and the other under the bottom shelf. Design both lights to automatically turn on when the cabinet door is opened and turn off when the door closes.

(2) Convenience Outlets

Provide a 120V (+/-10%) GFCI duplex receptacle of the 3-wire grounding type in the cabinet in a location that presents no electrical hazard when used by service personnel for the operation of power tools and work lights. Provide at least one surge protected 120V (+/-10%) GFCI duplex receptacle of the 3-wire grounding type in the cabinet.

(3) Circuit Protection

Protect the CCTV controller, accessories, and cabinet utilities with thermal magnetic circuit breakers. Provide the controller cabinet with a main circuit breaker sized according to the NEC. Use appropriately sized branch circuit breakers to protect and service CCTV equipment and cabinet utilities.

(B) Type A

Furnish and install pole-mounted cabinets to house CCTV related equipment described herein. Provide the cabinets with 19-inch communications rack for all equipment. It is the Design-Build Team's responsibility to size the cabinet appropriate to fit all the equipment installed within the cabinet at the particular location.

Furnish, at a minimum, Type 336 CCTV cabinets meeting the following minimum requirements as applicable to the specific installation:

- Pole mounting brackets
- Grounding bus bar
- 120 VAC power supply
- 120 VAC GFCI-protected duplex outlets for tools
- 120 VAC SPD-protected duplex outlets for equipment
- SPD lightning and surge protection on incoming and outgoing electrical lines (power and data)
- 19-inch rack system for mounting of all devices in the cabinet
- Pull-out shelf for laptop and maintenance use
- Fluorescent lighting
- Two ventilation fans with independent thermostat controls
- Power strip along vertical rail
- Termination of the composite cable to the camera
- Fiber-optic interconnect center
- Maintenance access points for data and video connections to observe camera images and program/monitor camera status
- Video encoder
- Ethernet edge switch

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

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 dual fans with thermostats incorporated into the ventilation system.

Provide the cabinets with vent openings in the doors to allow convection cooling of electronic components. Locate the vent opening on the lower portion of the cabinet doors and shall be covered fully on the inside with a commercially available disposable three layer graded type filter.

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.

(C) Type C

Furnish and install pole-mounted Type 5052-H32 aluminum NEMA 4 cabinets to house RWIS related equipment described herein. It is the Design-Build Team's responsibility to size the cabinet appropriate to fit all the equipment installed within the cabinet at the particular location.

Furnish cabinets meeting the following minimum requirements:

- RWIS structure mounting brackets,
- Grounding bus bar,
- 120 VAC power supply,
- 120 VAC GFCI-protected duplex outlets for tools,
- 120 VAC SPD-protected duplex outlets for equipment,
- Communications cabling to ITS network,
- Termination of the cables to the weather sensors,
- Maintenance access points for data connections to check data and program/monitor RWIS status.

Provide cabinets complete with a prefabricated cabinet shell, and all internal components and equipment, back and side panels, single door, terminal strips, cabling and harnesses, surge protection for power and communication circuits, power distribution blocks or assemblies, shelf, connectors and all mounting hardware necessary for installation of equipment.

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

Provide all cabinets and door exterior seams with smooth and continuous welds. Provide all cabinets with a single full-size door. Provide the door with three hinges, or a full-length stainless steel piano hinge, with stainless steel pins spot-welded at the top. 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 padlock hasp. Provide two keys for each cabinet. Provide door openings with double flanges on all four sides.

Provide both the door of sufficient strength to withstand a simulated wind load of five pounds per square foot of door area applied to the both inside and outside surfaces without failure, permanent deformation, or compromising of door position and normal operation. Provide the cabinets without auxiliary police doors.

Ensure that cabinet doors include a gasket to provide a dust and weather-resistant seal when closed. Provide the gasket material with closed-cell neoprene and shall maintain its resiliency after exposure to the outdoor environment. The gasket shall show no sign of rolling or sagging, and shall ensure a uniform dust and weather-resistant seal around the entire door facing.

Provide mounting hardware to mount the cabinet to the tower according to the manufacturer's recommendations.

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, 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.

(D) Type D

(1) General

Furnish the DMS controller ground mounted cabinet with, but not limited to, the following:

- Cabinet anchor bolts
- Base adaptor
- Grounding bus bar
- 120 VAC power supply and distribution assembly
- 120 VAC GFCI-protected duplex outlets for tools
- 120 VAC SPD-protected duplex outlets for equipment
- 19-inch rack system for mounting of all devices in the cabinet
- Pull-out shelf for laptop and maintenance use

- Power line filtering hybrid surge protectors
- Radio interference suppressor
- Fiber-optic interconnect center
- Communications surge protection devices
- Industrial-grade telephone line surge and lightning protector
- Adjustable shelves as required for components
- Interior fluorescent lighting and duplex receptacle
- Ventilation fans
- Temperature control system
- Local Disconnect
- Local user interface
- Serial interface port for local laptop computer
- Display driver and control system (unless integral to the DMS)
- Microprocessor based controller
- Ethernet edge switch,
- 12" base extender
- All interconnect harnesses, connectors, and terminal blocks
- All necessary installation and mounting hardware

(2) Cabinet Shell

Furnish the DMS controller and associated equipment completely housed in a NEMA 3R cabinet made from 5052-H32 sheet aluminum at least .125-inch thick. Use natural aluminum cabinets. Perform all welding of aluminum and aluminum alloys in accordance with the latest edition of AWS D1.2, Structural Welding Code - Aluminum. Continuously weld the seams using Gas Metal Arc Welding (GMAW).

Slant the cabinet roof away from the front of the cabinet to prevent water from collecting on it.

Do not place a manufacturer name, logo, or other information on the faces of the controller cabinet visible to the motorist.

Provide cabinets capable of housing the components and sized to fit space requirements. Design the cabinet layout for ease of maintenance and operation, with all components easily accessible. Submit a cabinet layout plan for approval by the Engineer.

Locate louvered vents with filters in the cabinet to direct airflow over the controller and auxiliary equipment, and in a manner that prevents rain from entering the cabinet. Fit the inside of the cabinet, directly behind the vents, with a replaceable, standard-size, commercially available air filter of sufficient size to cover the entire vented area.

Provide a torsionally rigid door with a continuous stainless steel hinge on the side that permits complete access to the cabinet interior. Provide a gasket as a permanent and weather resistant seal at the cabinet door and at the edges of the fan / exhaust openings. Use a non-absorbent gasket material that will maintain its resiliency after long-term exposure to the outdoor environment. Construct the doors so that they fit firmly and evenly against the gasket material when closed. Provide the cabinet door with louvered vents near the bottom, and with air filters as described in the paragraph above.

Provide a Plexiglas rack of appropriate size at a convenient location on the inside of the door to store the cabinet wiring diagrams and other related cabinet drawings. Provide a Corbin #2 main door lock made of non-ferrous or stainless steel material. Key all locks on the project alike, and provide 10 keys to the Engineer. In addition, design the handle to permit padlocking.

Provide a bug-proof and weatherproof thermostatically controlled fan and safety shield in the top of the cabinet. Size the fan to provide at least for two air exchanges per minute. Fuse the fan at 125% of the capacity of the motor. The magnetic field of the fan motor must not affect the performance of the control equipment. Use a fan thermostat that is manually adjustable to turn on between 80^{o}F and 160^{o}F with a differential of not more than 10^{o}F between automatic turn-on and turn-off. Mount it in an easily accessible location, but not within 6 inches of the fan.

Install additional fans and/or heaters as needed to maintain the temperature inside the cabinet within the operating temperature range of the equipment within the cabinet as recommended by equipment manufacturer(s).

(3) Electrical System and Wiring

The requirements stated herein shall apply for any DMS controller cabinet. Neatly arrange and secure the wiring inside the cabinet. Where cable wires are clamped to the walls of the control cabinet, provide clamps made of nylon, metal, plastic with rubber or neoprene protectors, or similar. Lace and jacket all harnesses, or tie them with nylon tie wraps spaced at 6 inches maximum to prevent separation of the individual conductors.

All conductors shall be individually and uniquely labeled. All conductor labels shall be clearly visible without moving the conductor. All terminal conductors shall connect to the terminal strip in right angles. Excess conductor shall be removed before termination of the conductor. The conductor shall be molded in such a fashion as to retain its relative position to the terminal strip if removed from the strip. No conductor shall run across a work surface with the exception of connecting to that work surface. No conductor bundles can be supported by fasteners that support work surfaces. All connectors, devices, and conductors shall be installed in accordance to manufactures guidelines. All wiring shall comply with the latest NEC guideline in effect during installation. No conductor or conductor bundle may hang loose or create a snag hazard. All conductors shall be protected from damage. All solder joints shall be completed using industry accepted practices and shall not fail due to vibration or movement. All welds must be in a manner that will not fail due to vibration. Lamps and control boards shall be protected from damage.

Insulate all conductors and live terminals so they are not hazardous to maintenance personnel.

Route and bundle all wiring containing line voltage AC and / or shield it from all low voltage control circuits. Install safety covers to prevent accidental contact with all live AC terminals located inside the cabinet.

Use industry standard, keyed type connectors with a retaining feature for connections to the Controller.

Label all equipment and equipment controls clearly.

Supply each cabinet with one complete set of wiring diagrams that identify the color-coding or wire tagging used in all connections. Furnish a water-resistant packet adequate for storing wiring diagrams, operating instructions, and maintenance manuals with each cabinet.

a. Power Supply

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, 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.

Provide power supply monitoring circuitry to detect power failure and to automatically report the occurrence to the control software.

Blackout, brownout, hunting, line noise, chronic over-voltage, sag, spike, surge, and transient effects are considered typical AC voltage defects. Protect the DMS system equipment so that these defects do not damage the DMS equipment or interrupt their operation. Equip all cabinets with devices to protect the equipment in the cabinet from damage due to lightning and external circuit power and current surges.

b. Surge Suppression

Install and clearly label filtering hybrid power line surge protectors on the load side of the branch circuit breakers in a manner that permits easy servicing. Ground and electrically bond the surge protector to the cabinet within two inches. The surge suppression shall meet UL 1449.

Electrical Power

Provide power line surge protector that meets the following requirements:

Peak surge current occurrences	20 minimum
Peak surge current for an 8 x 20 microsecond wave shape	50,000 amperes
Energy absorption	> 500 Joules
Clamp voltage	240 volts
Response time	<1 nanosecond
Minimum current for filtered output	15 amperes for 120VAC*
Temperature range	-40 degrees F to +140 degrees F

*Capable of handling the continuous current to the equipment

Radio Interference Suppressor

Provide each controller cabinet with sufficient electrical and electronic noise suppression to enable all equipment in it to function properly. Provide one or more radio interference

suppressors (RIS) connected between the stages of the power line surge suppressor that minimize interference generated in the cabinet in both the broadcast and the aircraft frequencies. Each RIS must provide a minimum attenuation of 50 decibels over a frequency range of 200 KHz to 75 MHz. Clearly label the suppressor(s) and size them at least at the rated current of the main circuit breaker but not less than 50 amperes.

Provide RIS that are hermetically sealed in a substantial metal case, which is filled with a suitable insulating compound, and have nickel plated 10/24 brass stud terminals of sufficient external length to provide space to connect #8 AWG wires. Mount them so that the studs cannot be turned in the case. Properly insulate ungrounded terminals from each other, and maintain a surface linkage distance of not less than ¼" between any exposed current conductor and any other metallic parts. The terminals must have an insulation factor of 100-200 MΩ, dependent on external circuit conditions. Use RIS designed for 120 VAC ± 10%, 60Hz, and which meet the standards of UL and the Radio Manufacturers Association.

Communications Surge Protector

Equip the cabinet with properly labeled hybrid data line surge protectors that meet the following general requirements:

Surge current occurrences at 2000 ampere, 8 x 20 microsecond waveform	> 80
Surge current occurrences at 400 ampere, 10x700 microsecond waveform	> 80
Peak surge current for 8 x 20 microsecond waveform	10,000 A (2500 A/line)
Peak surge current for 10x700 microsecond waveform	500 A/line
Response time	< 1 nanosecond
Series resistance	< 15 Ω
Average capacitance	1500 pF
Temperature range	-10 degrees F to 150 degrees F
Clamp Voltage	As required to match equipment in application

Lightning Arrester

Protect the system with an UL-approved lightning arrester installed at the main service disconnect. It shall meet the following requirements:

Type of design	Silicon Oxide Varistor
Voltage	120/240 Single phase, 3 wires
Maximum current	100,000 amps
Maximum energy	3000 joules per pole
Maximum number of surges	Unlimited
Response time one milliamp test	5 nanoseconds
Response time to clamp 10,000 amps	10 nanoseconds
Response time to clamp 50,000 amps	25 nanoseconds
Leak current at double the rated voltage	None
Ground Wire	Separate

c. Deleted Section on Uninterruptible Power Supply (UPS)

(4) Local User Interface

Provide the controller with a Local User Interface (LUI) for at least the following functions:

- On / Off Switch: controls power to the controller.
- Control Mode Switch: for setting the controller operation mode to either remote or local mode.
- LCD Display and Keypad: Allow user to navigate through the controller menu for configuration (display, communications parameter, etc) running diagnostics, viewing peripherals status, message creation, message preview, message activation, etc. Furnish a LCD display with a minimum size of 240x64 dots with LED back light.

8.3 CONSTRUCTION METHODS

(A) General

Ground all cabinets in accordance with the requirements of this Scope of Work. Keep the ground wire from the cabinet ground bus bar to the ground rod assembly or array as short as possible. Ensure the ground wire is not in contact with any other part of the cabinet.

Tag and identify all cabinet wiring by the use of insulated pre-printed sleeves. The wire markers shall identify in plain words with sufficient details without abbreviations or codes

.

Neatly arrange all wiring, firmly lace or bundle it, and mechanically secure the wiring without the use of adhesive fasteners. Route and secure all wiring and cabling to avoid sharp edges and to avoid conflicts with other equipment or cabling. Terminate all wiring on a terminal block, strip, bus bar, device clamp, lug; or connector, do not splice any wiring. Label all wiring, cables, terminal strips, and distribution blocks. 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; bus bars, panel, and socket mounted SPD, 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.

Provide cabinets with all mounting plates, anchor bolts, and any other necessary mounting hardware in accordance with these Scope of Work and the project plans.

Seal all unused conduit installed in cabinets at both ends to prevent water and dirt from entering the conduit and cabinet with approved sealing material.

Install a ground bushing attached inside the cabinet on all metal conduits entering the cabinet. Connect these ground bushings to the cabinet ground bus.

Ground the cabinet per Sections 1098 and 1700 of the *Standard Specifications*, applicable addenda, the ITS Concept Plans and this Scope of Work. Provide grounding circuits that are permanent and electrically continuous with a current carrying capacity high enough and an impedance low enough to limit the potential above ground to a safe level.

Run the power company neutral, conduit grounds, and all equipment grounds directly and independently off the ground bus. Use ground clamps, grounding and bonding bushings, lock nuts, and grounding electrodes that comply with UL Standard Electric Grounding and Bonding Equipment. Use ground rods of 5/8 inch minimum diameter, 10 feet long, and made of copper clad steel.

Make connections between ground electrodes and the ground wire using an exothermic welding process, cadweld, or equivalent.

Ensure completed cabinet grounds have a resistance to ground of not more than 20 Ohms.

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

Equip the cabinets with SPD lightning and surge protection described separately in this Scope of Work.

Mount the fiber-optic drop cable assembly patch panel in accordance with the “Fiber-Optic Communications Cable” section of this Scope of Work. Install the Ethernet edge switch inside the cabinet in accordance with the “Communications Hardware” section of this Scope of Work.

Connect the appropriate connectors on the drop cable patch panel with those on the Ethernet edge switch using SMFO jumpers.

(B) Type A

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

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 with an interface panel to allow maintenance access for both video and data channels. This access should provide a means to connect analog video 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 video splitter to provide to the video encoder and the video monitor port simultaneously. The video cables shall interface with the CCTV camera cabinet test point connection and be fitted for interconnection to a BNC receptacle.

Provide a switch for selecting and local camera PTZ control. 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 USB to RS-232/422 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 USB data port. Two sets of cables shall be provided, two for data and two for video.

Mount the digital video encoder in the 19” equipment rack inside the cabinet in accordance with the “Central Video Equipment” section of this Scope of Work.

(C) Type C

It is desirable to locate the cabinet at least 100 feet from the roadway to minimize water spray on the cabinet. Mount the cabinet for the RWIS site on the tower supporting the sensors. The cabinet should be at least as high or higher as the edge of the adjacent roadway, if local conditions permit. Install the cabinet and all cabling per the manufacturer’s recommended procedures.

Install only rigid metal conduit risers into the cabinet.

Provide one key-operated, pin tumbler, dead bolt padlock, with brass or bronze shackle and case, conforming to Military Specification MIL-P-17802E (Grade I, Class 2, Size 2, Style A) for each electrical panel and switch on the project. Key all padlocks alike, and provide 10 keys to the Engineer.

Provide a switch for selecting and local camera RWIS control. Provide a communication cable for connection to a typical laptop for future maintenance activities. The data cable shall

consist of an integral USB to RS-232/422 converter as required to support the RWIS protocol and shall be compatible with the RWIS RPU. The data cable shall plug into the test point connector as provided in the cabinet and into a typical laptop USB data port. Two sets of data cables shall be provided.

(D) Type D

Provide the interior of the cabinet with ample space for housing the controller and all associated equipment and wiring; use no more than 75% of the useable space in the cabinet. Provide ample space in the bottom of the cabinet for the entrance and exit of all power, communications, and grounding conductors and conduit.

Arrange the equipment to permit easy installation of the cabling through the conduit so that they will not interfere with the operation, inspection, or maintenance of the unit. Provide adjustable metal shelves, brackets, or other support for the controller unit and auxiliary equipment. Leave a 3-inch minimum clearance from the bottom of the cabinet to all equipment, terminals, and bus bars.

No cabinet resident equipment shall utilize the GFCI receptacle. There shall be one spare non-GFCI receptacle for future addition of equipment.

9. METAL CCTV AND MVDS POLES

9.1 GENERAL

Furnish and install new metal CCTV and MVDS poles, grounding systems, and all necessary hardware. The work covered by this special provision includes requirements for the design, fabrication, and installation of custom/site specifically designed CCTV and MVDS poles and associated foundations. The Design-Build Team may use CCTV poles with or without lowering devices but shall not compromise the camera viewing requirements described in this scope of work. The minimum CCTV mounting height shall be 45’ above the adjacent roadway whether it is the mainline, ramp or crossing roadway, whichever is higher. The minimum mounting height and resultant pole length of the MVDS above the roadway edge of pavement shall be established by the manufacturer’s recommended guidelines. For cases where the pole location is well above the grade of the roadway, a shorter pole will be allowed if the Design-Build Team documents there will be no loss of functionality or sight distance.

The Design-Build Team may use NCDOT’s standard strain poles and foundations for the CCTV and MVDS poles or they may custom design the poles and foundations used the design procedures described in this scope of work. Screw, auger, or helix pole foundations shall not be used for CCTV poles.

Provide metal CCTV and MVDS poles that contain no guy assemblies, struts, or stay braces. Provide designs of completed assemblies with hardware that equals or exceeds the requirements of the latest Edition of the 2001 AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals”, including the latest interim specifications. Provide assemblies with a round cross-sectional design.

Ensure that materials and construction are in accordance with Section 11 of the “Project Special Provisions for Signals and Intelligent Transportation Systems”. Ignore references to mast-arm poles and traffic signal related equipment. Replace references to “Contractor” with

"Design-Build Team". Replace references to "signal poles" with "CCTV and MVDS poles". Replace references to "Department" with "NCTA".

9.2 MATERIALS

(A) General

Furnish poles and foundations that meet or exceed the following functional requirements with all CCTV and/or MVDS units, power meter, service disconnect, and all equipment cabinets attached and all risers, condulets, and weather head accessories in place:

- Maximum deflection at top of pole in 30 mph, non-gusting wind: 2 inches
- Ultimate load: 90 mph wind with a 30% gust factor

Furnish poles and foundations that sustain the dead load of all equipment attached to the pole with a safety factor of 1.5.

Furnish MVDS poles that when erected in foundation and completely installed are at a minimum height as recommended by the MVDS manufacturer.

(B) Metal Pole

Design poles according to the ITS Concept Plans.

Furnish hot-dipped galvanized steel poles to mount CCTV / MVDS units and equipment cabinets that meet or exceed the requirements of the NCDOT *Standard Specifications* unless otherwise noted in the ITS Concept Plans or this Scope of Work.

Furnish CCTV poles with ½ inch diameter air terminal, with #4 AWG wire, routed down pole and attached to cabinet equipment grounding system. Furnish an air terminal that extends high enough to provide a 45 degree cone of protection of the camera, as shown in the ITS Concept Plans.

Provide materials in accordance with Section 11.2 of the "Project Special Provisions for Signals and Intelligent Transportation Systems".

(C) Foundation

Prepare a design for the pole's concrete foundation and submit to the Engineer for review. The top of the drilled shaft foundation shall be flush with finished grade. Unstable soil may require a deeper foundation. Concrete for the foundation shall be 3000 psi minimum. Foundation design shall meet all NCDOT requirements and be prepared and sealed by a North Carolina registered professional engineer. Prepare design, optional custom design and perform soil tests for each CCTV metal pole foundation location in accordance with Section 11.4.B of the "Project Special Provisions for Signals and Intelligent Transportation Systems".

Conduit elbows in foundation shall have a minimum radius of 15 inches (380 mm).

(D) Camera Lowering Device

If the Design-Build Team chooses to use a camera lowering device, provide them on a steel pole as shown in the ITS Concept Plans. Consider the lowering device and pole as two interdependent components of a single unit, and provide them together to ensure compatibility of the pole and lowering device.

(1) Pole

Use a pole as shown in the ITS Concept Plans that meets the requirements of this section of this Scope of Work. The lowering mechanism and cabling shall be internal to the pole. Provide the pole with a 1.25" PVC conduit inside to house the composite camera cable. This conduit separates the cable from the winch cable. Use a pole that is equipped with a hand hole of sufficient size to provide access to the pole interior and for temporarily securing and operating the lowering tool. Ensure that the pole-top tenon is rotatable.

(2) Lowering Device

Use a lowering device as shown in the ITS Concept Plans. Ensure that the lowering device provides the electrical connections between the control cabinet and the equipment installed on the lowering device without reducing the function or effectiveness of the equipment installed on the lowering device or degrading the overall system in any way. Ensure that the only cable in motion when operating the lowering device is the stainless steel lowering cable contained within the pole. Ensure that the lowering device includes a disconnect unit for electrically connecting the equipment installed on the lowering device's equipment connection box to the power, data, and video cables (as applicable); a divided support arm, a pole adapter for the assembly's attachment to the rotatable pole-top tenon, and a pole-top junction box, as shown in the ITS Concept Plans.

Ensure that all of the lowering device's external components are made of corrosion-resistant materials that are powder-coated, galvanized, or otherwise protected from the environment by industry-accepted coatings that withstand exposure to a corrosive environment.

(3) Equipment Connection Box

Provide an equipment connection box for connecting the CCTV camera to the lowering device. Ensure that the equipment connection box is watertight and able to seal the interior from moisture and dust.

(4) Disconnect Unit

Ensure that the disconnect unit has a minimum load capacity of 200 pounds with a 4:1 safety factor. Ensure that the fixed and movable components of the disconnect unit have a locking mechanism between them. Provide a minimum of two mechanical latches for the movable assembly and, when latched, ensure that all weight is removed from the lowering cable. Ensure that the fixed unit has a heavy-duty cast tracking guide and a means to allow latching in the same position each time.

Ensure that the disconnect unit is capable of securely holding the lowering device and the equipment installed on the lowering device. Use interface and locking components that are stainless steel or aluminum.

(5) Disconnect Unit Housing

Ensure that the disconnect unit housing is watertight with a gasket provided to seal the interior from dust and moisture.

(6) Connector Block

Provide a connector block as shown in the ITS Concept Plans and directed by the Engineer. Provide modular, self-aligning, and self-adjusting female and male socket contact halves in the

connector block. Provide a minimum of nine, including two spare contacts, and a maximum of 20 contacts. Provide contact connections between the fixed and movable lowering device components that are capable of passing EIA-232, EIA-422, EIA-485, and Ethernet data signals and 1 volt peak to peak (Vp-p) video signals, as well as 120 VAC, 9-24 VAC, and 9-48 VDC power. Ensure that lowering device connections are capable of carrying the signals, voltages, and current required by the device(s) connected to them under full load conditions.

Ensure that the female socket contacts and the male contact halves of the connector block are made of heavy-duty molded synthetic rubber, molded chlorosulfonated polyethylene, or approved equal. Provide connector pins made of brass- or gold-plated nickel, or gold-plated copper.

Ensure that the current-carrying male and female contacts are a minimum of 0.102 inch in diameter. Provide two male contacts that are longer than the other contacts to mate first and break last, providing optimum grounding performance.

Provide cored holes in the rubber to create moisture-tight seals when mated with the male connector. Permanently mold the wire leads from both the male and female contacts in a body of heavy-duty molded synthetic rubber, chlorosulfonated polyethylene, or an approved equal. Provide current-carrying wires and signal wires of American Wire Gauge (AWG) #18/1 jacketed wire.

Ensure that the contacts are self-wiping with a shoulder at the base of each male contact so that it is recessed in the female block, thereby giving each contact a rain-tight seal when mated.

(7) Lowering Tool

Provide a metal-frame lowering tool with winch assembly and a cable with a combined weight less than 35 pounds, a quick release cable connector, and an adjustable safety clutch. Ensure that the lowering tool can be powered using a half-inch chuck, variable-speed reversible industrial-duty electric drill to match the manufacturer-recommended revolutions per minute, or supply a drill motor for the lowering tool.

Ensure that the lowering tool supports itself and the load. Ensure that the lowering tool is equipped with a positive braking mechanism to secure the cable reel during raising and lowering operations, and to prevent freewheeling.

Use a lowering tool equipped with gearing that reduces the manual effort required to operate the lifting handle to raise and lower a capacity load. Provide the lowering tool with an adapter for operating the lowering device with the portable half-inch chuck drill using a clutch mechanism.

Ensure that the lowering tool is manufactured of durable, corrosion-resistant materials that are powder-coated, galvanized, or otherwise protected from the environment by industry-accepted coatings that withstand exposure to a corrosive environment.

Provide a minimum of one lowering tool plus any additional tools. Upon a project’s final acceptance, deliver the lowering tool to NCTA.

(8) Lowering Cable

Provide a lowering cable with a minimum diameter of 0.125 inch. Construct it of stainless steel aircraft cable with a minimum breaking strength of 1,740 pounds, and with seven strands of

19-gauge wire each. Ensure that the prefabricated components for the lift unit support system preclude the lifting cable from contacting the power or video cables.

(9) Wiring

Ensure that all wiring meets NEC requirements and follows the equipment manufacturers' recommendations for each device connected on the pole, at the lowering device, and in the field cabinet.

9.3 CONSTRUCTION METHODS

(A) General

Obtain approval from the Engineer for final field locations of the CCTV/MVDS metal poles before developing shop drawings and installing the poles. Obtain shop drawings, signed and sealed by a North Carolina registered engineer, for each pole location (each combination of pole height and equipment mix) and submit to Engineer for approval. When approved, submit to pole manufacturer. Determine and provide to pole manufacturer the effective projected area of all items to be attached to each pole at each pole location. Construct drilled pier foundations, drilled pier wing-wall foundations, and erect pole in accordance with Section 11.4 of the "Project Special Provisions for Signals and Intelligent Transportation Systems".

(B) Camera Lowering Device

Preassemble all components on the ground and tension the lifting cables. Assemble and install the pole and lowering device according to the manufacturer's recommended procedures.

Make a watertight seal between the lowering device and CCTV dome housing. Test the watertight seal of the lowering device and CCTV dome. Test the seal with a water hose.

Ensure that all other cables remain stable and secure during lowering and raising operations and are not entangled or abraded by movement of the lowering cable.

Ensure that the divided support arm and receiver brackets self-align the contact unit with the pole centerline during installation and that the contact unit cannot twist when subjected to the design wind speeds defined in the Standard Drawings for Metal Poles Drawing M 1. Supply an internal conduit in the pole for the power and video cabling.

Ensure all pulleys installed for the lowering device and portable lowering tool have sealed, self-lubricated bearings, oil-tight bronze bearings, or sintered bronze bushings.

10. CCTV FIELD EQUIPMENT

10.1 DESCRIPTION

Design CCTV camera locations to provide full viewing coverage of the project corridor. Also, provide camera coverage of the crossing roads (out to approximately ¼ mile) that interchange with above-mentioned facilities. The ITS Concept Plans show possible locations but the final locations and quantity are the responsibility of the Design-Build Team. All cameras must be serviceable either by a) camera lowering device or b) aerial lift truck with a working height of 50 feet or less, without a lane closure. Locate CCTV and poles to minimize further clearing and grubbing of the right of way. Provide traffic control for the installation of those proposed cameras along existing roadways within the project limits. The video shall be encoded

using MPEG-4 video compression for transmission over an Ethernet network on single-mode fiber-optic cable.

Furnish and install CCTV field equipment, cabinets and local camera control software described in this Section and as shown in the ITS Concept Plans.

Provide a system to protect field devices and electronic equipment from lightning and surge protection using transient voltage and surge suppression (SPD) technology and standards.

10.2 MATERIALS

(A) General

Furnish new CCTV camera assemblies and CCTV cabinets.

Each CCTV camera assembly shall consist of the following:

- NEMA environmental dome enclosure
- CCTV day/night color digital signal processing camera unit with zoom lens, filter, control circuit, and accessories
- Control receiver/driver that complies with the NTCIP specifications listed below,
- Motorized pan, tilt, and zoom
- Power supplies
- Pole-mount camera lowering device 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
- Composite cable for power supply and video and data transmission
- Surge suppression devices (SPDs)

(B) Standards

- ANSI
- ASTM
- CE, Class B
- EIA Standards 170, 232, 422, 250C and 485
- FCC Rules Part 15, Sub-part J
- FCC Class A
- FCC, Class B
- IEEE
- ICEA
- IMSA
- ISO 9001
- NEC
- NEMA 4X, IP 66
- NEMA Type 1
- NTSC
- UL Listed

Provide UL listed SPD 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 EXview HAD (Hole-Accumulation Diode) 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,
- Image sensor resolution: 540 TV lines,
- Image resolution (NTSC): 768 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,
- Primary power: 120 VAC,
- Power: Nominal 24 VAC or 24 VDC, and
- Camera power: 73 VA with heater at 24 VAC or 3 amps at 24 VDC.

(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: 56 degrees at 3.4 mm wide zoom and 1.7 degrees at 119 mm telephoto zoom,
- Focal length: 0.14” – 4.68”, 35X optical zoom, 12X electronic zoom,
- Zoom Speed: 3.2, 4.6 and 6.6 seconds,
- Lens aperture: Minimum of f/1.4,
- Maximum Sensitivity at 35 IRE: .055 lux at ½ second color, .018 lux at 1/2 second color, .00018 lux at ½ sec black and white, and
- Preset positioning: Minimum of 256 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 a mounting assembly for attachment to the CCTV camera-lowering device, or to the pole if lowering devices are not used. 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 high impact acrylic plastic.

A dome-type environmental housing shall have a sustained ambient operating temperature of -29 degrees F to 165 degrees F, with 100 percent non-condensing relative humidity as defined within the NEMA TS-2 (1998) standard.

The enclosure shall have a NEMA 4X/IP-66 rating.

(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. Equip the drive unit with electronic image stabilization and image enhancement. The pan and tilt units must meet or exceed the following specifications:

- Pan: Continuous 360 degrees,
- Tilt: +2 degrees to -92 degrees unobstructed minimum,
- Presets: Minimum of 256 presets,
- Pan speed: .1 degrees/second to 80 degrees/second,
- Tilt speed: .1 degrees/second to 40 degrees/second,
- Preset Speeds: 400 degrees/second pan and 400 degrees/second tilt,
- Input voltage: 24 VAC 60 Hz or 24 VDC, and
- Motors: Variable speed, continuous duty, instantaneous reversing.

(F) Power Supplies

Provide all power supplies necessary for the camera and its pan tilt unit. Mount power supplies in the camera cabinet and utilize composite cable to supply power the camera and pan tilt unit.

(G) 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 256 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.

(H) Video Cabling

Provide video cabling meeting the following requirements:

- Analog video cable between camera and cabinet: RG-59, 75 ohm, solid copper AWG-20, foam dielectric, copper braided foil shield, polyethylene outer jacket with BNC connectors on both ends, and
- Analog video cable within the camera-lowering device and within camera cabinet: RG-59u, 75 ohm, solid copper AWG-22, foam dielectric, copper braided foil shield, polyethylene outer jacket with BNC connectors on both ends.

(I) 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. Provide an on-screen compass direction indication. 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.

(J) CCTV Camera Attachment to Pole

Comply with the Section on Metal CCTV and MVDS poles in this Scope of Work.

(K) Surge Suppression

Provide a maximum 20 ohm ground impedance measurement, and the placement of transient voltage protection both ahead of and behind the ITS device electronics for CCTV installations. All SPD devices shall have an ambient operating temperature of -29 degrees F to 165 degrees F with 95 percent non-condensing relative humidity.

(1) Grounding

Furnish a grounding system as shown in the ITS Concept Plans. Provide all connections to the grounding electrode with an exothermic weld. Bond (i.e., connect) 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.

(2) Load Side CCTV Power

Load side protection is designed to restrict surge current transients from entering the power source from the CCTV device and/or site. The SPD 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 SPD 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 SPD 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) Line Side CCTV Power

The SPD 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 SPD 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 SPD 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 Load Side

The SPD shall have an operating voltage to match the characteristics of the CCTV, such as 24 volts of direct current (VDC) and less than five VDC for data and video functions. These specialized SPD units shall be UL listed according to the *UL 497A* standard. The minimum surge current rating for the SPD shall be 2,000 amps for data and telecommunications, and 4,000 amps for binary network connectors (BNC).

10.3 CONSTRUCTION METHODS

(A) Electrical and Mechanical Requirements

Ground all equipment as called for in the *Standard Specifications*, this Scope of Work, and the ITS Concept 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 the height specified in Section 9.1. Install CCTV assemblies at the locations shown on the ITS Concept Plans unless otherwise approved by the Engineer.

Mount the CCTV camera on the side of pole nearest the intended field of view so that the mounting 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 120 Volt power service. Comply with the "Electrical Service" section of this Scope of Work.

(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 ITS Concept 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) Load Side CCTV Power

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

(3) Line Side CCTV Power

Install a SPD 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-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 Line and Load Side

Install specialized SPD devices at the line 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 6 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.

11. MICROWAVE VEHICLE DETECTION SYSTEM

11.1 GENERAL

Furnish and install a microwave vehicle detection system (MVDS) as shown in the ITS Concept Plans and directed by the Engineer that is capable of traffic data collection meeting this section's requirements. Ensure that the MVDS can be mounted on new MVDS poles, CCTV poles, or toll gantry structures, for a side-fire configuration. The final locations and quantity to provide the minimum coverage shown in the ITS Concept Plans are the responsibility of the Design-Build Team.

The detection units shall use Ethernet communications for monitoring and control from the STOC and monitoring only from the NCTA Executive Offices.

11.2 MATERIALS

(A) General

Provide an MVDS assembly for the project site that consists of microwave radar sensor(s) in enclosed housing(s) (i.e., the detectors), as shown in the ITS Concept Plans and directed by the Engineer. Provide an installation kit with mounting brackets; home run cable for the transmission and receipt of data and communications between the field detector and the communication system hardware; and all required power and data cables, as detailed in the ITS Concept Plans.

(B) Detector

Provide a (MVDS) that uses a Federal Communications Commission (FCC)-certified, low-power microwave radar beam to detect vehicle passage and generate volume, occupancy, length-based classification, and speed data. Ensure that the MVDS is a true-presence microwave radar that uses the frequency modulated continuous wave (FMCW) principle. Ensure that any non-background targets reflect the signal back to the microwave radar detector, where the targets are detected and their range measured.

Ensure that the MVDS provides speed-trap emulation and has the ability to detect automatically sensor settings, baud rates, loop spacing, and communication port settings to select an operational mode.

Ensure that the detector has the ability to self-tune and allow manual calibration via supplied vendor software. Ensure that the MVDS is capable of auto-calibration and auto-configuration, and that it does not transmit any signals outside its FCC-approved frequency. Provide a setup program that allows the operator to define detection zones within the detector's field of view. Ensure that the detector automatically configures zones, requiring minimal external tuning. Verify that the unit is not adversely affected by varied weather conditions, such as rain, fog, heat, or wind.

Ensure that the MVDS can compute, store, and provide all required traffic parameter measurements per detection zone in user-selected time intervals from 0 to 60 minutes, including, but not limited to, 10 seconds, 20 seconds, 30 seconds, 60 seconds, 5 minutes, 10 minutes, 15 minutes, 30 minutes, and 60 minutes. The MVDS shall log and store vehicle volume, occupancy, length-based classification and speed data for a minimum of seven days regardless of collection interval. Data storage within the MVDS shall utilize a first in/first out architecture such that the oldest stored data record is overwritten with the newest data record when the storage device is at full capacity.

(1) Communications

Ensure that the MVDS generates and transmits traffic data either in serial format using an Electronic Industries Alliance (EIA) standard EIA-232 communication port or an Internet Protocol (IP) interface. If the detector does not have Ethernet communications integral to the detector provide data translators to provide for Ethernet communications. Ensure that the MVDS can generate contact closures emulating the output of a pair of 6-foot by 6-foot loops with leading edges placed 16 feet apart.

Verify that the MVDS is IP addressable. Ensure that all device communication addresses are user programmable.

Ensure that the MVDS supports Ethernet protocols. Ensure that the setup program assigns an IP address to the detection unit. Ensure that the MVDS responds to a polling request from the TMC for traffic data. Verify that the detection unit responds with the accumulated traffic parameter measurements from the period since the last request was issued.

Verify that the MVDS stores all system configuration and traffic parameter data within internal nonvolatile memory. Verify that traffic data can be locally and remotely transferred by issuing requests from a personal computer (PC) across the communication network connecting the detector and the TMC operator workstation or other PC.

(2) Configuration and Management

Ensure that the MVDS software application provides PC desktop display of the detection zones and control of any vehicle detector connected to the network. Ensure that the MVDS setup program enables the operator to select whether data is output as contact closures emulating standard loop detector outputs, and/or as accumulated statistical data using detector serial ports.

Verify that the sensor holds a vehicle's presence in the specified detection zone until the vehicle is clear of the zone. Ensure that the sensor does not tune out stationary vehicles within a detection zone and thereby give a false clear status to the lane, even if a vehicle has stopped for a period exceeding 30 minutes. Provide a detector that is capable of resolving closely spaced vehicles.

Provide an assembly manufactured in such a way as to prevent reversed or improper installation. Ensure that the MVDS design provides high-voltage exposure protection to personnel during equipment operation, adjustments, and maintenance.

Provide software licenses.

Ensure that an operator using a locally connected laptop computer can conduct system setup, calibration, diagnosis, and data retrieval operations. Ensure that the MVDS is capable of having its configuration data saved to a laptop computer or TMC server, which can later transfer the data back to the MVDS for reloading.

Ensure that the MVDS operator can use a laptop computer or TMC server to edit previously defined detection configurations to permit adjustments to the detection zone's size, placement, and sensitivity, and to reprogram the detector's parameters.

Ensure that the laptop computer and the MVDS can communicate when connected directly by an EIA-232 cable. Ensure that the laptop computer and MVDS can communicate across the ITS system's communication network using the NTCIP standards described in this Scope of Work. Ensure that the software allows communication between multiple users and multiple field devices concurrently across the same communication network.

Once programmed, ensure that no periodic adjustments are required to the detection zones unless physical roadway conditions change, such as lane shifts or closures.

(3) Electrical Requirements

Ensure that the MVDS field hardware meets the requirements in the FCC's 2005 Code of Federal Regulation (CFR), Title 47, Part 15. The detector shall not interfere with any known equipment.

Ensure the MVDS operates using a nominal input voltage at the field cabinet of 120 volts of alternating current (V_{AC}). Ensure that the system's power supply will operate with an input voltage ranging from 89 to 135 V_{AC}. For any device requiring a source input other than the standard 120 V_{AC}, supply the appropriate means of conversion.

Provide an assembly manufactured in such a way as to prevent reversed or improper installation. Ensure that the MVDS design provides high-voltage exposure protection to personnel during equipment operation, adjustments, and maintenance.

Furnish all equipment with the appropriate power and communication cables. Install the power cable and the communication cables according to the manufacturer's recommendation. Ensure that the cables comply with NEC sizing requirements as presented in NEC Article 210-19(a), Fine Print Note (FPN) No. 4, and meet all other applicable standards, specifications and local code requirements.

Ensure that the power cable running between the MVDS and its electrical service is in a separate conduit. Do not install communication cables in the same conduit as power cables carrying voltage greater than 24 V_{DC}/V_{AC} or current in excess of 1.5 amps. Do not install the power and communication cables in the same pull boxes.

Cut all wires to their proper length before assembly. Do not double back any wire to take up slack. Neatly lace wires into cables with nylon lacing or plastic straps. Secure cables with clamps and provide service loops at all connections.

In the event that power to the MVDS or a subcomponent thereof is interrupted, ensure that the equipment automatically recovers after power is restored. Ensure that all programmable system settings return to their previous configurations and the system resumes proper operation.

Ensure that the MVDS operator is able to select and use 12 to 24 volts of direct current (V_{DC}) and 115 V_{AC} at 60 Hz.

Ensure that the detector is FCC certified and that the FCC's identification number is displayed on an external label. Ensure that the detector transmits within a frequency band of 10.525 gigahertz, ±25 megahertz, or another FCC approved spectral band.

(4) Environmental Requirements

Provide MVDS that meet all specifications during and after being subjected to an ambient operating temperature range of -29 degrees F to 165 degrees F with a maximum non-condensing relative humidity as defined in the environmental requirements section of the NEMA TS 2 standard.

Verify that the MVDS manufacturer certifies that its device has successfully completed environmental testing as defined in the NEMA TS 2 standard. Verify that vibration and shock resistance meet the requirements of Sections 2.1.9 and 2.1.10, respectively, of NEMA TS 2.

Ensure that no item, component, or subassembly emits a noise level exceeding the peak level of 55 decibels adjusted (dBa) when measured at a distance of 3.3 feet away from its surface.

Ensure that MVDS components comply with the environmental requirements detailed in the NEMA TS 2 standard.

(5) Detector Housing

Furnish and install an environmentally resistant and tamper-proof sensor enclosure for any detector assembly exposed to the elements. Ensure that the enclosure is environmentally sealed upon installation and that it is light in color.

(6) Wind Loads

Design MVDS poles in accordance with the 4th Edition 2001 AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, including all of the latest interim revisions.

(7) Performance

Provide a MVDS capable of meeting the minimum total roadway segment accuracy levels of 95% for volume, 90% for occupancy, 90% for length based classification and 90% for speed for all lanes, up to the maximum number of lanes that the device can monitor as specified by the manufacturer. This evaluation (by necessity) shall take place during the Observation Period.

To verify conformance with the accuracy requirements in this section, perform evaluations by comparing sample data collected from the vehicle detection system with ground truth data collected during the same time by human observation or by another method approved by the Engineer. Base the vehicle detection system's performance evaluation on sample data taken over several periods under a variety of traffic conditions. Develop and adhere to a methodology to collect data and calibrate and evaluate the performance of each device using speed, volume, and occupancy data.

(C) Software

Provide software to perform the following tasks:

- Device configuration and setup,
- Diagnostic testing,
- Device management,
- Data retrieval, analysis, reporting and storage,
- Data importing from NCDOT's MVDS database,
- Data exporting to other systems, including but not limited to:
    - Toll collection system for congestion pricing
    - Dynamic Message Signs for travel time posting
    - NCDOT for posting on a speed map
- Independent travel time calculation from first mainline MVDS to US 601, and from US 601 to last mainline MVDS, in each direction.

Provide software to collect data from each sensor as frequently as 20-second intervals.

The report function shall include user-definable queries in graphical, text and tabular formats.

The software shall perform database translations, data types and file formats to accomplish the above data exporting. The software should utilize the following minimum file formats: XML, HTML, SQL, Excel, and PDF. Software shall include "on-demand" and scheduled data translation.

The Design-Build Team shall update the NCTA website speed map by depicting:

- Location of each MVDS on Monroe Connector/Bypass,
- Background map suitable in detail and for use on Internet website.

The maps shall be expanded to display all of the Monroe Connector/Bypass and the crossing routes (whether interchange or otherwise). Depict on the map local names, route numbers, and major landmarks. The Design-Build Team shall develop a verification plan to be approved by Engineer to verify that speeds displayed on the map are accurate. This verification shall take place during the Observation Period.

Provide device drivers for detectors provided in this Scope of Work.

11.3 CONSTRUCTION METHODS

Install, configure, and demonstrate a fully functional vehicle side-fire detection system. Connect all field hardware to the communication network, and provide all materials specified in this Scope of Work. Install all equipment according to the manufacturer's recommendations or as directed by the Engineer.

(A) Electrical and Mechanical Requirements

Ground all equipment as called for in the *Standard Specifications*, this Scope of Work, and the ITS Concept Plans.

Install surge protectors on all ungrounded conductors entering the MVDS enclosure as described below. House the surge protectors in the MVDS cabinet on the pole in a manner approved by the Engineer. The air terminal ground wire must not pass through this cabinet.

(B) MVDS

Ensure that the MVDS can be mounted on new MVDS poles or CCTV poles, in a side-fire configuration. Mount each MVDS at height and setback corresponding to the manufacturer's recommendations for the number of lanes and the detection zone. For CCTV poles with lowering devices, provide a detector-mounting bracket to mount the detector on the side of the pole 90 degrees to traffic so the camera and lowering device do not strike the detector. For locations where the minimum setback cannot be met when mounting on front face of pole, provide a mounting bracket to mount on the side of the pole 90 degrees to traffic so the camera and lowering device do not strike the detector. Use this method only if that provides the minimum setback.

Mount the MVDS detector as detailed in the ITS Concept Plans. In either configuration, mount the detector level with respect to the centerline of the roadway. Tilt the unit downward toward the roadway to ensure detection of all lanes.

Ensure that the MVDS sensor has a 200-foot range, and that the viewing angle is a minimum of 40 degrees vertical and a maximum of 15 degrees horizontal. Verify that all detection zones are contained within the specified elevation angle according to the manufacturer's recommendations and that the MVDS is capable of fully detecting all vehicles in a minimum of eight lanes or zones. Ensure that the configuration also provides accurate collection of all data types as detailed in this specification.

Provide a detector housing that can be pole-mounted, as indicated in the ITS Concept Plans. Supply a universal mounting bracket that is adjustable on two axes for optimum alignment.

Attach the mounting bracket with approved stainless steel bands that are 0.75 inch wide and 0.025 inch thick, or mount to a concrete structure using two stainless steel expansion bolts of sufficient length and diameter to support 100 pounds.

When installing a detector near metal structures, such as buildings, bridges, or sign supports, mount the sensor and aim it so that the detection zone is not under and does not pass through any structure to avoid distortion and reflection.

Ensure that the detector is factory calibrated to comply with all applicable standards, specifications, and requirements.

Provide an interface to external equipment with a single connector. Ensure that the connector provides power to the unit and allows generation of contact closure output pairs. Ensure that the connector includes serial communication lines for programming, testing, and interfacing with the modem/switch at 9,600 to 115,000 bps baud rate and that it has at least 26 pins. Ensure that the serial port's data format is standard binary non-return to zero (NRZ) modulation with 8-bit data, 1-stop bit, and no parity.

Ensure that the homerun cable is a polyurethane-jacketed cable approved by the Engineer, with polyvinyl chloride (PVC) insulated conductors. The homerun cable shall have a 300-volt rating and a temperature rating of 200° F. Ensure that the cable is equipped with #20 or #22 American Wire Gauge (AWG) conductors.

Crimp or solder the detector connector pins to the cable conductors. Assemble and test the cable prior to onsite installation and pulling. Cut all wires to their proper length before installation. Do not double back wire to take up slack. Neatly lace wires into cable with nylon lacing or plastic straps, and secure cables with clamps. Provide service loops at all connections.

Perform continuity tests on the detector's stranded conductors using a meter having a minimum input resistance of 20,000 Ω per volt and show that each conductor has a resistance of not more than 16 Ω per 984.25 feet of conductor.

Measure the insulation resistance between isolated conductors and between each conductor, ground, and shield using a meter designed for measuring insulation resistance. The resistance must be infinity. Perform all resistance testing after final termination and cable installation, but prior to the connection of any electronic or field devices.

(C) Power Service

Provide 120VAC power service. Comply with the "Electrical Service" section of this Scope of Work.

(D) Surge Suppression

(1) Grounding

Connect all grounding points related to the MVDS to a single point main grounding electrode as shown in the ITS Concept 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 MVDS 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) Load Side Detector Power

Install a transient voltage suppressor (SPD) at the MVDS 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) Line Side Detector Power

Install a SPD in the power line side ahead of all MVDS 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) Load Side Detector Data

Install specialized SPD devices at the supply and line sides of all low voltage connections to the MVDS and its operating subsystems. These connections include, but are not limited to, Category 6 data cables, and low voltage control cables that comply with EIA requirements as detailed in the EIA-232/422/485 standards.

(E) Software

If software is required, install the software application(s) on the STOC virtual servers for access by all TMC operators, NCTA CSC workstation, and NCTA Executive Office access. Coordinate with Toll Systems Integrator to define the data variables, database type and file format for congestion pricing. Configure data translation applications for those services described above.

12. DYNAMIC MESSAGE SIGN (DMS) SYSTEM

12.1 DESCRIPTION

(A) General

Furnish and install new NTCIP v2 compliant Dynamic Message Signs (DMS), and DMS power and communications equipment in accordance with this Scope of Work and ITS Concept Plans. Integrate the signs into the STOC software. The DMS signs shall be fully compatible with the Vanguard® DMS control software version currently in use at the STOC to ensure seamless integration of new signs with NCDOT's existing central command and control system.

Furnish and install DMS signs compliant with UL standards 48, 50, 879, and 1433.

Add and configure the new DMS signs in the existing NCDOT *Vanguard* database on the proposed servers. Furnish, install, test, integrate, and make fully operational the new DMSs at locations shown on the project plans. The Design-Build Team shall also be responsible for any MIB development and configuration if the NCDOT STOC does not already have MIBs for the DMS.

The structures supporting the DMS signs are described elsewhere in this RFP. Furnish, install, test, integrate and make fully operational the new DMSs at locations shown in the ITS Concept Plans.

For DMS A1 and DMS A2, establish Ethernet radio communications from the fiber-optic communications network to these devices.

For each new location, the DMS system shall include:

- Color, full matrix LED technology
- Minimum 27 pixels high by 110 pixels wide display (27 by 90 pixels for A1 and A2)
- DMS controller
- Cabinet and accessories with interconnect, power cabling and conduit
- Electrical service and related equipment
- All other equipment and incidentals required for furnishing, installing, and testing system and system components
- Use only UL listed and approved electronic and electrical components in the DMS system
- Walk-in housing or front access, as shown on the ITS Concept Plans

12.2 MATERIALS

(A) General

Construct the DMS to display at least three lines of text that, when installed, are clearly visible and legible to a person with 20/20 corrected vision from a distance of 900 feet in advance of the DMS at an eye height of 3.5 feet along the axis.

When displaying three lines, each line must display 15 equally spaced and equally sized alphanumeric individual characters for A1 and A2, and 18 such characters for all other signs. Each character must be at least 18 inches in height and composed from a luminous dot matrix.

(B) Environmental Requirements

Construct the DMS and DMS controller-cabinet so the equipment within is protected against moisture, dust, corrosion, and vandalism.

Design the DMS system to comply with the requirements of Section 2.1 (Environmental and Operating Standards) of NEMA TS 4-2005.

Construct the DMS and housing so that it can withstand AASHTO 2002 50-year wind speed for the area where the DMS will be installed.

(C) DMS Enclosures

The DMS enclosure construction shall comply with the requirements of Section 3 (Sign Mechanical Construction) of NEMA TS 4-2005. The following requirements complement TS 4-2005.

Paint the DMS face matte black. All grind marks and discoloration shall be removed from the surfaces.

All nuts, bolts, washers, and other mounting and bonding parts and components used on the exterior of the DMS enclosure shall be corrosion resistant and sealed against water intrusion.

Do not place a manufacturer name, logo, or other information on the front face of the DMS or shield visible to the motorist.

Do not paint the stainless steel bolts on the Z-bar assembly used for mounting the enclosure.

(1) Front Access DMS

The DMS enclosure construction shall comply with the requirements of Section 3 (Sign Mechanical Construction) of NEMA TS 4-2005 as it applies to front access enclosures. Construct the enclosure of welded aluminum type 5052-H32, or of an Engineer approved alternate. The sheet aluminum skin shall be a minimum of .090-inch thick. Perform all welding of aluminum and aluminum alloys in accordance with the latest edition of AWS D1.2, Structural Welding Code - Aluminum. Continuously weld the seams using Gas Metal Arc Welding (GMAW).

(2) Walk-in DMS

The DMS enclosure construction shall comply with the requirements of Section 3 (Sign Mechanical Construction) of NEMA TS 4-2005 as it applies to Walk-in enclosures. Construct the enclosure of welded aluminum type 6061-T6 (major structural components), 5052-H32 (minor structural components and exterior shell), or of an Engineer approved alternate at least .125-inch thick. Perform all welding of aluminum and aluminum alloys in accordance with the latest edition of AWS D1.2, Structural Welding Code - Aluminum. Continuously weld the seams using Gas Metal Arc Welding (GMAW). All structural attachment hardware (direct tension indicators, nuts, bolts, washers) shall be either stainless or galvanized steel A325 high strength steel.

Construct the DMS with a metal walk-in enclosure excluding the face. Provide an aluminum walking platform with a slip resistant surface inside the enclosure that is at least 28 inches wide. The width of the walking platform shall be free of obstructions to a height of 7 feet.

Provide one key lockable, hinged, gasket-sealed inspection door for service and maintenance along each end of the enclosure. Equip the doors with locks operable from the inside. Install one appropriately sized fire extinguisher within 12 inches of each maintenance door. Equip the door with a door-hold-open device.

(D) Structural Requirements

(1) General

Mount the DMS enclosure and interconnect system securely to supporting structures as described in this RFP. For Walk-in DMS, design the enclosure supports to allow access to the DMS enclosure inspection door.

Submit plans for the DMS enclosure, mounting description and calculations to the Engineer for approval. Have such calculations and drawings approved by a Professional Engineer registered in the state of North Carolina, and bear his signature, seal, and date of acceptance.

Provide removable lifting eyes or the equivalent on the DMS enclosure rated for its total weight to facilitate handling and mounting the DMS enclosure.

Design the DMS structure to conform to the applicable requirements of the *Standard Specifications for Structural Supports for Highway Signs, Luminaires*, and the section titled "Dynamic Message Sign Assembly" of this Scope of Work.

(2) Direct Tension Indicators

Use direct tension indicators whose material, manufacturing process, performance requirements, workmanship and certification requirements conform to the requirements of ASTM F959.

For Type 3 high strength bolts, use direct tension indicators mechanically galvanized to ASTM B695 Class 50, then with 1 mil of baked epoxy applied.

For plain Type 1 high-strength bolts, use direct tension indicators that are plain or mechanically galvanized to ASTM B695 Class 50.

For galvanized Type 1 high strength bolts, use direct tension indicators that are mechanically galvanized to ASTM B695 Class 50 only.

(E) DMS Enclosure Structure Mounting

Provide vertical I-beams or Z-bars bolted through the exterior shell to the structural frame to mount the sign on the structure. Utilize aluminum type 6061-T6 structural members and either stainless or galvanized steel A325 high strength steel mounting hardware. Design and fabricate the vertical supports so hanger attachments can be mounted without affecting or penetrating the outer shell of the sign.

Design the DMS enclosure supports and structure to allow access to the DMS enclosure inspection doors on walk in signs or access panels on front access signs. Design and ensure the penetrations through the exterior shell remain watertight.

(F) Front Panel

Protect the DMS face with contiguous, weather-tight, removable panels. Manufacture these panels of sheets of polycarbonate, methacrylate, GE Lexan Type SG300 or equivalent that are ultraviolet protected, have an antireflection coating, and are a minimum of 1/8-inch thick. For substitutes, submit one 12” x 12” sample of the proposed material together with a description of the material attributes to the Engineer for review and approval. Install a .09” aluminum mask on the front of the panel (facing the motorists) that contains circular openings for each LED pixel. Front side of the aluminum mask, which faces the viewing motorists, shall be primed and coated with automotive-grade flat black acrylic enamel paint or an approved equivalent. All painted surfaces shall provide a minimum outdoor service life of 20 years.

Design the panels so they will not warp nor reduce the legibility of the characters. Differential expansion of the DMS case and the front panel must not cause damage to either component or allow openings for moisture or dust. Glare from sunlight, roadway lighting, commercial lighting, or vehicle headlights must not reduce the legibility or visibility of the DMS. Install the panels so that a maintenance person can easily remove or open them for cleaning. Cover the areas of the panels between characters and lines with a flat black, UV-treated, colorfast material to reduce glare.

For front access signs, provide access internal to the sign housing by one of two methods. Method one is provide a hinged front face from the top to allow access to the interior of the sign and all of its components. Method two is the provision of a means to remove any and all display modules described below to access to the interior of the sign and all of its components.

(G) Display Modules

Manufacture each display module with a standard number of pixels, not to exceed an array of 9 x 5 that can be easily removed. Assemble the modules onto the DMS assembly contiguously to form a continuous matrix to display the required number of lines, characters, and character height.

Design display modules that are interchangeable and replaceable without using special tools. All power and communication cables connected to a display module shall be plug-in types to allow easy removal for maintenance and repair. Provide a positive locking mechanism to hold the boards in place.

Construct each display module as a rectangular array of 5 horizontal pixels by 7 to 9 vertical pixels. Provide the module with an equal vertical and horizontal pitch between pixels, and columns that are perpendicular to the rows (i.e., no slant). Design each module to display:

- All upper and lower case letters,
- All punctuation marks,
- All numerals 0 to 9, and
- Special user-created characters.

Display upper-case letters and numerals over the complete height of the module. Optimize the LED grouping and mounting angle within a pixel for maximum readability.

(H) LED Pixels

A pixel is defined as the smallest programmable portion of a display module that consists of a cluster of closely-spaced discrete LEDs. Design each pixel to be a maximum of 2.60 inches center to center.

Pixels shall be constructed with two strings of LEDs. The number of LEDs in each string shall be determined by the manufacturer to produce the candela requirement as stated herein.

Ensure that all pixels in all signs in a project, including operational support supplies, have equal color and on-axis intensity. Ensure that the sign display produces an overall luminous intensity of at least 92 candelas per square meter when operating at 100% intensity. Measure the brightness of each LED in accordance with the International Commission on Illumination's (CIE) requirements detailed in Test Method A of the CIE 127 (1997) standard. Provide the LED brightness and color bins that are used in each pixel to the Engineer for approval. Provide a letter of certification from the LED manufacturer that demonstrates testing and binning according to the CIE 127 (1997) standard. Ensure each pixel contains two interlaced strings of LEDs. Ensure that all LEDs operate within the LED manufacturer's recommendations for typical forward voltage, peak pulsed forward current, and other ratings. Component ratings shall not be exceeded under any operating condition.

Provide a pixel test as a form of status feedback to the TMC from the local sign controller. Ensure that the operational status of each pixel in the sign can be automatically tested once a day. The operational status may also be tested when the STOC or a laptop computer prompt defective pixels as transmitted to the STOC or a laptop computer. Ensure that the log file includes the pixel status, module number, column number, and pixel number. Ensure that the pixel status test determines the functional status of the pixel as stuck-on or stuck-off and does not affect displayed message for more than half a second.

Each pixel shall contain the quantity of discrete LEDs needed to output white colored light at a minimum luminous intensity of 12,400 candelas per square meter when operated within the forward current limits defined in this Scope of Work.

Power the LEDs in each pixel in strings. Use a redundant design so that the failure of an LED in one string does not affect the operation of any other string within the pixel. Provide the sign controller with the ability to detect the failure of any LED string and identify which LED string has failed. Submit a complete schematic of the LED power and driver circuits with the catalog cuts.

Protect LEDs from degradation due to sunlight via flat black louvers or a functionally equivalent methodology. Place these louvers or equivalent behind the front panel. Use a method that does not reduce the display viewing-angle below that provided by the LED. Install the louvers or equivalent in such a way as to promote cooling of the LEDs and so that they are easily removable for cleaning or maintenance.

(I) Discrete LEDs

Provide discrete LEDs with a nominal viewing cone of 30 degrees with a half-power angle of 15 degrees measured from the longitudinal axis of the LED. Viewing cone tolerances shall be as specified in the LED manufacturer's product specifications and shall not exceed +/- 3 degrees half-power viewing angle of 30 degrees.

Provide LEDs with a MTBF (Mean Time Between Failure) of at least 100,000 hours of permanent use at an operating point of 140 degrees F or below at a specific forward current of 20mA. Discrete LED failure is defined as the point at which the LED's luminous intensity has degraded to 70% or less of its original level.

Obtain the LEDs used in the display from a single LED manufacturer that have a single part number. Obtain them from batches sorted for luminous output, where the highest luminosity LED is not more than fifty percent more luminous than the lowest luminosity LED when the LEDs are driven at the same forward current. Do not use more than two successive and overlapping batches in the LED display. Distribute the batches consistently and evenly across the sign face. Document the procedure to be used to comply with this requirement as part of the catalog cut submittal.

Individually mount the LEDs on circuit boards that are at least 1/16-inch thick FR-4 fiberglass, flat black printed circuit board in a manner that promotes cooling. Ensure the LEDs are mounted parallel and flush to the circuit board. Protect all exposed metal on both sides of the LED pixel board, except the power connector, from water and humidity exposure by a thorough application of acrylic conformal coating. Design the boards so bench level repairs to individual pixels, including discrete LED replacement and conformal coating repair is possible.

Operate the LED display at a low internal DC voltage not to exceed 24 Volts.

Design the LED display operating range to be –20 degrees F to +140 degrees F at 95% relative humidity, non-condensing.

Supply the LED manufacturer's technical specification sheet with the catalog cuts.

Provide LEDs that are untinted, non-diffused, high output solid-state lamps manufactured by Toshiba or Hewlett-Packard. The red LEDs shall utilize aluminum indium gallium phosphide (AlInGaP) technology with a peak wavelength of 625 ± 10 nm. The green LEDs shall utilize indium gallium nitride (InGaN) technology with a peak wavelength of 527 ± 7.5 nm. The blue

LEDs shall utilize indium gallium nitride (InGaN) technology with a peak wavelength of 467 ± 3 nm. No substitutions will be allowed. Provide T 1¾, mm size LEDs.

(J) LED Power Supplies

Power the LED display by means of multiple regulated switching DC power supplies that operate from 120 volts AC input power and have an output of 24 volts DC or less. Wire the supplies in a redundant parallel configuration that uses multiple independent power supplies per display. Provide the supplies with current sharing capability that allows them to provide equal amounts of current to their portion of the LED display. Provide power supplies rated such that if one supply fails the remaining supplies will be able to operate their portion of the display under full load conditions (all pixels on at maximum brightness) and at a temperature of 140 degrees F.

Provide power supplies to operate within a minimum input voltage range of +110 to +130 volts AC and within a temperature range of –22 degrees F to 140 degrees F. Power supply output at 140 degrees F must not deteriorate to less than 65% of its specified output at 70 degrees F. Provide power supplies that are overload protected by means of circuit breakers, and that have an efficiency rating of at least 75%, a power factor rating of at least .95, and are UL listed. Provide all power supplies from the same manufacturer and with the same model number. Design the power driver circuitry to minimize power consumption.

Design the field controller to monitor the operational status (normal or failed) of each individual power supply and be able to display this information on the client computer screen.

(K) Character Display

Design display modules to be easily removable without the use of tools. Position cooling fans so they do not prevent removal of an LED pixel board or driver board.

Use continuous current to drive the LEDs at the maximum brightness level. Design the light levels to be adjustable for each DMS / controller so the Engineer may set levels to match the luminance requirements at each installation site.

Design the controller to automatically detect failed LED strings or drivers and initiate a report of the event to the control software. Design the controller to be able to read the internal temperature of the DMS enclosure and the ambient temperature outside the DMS enclosure and report these to the control software.

(L) Display Capabilities

Design the DMS with at least the following message displays:

- Static display,
- Flashing display with dynamic flash rates, and
- At least two alternating static and / or flashing sequences (multi-page messages).

(M) DMS Interior Environment Monitoring and Control

Design the local field controller to monitor and control the interior DMS environment. Design environmental control to maintain the internal DMS temperature within +/- 10 degrees F of the outdoor ambient temperature. Provide the DMS environmental monitoring and control system with five primary subsystems as follows:

(1) Photo-Electric Sensors

Install three photoelectric sensors with ½-inch minimum diameter photosensitive lens inside the DMS enclosure. Use sensors that will operate normally despite continual exposure to direct

sunlight. Place the sensors so they are accessible and field adjustable. Point one sensor point down on the bottom of the sign. Place the other two, on the back wall and one on the front wall of the sign enclosure. Alternate design maybe accepted provided the sensor assembly is accessible and serviceable from inside the sign enclosure.

Provide controls so that the Engineer can field adjust the following:

- The light level emitted by the pixels elements in each Light Level Mode.
- The ambient light level at which each Light Level Mode is activated.

(2) Internal Temperature Sensors

Provide the DMS with two internally mounted temperature sensors which are equipped with external thermocouples and which the field controller continuously monitors. Design the field controller to use this temperature information to determine when to activate and deactivate the environmental control systems described herein. Locate sensors on opposite ends of the upper 1/3 of the LED display matrix with their external thermocouples attached to and making contact with an LED pixel circuit board. Design the thermocouple and LED board to be easily detachable, in the event that one of the units requires removal and replacement. Provide sensors capable of measuring temperatures from -40 degrees F to +176 degrees F. Design the field controller to automatically shut down the LED display whenever one or both sensors indicates that LED board temperature has exceeded +140 degrees F, and to automatically restart the LED display whenever the suspect temperature falls below +130 degrees F. Design both shutdown and re-start temperature thresholds to be user-programmable. Design the field controller to report sensor temperatures and DMS shutdown/re-start events to the DMS control software.

(3) Housing Cooling System

Provide the DMS housing with a cooling system that circulates outside air into the DMS housing whenever the LED board temperature exceeds a user-programmable threshold. Provide this system with enough ventilation fans to exchange the internal DMS housing air volume at a minimum rate of four times per minute. Provide steel ball-bearing type fans. Mount fans in a line across the upper rear wall of the DMS housing to direct air out of the cabinet. Provide one filtered air intake port for each exhaust fan. Locate intake ports in a line across the lower rear wall of the DMS housing. Provide intake ports with a removable filter that will remove airborne particles measuring 500 microns in diameter and larger. Provide a filter that is of a size and style that is commercially readily available. Program the field controller to activate the DMS housing cooling system whenever the LED board temperature exceeds +90 degrees F and to turn the cooling system off whenever LED board temperature falls below +85 degrees F. On the DMS housing rear exterior wall, cover all air intake and exhaust ports on their top, front, and sides by an aluminum shroud fabricated from 0.090-inch aluminum sheeting. Taper the shrouds at the top to discourage birds from nesting in them. Securely fasten shrouds to the DMS housing, and provide gaskets at the interface to prevent water from entering the DMS. Design all air filters and fans to be removable from inside the DMS housing. Provide the DMS housing cooling system with an adjustable timer that will turn fans off after the set time has expired. Provide a timer that is adjustable to at least 4 hours, and locate it just inside the DMS housing door, within easy reach of a maintenance technician standing outside the DMS doorway.

(4) LED Display Cooling System

Provide the DMS with an LED display cooling system, which directs air across the LED display modules whenever LED board temperature exceeds a user-programmable threshold. Direct fan-forced air vertically across the backside of the entire LED display matrix using multiple ball-bearing fans. Program the field controller to activate the LED cooling fan system whenever LED board temperature exceeds +90 degrees F and to deactivate the system whenever LED board temperature falls to +85 degrees F. Locate cooling fans so as not to hinder removal of LED display modules and driver boards.

(5) Front Face Panel Defog/Defrost System

Provide the DMS with a defog/defrost system which circulates warm, fan-forced air across the inside of the polycarbonate front face whenever LED board temperature falls below a user-programmable threshold. Provide multiple steel ball-bearing fans that provide uniform airflow across the face panel. Program the field controller to activate the defog/defrost system whenever LED board temperature falls below +40 degrees F and to deactivate the defog/defrost system whenever LED board temperature exceeds +106 degrees F. Mount a 100-watt pencil-style heating element in front of each defog/defrost fan to warm the air directed across the DMS face. Design heating elements to be on only when the defog/defrost fans are on.

Install additional fans and/or heaters as needed to maintain the temperature inside the DMS enclosure within the operating temperature range of the equipment within the DMS enclosure as recommended by the equipment manufacturer(s).

(N) Electrical Requirements

The requirements stated herein shall apply wherever electrical wiring is needed for any DMS system assemblies and subassemblies such as controller cabinet, DMS enclosure, electrical panel boards, etc.

Neatly arrange and secure the wiring inside the cabinet. Where cable wires are clamped to the walls of the control cabinet, provide clamps made of nylon, metal, plastic with rubber or neoprene protectors, or similar. Lace and jacket all harnesses, or tie them with nylon tie wraps spaced at 6 inches maximum to prevent separation of the individual conductors.

All conductors shall be individually and uniquely labeled. All conductor labels shall be clearly visible without moving the conductor. All terminal conductors shall connect to the terminal strip in right angles. Excess conductor shall be removed before termination of the conductor. The conductor shall be molded in such a fashion as to retain its relative position to the terminal strip if removed from the strip. No conductor shall run across a work surface with the exception of connecting to that work surface. No conductor bundles can be supported by fasteners that support work surfaces. All connectors, devices, and conductors shall be installed in accordance to manufactures guidelines. All wiring shall comply with the latest NEC guideline in effect during installation. No conductor or conductor bundle may hang loose or create a snag hazard. All conductors shall be protected from damage. All solder joints shall be completed using industry accepted practices and shall not fail due to vibration or movement. All welds must be in a manner that will not fail due to vibration. Lamps and control boards shall be protected from damage.

Insulate all conductors and live terminals so they are not hazardous to maintenance personnel.

Route and bundle all wiring containing line voltage AC and / or shield it from all low voltage control circuits. Install safety covers to prevent accidental contact with all live AC terminals located inside the cabinet.

Use industry standard, keyed type connectors with a retaining feature for connections to the controller.

Provide one earth grounding lug that is electrically bonded to the sign housing.

Label all equipment and equipment controls clearly.

Supply each sign assembly with one complete set of wiring diagrams that identify the color-coding or wire tagging used in all connections.

Provide power supply monitoring circuitry to detect power failure in the DMS and to report automatically this fault to the control software. This requirement is in addition to reporting power failure at the controller cabinet.

(1) Lighting

Equip walk-in DMS enclosures with internal fluorescent lighting controlled with timers installed close to each inspection door. No light emitted from the fluorescent tubes or any other light source inside the enclosure not comprising the display shall leak to the outside of the enclosure.

(2) Convenience Outlets

Install GFCI duplex utility receptacles every 6 feet along the width of the DMS in convenient locations for powered service tools.

(3) Power Supply and Circuit Protection

Design the DMS and controller for use on a system with a line voltage of 120V $\pm$ 10% at a frequency of 60 Hz. $\pm$ 3 Hz. Under normal operation, do not allow the voltage drop between no load and full load of the DMS and its controller to exceed 3% of the nominal voltage.

Blackout, brownout, hunting, line noise, chronic over-voltage, sag, spike, surge, and transient effects are considered typical AC voltage defects. Protect the DMS system equipment so that these defects do not damage the DMS equipment or interrupt their operation. Equip all cabinets with devices to protect the equipment in the cabinet from damage due to lightning and external circuit power and current surges.

Protect the DMS sign, controller, accessories, and cabinet utilities with thermal magnetic circuit breakers. Provide the controller cabinet with a main circuit breaker sized according to the NEC. Use appropriately sized branch circuit breakers to protect the controller and accessories and for servicing DMS equipment and cabinet utilities.

(4) Surge Suppression

See the Cabinet Section of the Scope of Work for surge suppression equipment required in the DMS controller cabinet.

Install and clearly label filtering hybrid power line SPDs on the load side of the branch circuit breakers in a manner that permits easy servicing. Ground and electrically bond the surge protector to the cabinet within 2 inches.

Provide power line surge protector that meets the following requirements:

Peak surge current occurrences	20 minimum
Peak surge current for an 8 x 20 microsecond waveshape	50,000 amperes
Energy absorption	> 500 joules
Clamp voltage	240 volts
Response time	<1 nanosecond
Minimum current for filtered output	15 amperes for 120VAC*
Temperature range	-40^{o}F to +158^{o}F

* Capable of handling the continuous current to the equipment

(O) DMS / DMS Controller Interconnect

Furnish and install all necessary cabling, conduit, and terminal blocks to connect the DMS and the DMS controller. Use approved manufacturer's specifications and project plans for cable and conduit types and sizes. Conduit shall not be mounted on the exterior of the DMS structure. Conduits will be provided within the toll gantries for the DMS cabling and power supply.

(P) DMS Controller

Furnish and install one DMS controller with accessories per DMS in a cabinet described in this Scope of Work. Provide the DMS controller as a software oriented microprocessor and with resident software stored in non-volatile memory. The control software, controller, and communications must comply with the NTCIP Standards identified in this Scope of Work. Provide sufficient non-volatile memory to allow storage of at least 500 multi-page messages and a test pattern program.

(1) Controller Address

Assign each DMS controller a unique address. Preface all commands from the control software with a particular DMS controller address. The DMS controller compares its address with the address transmitted and if the addresses match, then the controller processes the accompanying data.

(2) Controller Modes of Operation

Provide each controller with two possible modes of operation based on the point of control:

- Remote Mode: The control software controls DMS display. and
- Local Mode: An on-site operator controls DMS display using the LCP or a laptop computer.

The controller will report its operational mode status to the Control Software when polled.

(3) Controller Functions

Design the DMS controller to continuously control and monitor the DMS independent of the control software.

Design the controller to display on the sign a message sent by the control software, a message stored in the sign controller memory, or a message input on-site by an operator.

The control software can direct the controller to perform the following major tasks: create, edit, and / or delete messages and their parameters, stop or change the message being displayed, and perform diagnostic and test programs.

Provide the DMS controller with a watchdog timer to detect controller failures and to reset the microprocessor, and with a battery backed up clock to maintain an accurate time and date reference. Set the clock through an external command from the control software or the LCP.

(4) Controller Memory

Design each DMS controller with its local non-volatile memory. Use the non-volatile memory to store and reprogram at least one test pattern sequence and 500 messages containing a minimum of two pages of 45 characters per page. The Engineer will furnish the initial set of messages. Load these messages into both the control software library and the DMS controller's non-volatile memory. The control software can upload messages into and download messages from each controller's non-volatile memory remotely.

Messages uploaded and stored in the controller's non-volatile memory may be erased and edited using the control software and the controller. New messages may be uploaded to and stored in the controller's non-volatile memory using the control software and the controller. These actions shall be accomplished without removing the non-volatile memory from the controller and installing another non-volatile memory in the controller.

(Q) DMS Mini-Controller

Furnish and install a mini-controller inside the DMS that is interconnected with the main controller using a fiber-optic cable, CAT-5 cable, or an approved alternate. The mini-controller will enable a technician to perform all functions available from the main controller. Provide the mini-controller with an LCD/keypad interface. Size the LCD display screen to allow preview of an entire one-page message on one screen. Provide a 4 X 4 keypad.

Alternatively, install an EIA/TIA-232E port inside the DMS enclosure to enable a maintenance technician to communicate with the DMS main controller, obtain access to, and perform all functions of the main controller.

(R) NTCIP Requirements

This portion of the specification defines the detailed NTCIP requirements for the DMS signs covered by this Scope of Work.

For compatibility with Vanguard software, implement all objects found on the attached MIB file except for the objects that are exclusively applicable to proprietary hardware features found in Vanguard DMSs.

(1) References

This specification references several standards through their NTCIP designated names. The following list provides the full reference to the current version of each of these standards.

Implement the most recent version of the standard including any and all approved or recommended amendments to these standards for each NTCIP component covered by these project specifications.

Table 1: NTCIP Standards

Abbreviated Number	Full Number	Title
NTCIP 1101	NTCIP 1101:1997	Simple Transportation Management Framework
NTCIP 1201	NTCIP 1201:1997	Global Object Definitions
NTCIP 1203	NTCIP 1203 v03:2009	Object Definitions for Dynamic Message Signs
NTCIP 2001	NTCIP 2001:1997	Class B Profile
NTCIP 2101	NTCIP 2101	SP-PMPP/232 Subnet Profile for PMPP over RS-232
NTCIP 2103	NTCIP 2103	SP-PPP/232 Subnetwork Profile for PPP over RS232 (Dial Up)
NTCIP 2104	NTCIP 2104	SP-Ethernet Subnet Profile for Ethernet
NTCIP 2201	NTCIP 2201	TP-Null Transport Profile
NTCIP 2202	NTCIP 2202	TP-Internet Transport Profile (TCP/IP and UDP/IP)
NTCIP 2301	NTCIP 2301	AP-STMF AP for Simple Transportation Management Framework

Note: this project features color signs with the ability to post graphics. The color DMS signs shall comply with NTCIP Standard 1203 Object Definitions for Dynamic Message Signs version 02, dated 2007. Comply with all mandatory objects pertaining to the displaying and monitoring of graphics and color messages. Comply with all optional objects necessary to support the displaying and monitoring of graphics and color messages.

(2) General Requirements

a. Subnet Level

Ensure NTCIP components support NTCIP 2104.

NTCIP Components may support additional Subnet Profiles at the manufacturer's option. At any one time, only one Subnet Profile shall be active on a given serial port of the NTCIP Component. Ensure the NTCIP Component can be configured to allow the field technician to activate the desired Subnet Profile and provide a visual indication of the currently selected Subnet Profile.

b. Transport Level

Additionally, NTCIP components shall support NTCIP 2104.

NTCIP Components may support additional Transport Profiles at the manufacturer's option. Ensure Response datagrams use the same Transport Profile used in the request. Ensure each NTCIP Component supports the receipt of datagrams conforming to any of the identified Transport Profiles at any time.

c. Application Level

Ensure each NTCIP Component complies with NTCIP 1103 and meets the requirements for Conformance Level 1 (NOTE - See Amendment to standard). Ensure each NTCIP Component supports SNMP traps. An NTCIP Component may support additional Application Profiles at the manufacturer's option. Ensure responses use the same Application Profile used by the request. Ensure each NTCIP Component supports the receipt of Application data packets at any time allowed by the subject standards.

d. Information Level

Each NTCIP Component shall provide Full, Standardized Object Range Support of all objects required by these procurement specifications unless otherwise indicated below. The maximum Response shall be 100 milliseconds plus one millisecond per each byte in the response bindings field.

Design the DMS to support all mandatory objects of all mandatory Conformance Groups as defined in NTCIP 1201 and NTCIP 1203 v02: 2007. Table 2 indicates the modified object requirements for these mandatory objects.

Table 2: Modified Object Ranges for Mandatory Objects

Object	Reference	Project Requirement
ModuleTableEntry	NTCIP 1201 Clause 2.2.3	Contains at least one row with moduleType equal to 3 (software). The moduleMake specifies the name of the manufacturer, the moduleModel specifies the manufacturer's name of the component, and the modelVersion indicates the model version number of the component.
MaxGroupAddresses	NTCIP 1201 Clause 2.7.1	At least 1
CommunityNamesMax	NTCIP 1201 Clause 2.8.2	At least 3
DmsNumPermanentMsg	NTCIP 1203 Clause 2.6.1.1.1.1	At least 1*
DmsMaxChangeableMsg	NTCIP 1203 Clause 2.6.1.1.1.3	At least 21
DmsFreeChangeableMemory	NTCIP 1203 Clause 2.6.1.1.1.4	At least 700,000 bytes when no messages are stored.
DmsMessageMultiString	NTCIP 1203 Clause 2.6.1.1.1.8.3	The DMS supports any valid MULTI string containing any subset of those MULTI tags listed in Table 4
DmsControlMode	NTCIP 1203 Clause 2.7.1.1.1.1	Support at least the following modes: local, central and central override

* Ensure the Permanent Messages display the content shown in Table 3.

Table 4: Required MULTI Tags

Code	Feature
f1	field 1 - time (12hr)
f2	field 2 - time (24hr)
f8	field 8 – day of month
f9	field 9 – month
f10	field 10 - 2 digit year
f11	field 11 - 4 digit year
fl (and /fl)	Flashing text on a line-by-line basis with flash rates controllable in 0.5-second increments.
fo	Font
jl2	Justification – line – left
jl3	Justification – line – center
jl4	Justification – line – right
jl5	Justification – line – full
jp2	Justification – page – top
jp3	Justification – page – middle
jp4	Justification – page – bottom
Mv	moving text
Nl	new line
Np	new page, up to 2 instances in a message (i.e., up to 3 pages/frames in a message counting first page)
Pt	Page times controllable in 0.5-second increments.

The NTCIP Component implements all mandatory and optional objects of the following optional conformance groups with FSORS.

e. Test Heading

Time Management

As defined in NTCIP 1201

Timebase Event Schedule

As defined in NTCIP 1201. The following list indicates the modified object requirements for this conformance group.

Table 5: Modified Object Ranges for the Timebase Event Schedule Conformance Group

Object	Reference	Project Requirement
MaxTimeBaseScheduleEntries	NTCIP 1201 Clause 2.4.3.1	At least 28
maxDayPlans	NTCIP 1201 Clause 2.4.4.1	At least 14
maxDayPlanEvents	NTCIP 1201 Clause 2.4.4.2	At least 10

Report

As defined in NTCIP 1103v02-10b. The following list indicates the modified object requirements for this conformance group.

Table 6: Modified Object Ranges for the Report Conformance Group

Object	Reference	Project Requirement
maxEventLogConfigs	NTCIP 1103 Clause A.7.4	At least 50
eventConfigurationMode	NTCIP 1103 Clause A.7.5.1.3	The NTCIP Component supports the following Event Configuration Modes: other, onChange, greaterThanValue, smallerThanValue, hysteresisbound, periodic and addedWithValue.
MaxEventLogSize	NTCIP 1103 Clause A.7.6	At least 200
MaxEventClasses	NTCIP 1103 Clause a.7.5.12	At least 255

Font Configuration

As defined in NTCIP 1203. The following list indicates the modified object requirements for this conformance group.

Table 7: Modified Object Ranges for the Font Configuration Conformance Group

Object	Reference	Project Requirement
NumFonts	NTCIP 1203 Clause 2.4.1.1.1.1	At least 4*
MaxFontCharacters	NTCIP 1203 Clause 2.4.1.1.1.3	At least 127**

*Upon delivery, the first font is a standard 18” font. The character set for the first three fonts are defined in NEMA TS-4 section 5.6.1. The second font is a double-stroke 18” font. The third font is a 28” font. The fourth font is empty.

DMS Configuration

As defined in NTCIP 1203.

MULTI Configuration

As defined in NTCIP 1203. The following list indicates the modified object requirements for this conformance group.

Table 8: Modified Object Ranges for the MULTI Configuration Conformance Group

Object	Reference	Project Requirement
DefaultBackgroundColor	NTCIP 1203 Clause 2.5.1.1.1.1	The DMS supports the following background colors: black
DefaultForegroundColor	NTCIP 1203 Clause 2.5.1.1.1.2	The DMS supports the following foreground colors: amber
DefaultJustificationLine	NTCIP 1203 Clause	The DMS supports the

Object	Reference	Project Requirement
	2.5.1.1.1.6	following forms of line justification: left, center, right and full
defaultJustificationPage	NTCIP 1203 Clause 2.5.1.1.1.7	The DMS supports the following forms of page justification: top, middle and bottom
defaultCharacterSet	NTCIP 1203 Clause 2.5.1.1.1.10	The DMS supports the following character sets: eightBit

Default Message Control:

As defined in NTCIP 1203.

MULTI Error Control:

As defined in NTCIP 1203.

Illumination/Brightness Control

As defined in NTCIP 1203. The following list indicates the modified object requirements for this conformance group.

Table 9: Modified Object Ranges for the Illumination/Brightness Control Conformance Group

Object	Reference	Project Requirement
dmsIllumControl	NTCIP 1203 Clause 2.8.1.1.1.1	The DMS supports the following illumination control modes: photocell, timer and manual
dmsIllumNumBrightLevels	NTCIP 1203 Clause 2.8.1.1.1.4	At least 16

Scheduling

- As defined in NTCIP 1203. The following list indicates the modified object requirements for this conformance group.

Table 10: Modified Object Ranges for the Scheduling Conformance Group

Object	Reference	Project Requirement
NumActionTableEntries	NTCIP 1203 Clause 2.9.1.1.1.1	At least 21

Sign Status

As defined in NTCIP 1203.

Status Error

As defined in NTCIP 1203.

Pixel Error Status

As defined in NTCIP 1203.

Climate Control Status

As defined in NTCIP 1203.

Power Status

As defined in NTCIP 1203.

Temperature Status

As defined in NTCIP 1203. Install necessary hardware for the support of items above.

Table 11: Optional Object Requirements

Object	Reference	Project Requirement
DmsMultiOtherErrorDescription	NTCIP 1203 Clause 2.7.1.1.1.20	If the vendor implements any vendor-specific MULTI tags, the DMS shall provide meaningful error messages within this object whenever one of these tags generates an error.

(S) Ethernet Radio

Provide an 802.11 Ethernet radio system with a bi-directional, full duplex communications channel between two or more "line-of-sight" antennas using license-free, spread spectrum technology. Install radios that are fully compatible with the Ethernet switches to be used on the project.

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.

Furnish license free Ethernet radio transceivers with antennas, coaxial cable, and mounting hardware, and configuration software. Design radio transceivers to work in "point-to-point", "store and forward repeater", "point-to-multipoint" and "peer to peer" configurations. Provide radios that can operate as repeaters. Ensure the Ethernet radio transceivers meet the following minimum requirements:

- 10/100 Base T, IEEE 802.11 Ethernet
- License free (ISM) spread spectrum radio band (900 MHz or 2.4 GHz),
- Frequency hopping spread spectrum technology
- Programmable radio frequency (RF) output levels of 100mW to 1 Watt,
- Minimum 50 hopping channels per automatically generated pattern
- Ethernet interface capable of operating at 1.1 Mbps with a data rate of 345 Kbps,
- DB9-F connector for RS-232/422/485 serial port,
- 32 bit Cyclic Redundancy Check (CRC) error checking with auto re-transmit,
- Data encryption 128 bit WEP, 128 bit WPA, 256 Bit AES,
- Range with clear LOS: 60 miles

- Network Protocols: TCP, UDP, ARP, IMCP, DCHP, HTTP, SNMP, FTP
- System gain: 156 dB with Yagi antenna
- Front panel LED indicators: Power, Transmit, Receive, Data Port and Signal Strength.
- Operating temperature of –30 to +165 degrees F at 5 to 95% Humidity
- Power supply: 9 VDC to 30 VDC
- Typical current draw of no greater than 600 mA when powered with 12 VDC input
- Shelf mounted design not to exceed 5" long x 2" wide x 7" high.

Furnish a radio frequency signal jumper and Ethernet data interface cable in accordance with Section 10.2 of the "Project Special Provisions for Signals and Intelligent Transportation Systems".

Furnish units with a Windows® XP compatible software program that uses a GUI (Graphical User Interface) to provide "remote programming, radio configuration, remote maintenance, diagnostics and spectrum analyzer" features. Provide software approved by the Engineer that is designed to function with the approved radio. Provide configuration software that can be upgraded in the future at no additional charge.

Ensure the radio transceiver is configurable from a single location (i.e. master radio location) via supplied software (no extra cost). Ensure the supplied software contains pre-written drivers for industry standard dynamic message signs.

Ensure that the following materials are in accordance with Section 10.2 of the "Project Special Provisions for Signals and Intelligent Transportation Systems".

- Coaxial Cable
- Directional Antenna (Yagi)
- Signal Splitter
- Standard N-Type Male Connector
- Coaxial Cable Shield Grounding and Weatherproofing Kits
- Surge Protector
- Lightning Arrestor

12.3 CONSTRUCTION METHODS

(A) Description

This article establishes practices and procedures and gives minimum standards and requirements for the installation of Dynamic Message Sign systems, auxiliary equipment, and the construction of related structures.

Provide electrical equipment described in this Scope of Work that conforms to the standards of NEMA, UL, or Electronic Industries Association (EIA), wherever applicable. Provide connections between controllers and electric utilities that conform to NEC standards. Express wire sizes according to the American Wire Gauge (AWG).

Provide stainless steel screws, nuts, and locking washers in all external locations. Do not use self-tapping screws unless specifically approved by the Engineer. Use parts made of corrosion resistant materials, such as plastic, stainless steel, brass, or aluminum. Use construction materials that resist fungus growth and moisture deterioration. Separate dissimilar metals by an inert dielectric material.

(B) Layout

The Design-Build Team shall be responsible for the proper elevation, offset, level, and orientation of all DMS assemblies on the structures provided by others. Make actual field measurements to place conduit and equipment at the required location. Mark the proposed location of circuits and all other components for the Engineer's approval prior to installation. Submit a drawing showing all underground conduits and cables dimensioned from fixed objects or station marks.

(C) Structural Requirements

(1) General

Provide stainless steel screws, nuts, and locking washers in all external locations. Do not use self-tapping screws unless specifically approved by the Engineer. Use parts made of corrosion resistant materials, such as plastic, stainless steel, brass, or aluminum. Use construction materials that resist fungus growth and moisture deterioration. Separate dissimilar metals by an inert dielectric material.

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

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

Use two coats of a zinc rich paint to touch up minor scars on all galvanized materials.

(2) Access Platform for Walk-in DMS

Provide an access platform, a minimum of three feet wide, as measured parallel with the edge of the roadway, with open skid resistant surface and safety railing, on the DMS assembly for access to the DMS inspection door. Provide platforms with fixed safety railings along both sides from the beginning of the platform to the inspection door. The access platform shall attach only to the structure.

Connect the platform sections rigidly where sections join to avoid an uneven walking surface.

Install a 4”x 4” safety angle parallel to and along both sides of the platform and extend it the entire length of the platform. Design the safety angle to withstand loading equivalent to the platform.

(3) Direct Tension Indicators

Use direct tension indicators on all ASTM A325 high strength bolt connections in mainline toll gantry, overhead sign structures, and cantilever sign structures.

Provide direct tension indicators that conform to this Scope of Work, the requirements of ASTM F959 and the manufacturer's recommendations.

Install the direct tension indicators in strict compliance with the manufacturer's written instructions.

Install the direct tension indicator under the bolt head normally. If it is necessary to install the direct tension indicator under the nut, or if the bolt head must be turned, install additional hardened washers in accordance with the manufacturer's instructions.

Have a tension-indicating device on the project for determining the tension imposed on a fastener when the protrusions on direct tension indicator have been properly compressed.

Test three samples from each lot of direct tension indicators in the presence of the Engineer. Achieve a minimum bolt tension 5 percent greater than that required by Table 440-1 in Article 440-10 of the *Standard Specifications*. Do not substitute direct tension indicators for the hardened steel washers required with short slotted or oversized holes, but you may use them in conjunction with them.

Initially install the direct tension indicators to a snug tight condition as specified in Section 440-10 Paragraph (C) (3) of the *Standard Specifications*. After the initial tightening, fully tighten the fasteners, as recommended by the manufacturer of the direct tension indicators, beginning at the most rigid part of the joint and continuing toward its free edges.

Use a wrench to tighten fasteners containing direct tension indicators of the type and capacity recommended by the manufacturer and which is clean and lubricated. Use an air supply and hoses that are in good condition and provide air pressure of at least 100 psi at the wrench.

Perform any heating of structural steel required for corrections near fasteners before direct tension indicators are installed.

(4) Inspection

The Engineer will inspect for correct tightening of bolts by inserting a 0.005-inch thickness feeler gauge into the openings between adjacent flattened protrusions of the direct tension indicator. The tension is correct when the number of spaces the gage cannot enter is equal to or greater than the value shown in the table below.

Number of Spaces in Washer	Number of Spaces Gage is Refused
4	2
5	3
6	3
7	4

The gage must not be able to enter any spaces when the direct tension indicator is used under the turned element.

Do not tighten bolts to a no visible gap condition. Replace bolts that have a direct tension indicator with no visible gap and tighten the bolts with a direct tension indicator.

The Engineer will inspect at least 10 percent, but no less than 2, of the bolts in each connection, using the metal feeler gages provided by the Design-Build Team.

Ensure that the part of the fastener being restrained from turning does not rotate during the tightening process, thereby abrading away a portion of the direct tension indicator protrusions.

Ensure that none of the direct tension indicator protrusions is accidentally partially flattened before installing in the structural steel joints.

Do not reuse direct tension indicators. If it becomes necessary to loosen a bolt previously tensioned, discard and replace the direct tension indicator.

(5) Equipment and Cabinet Mounting

Mount equipment securely at the locations shown in the ITS Concept Plans, in conformance with the dimensions shown, and plumb and level. Install fasteners as recommended by the manufacturer and space them evenly. Use all mounting holes and attachment points for attaching DMS enclosures (and controller cabinets, if required) to structures.

Drill holes for expansion anchors of the size recommended by the manufacturer of the anchors and thoroughly clean them of all debris.

Seal all unused conduit installed in cabinets at both ends to prevent water and dirt from entering the conduit and cabinet with approved sealing material.

Install a ground bushing attached inside the DMS cabinet on all metal conduits entering the DMS cabinet. Connect these ground bushings to the cabinet ground bus.

(D) Electrical Requirements

Provide electrical equipment described herein that conforms to the standards of NEMA, UL, or Electronic Industries Association (EIA), wherever applicable. Provide connections between controllers and electric utilities that conform to NEC standards. Express wire sizes according to the American Wire Gauge (AWG).

(1) Conduit

Install the conduit system in accordance with Section 1715 of *Standard Specifications* and NEC requirements for an approved watertight raceway. Mount the conduit on the horizontal truss in such a manner to be hidden from approaching traffic

Make bends in the conduit so as not to damage it or change its internal diameter. Install watertight and continuous conduit with as few couplings as standard lengths permit.

Clean conduit before, during, and after installation. Install conduit in such a manner that temperature changes will not cause elongation or contraction that might damage the system.

Attach the conduit system to and install along the structural components of the DMS structure assembly with beam clamps or stainless steel strapping. Install strapping according to the strapping manufacturer's recommendations. Do not use welding or drilling to fasten conduit to structural components. Space the fasteners at no more than four feet for conduit 1.5 inches and larger, or 6 feet for conduit 1.25 inches and smaller. Place fasteners no more than 3 feet from the center of bends, fittings, boxes, switches, and devices.

Locate underground conduit as shown in the Plans in a manner consistent with these Scope of Work.

Do not exceed the appropriate fill ratio on all cable installed in conduit as specified in the NEC.

(2) Wiring Methods

Do not pull permanent wire through a conduit system until the system is complete and has been cleaned.

Color-code all conductors per the NEC (grounded neutral-WHITE, grounding-BARE or GREEN, and phase conductors RED and BLACK). Use approved marking tape, paint, sleeves or continuous colored conductors for No.8 AWG and larger. Do not mark a white conductor in a cable assembly any other color. You may strip white, red, or black conductor at all accessible points and use it as a bare equipment-grounding conductor.

Bury underground circuits at the depth shown in the plans and surround with at least 3 inches of sand or earth back-fill free of rocks and debris. Compact backfill in 6-inch layers. Do not splice underground circuits unless specifically noted in the plans.

(3) Cabinet and System Grounding

Ground the DMS enclosure and DMS structure per Sections 1098 and 1700 of the *Standard Specifications*, applicable addenda, typical drawings found in Appendix A, the ITS Concept Plans and this Scope of Work. Provide grounding circuits that are permanent and electrically continuous with a current carrying capacity high enough and an impedance low enough to limit the potential above ground to a safe level.

Make connections between ground electrodes and the ground wire using an exothermic welding process, cadweld or equivalent.

Ensure completed cabinet grounds have a resistance to ground of not more than 20 Ohms.

(E) Work Site Clean-Up

Clean the site of all debris, excess excavation, waste packing material, wire, etc. Clean and clear the work site at the end of each workday. Do not throw waste material in storm drains or sewers.

(F) Limits of Manufacturer's Proprietary Information

NCTA's electronics technicians will use the above documentation (schematics, drawings, software, firmware, manuals, etc.) exclusively for the following purposes: diagnosing and performing repairs on malfunctioning equipment, equipment circuit boards, and malfunctioning systems; operational test of repaired equipment, circuit boards, systems; and performing authorized upgrades to equipment, circuit boards, and software supplied under this contract. NCTA electronics technicians will not use or copy devices or software for any purpose other than diagnosis, repair, and testing or to perform authorized firmware or software upgrades.

Upon notification by the manufacturer, the Authority agrees not to divulge any proprietary or otherwise confidential information contained in the above-required documentation. NCTA agrees to protect and secure any proprietary documentation identified by the manufacturer as proprietary or confidential. Upon request by the manufacturer, NCTA agrees to sign a binding non-disclosure agreement with the manufacturer or other business that is providing documentation it considers proprietary or otherwise confidential.

(G) Testing and Integration

Integrate the DMS signs as described in this Scope of Work. Conduct testing upon completion of all work as described in the Testing and Acceptance Section of this Scope of Work.

(H) Ethernet Radio

Perform and/or construct the following items in accordance with Section 10.3 of the "Project Special Provisions for Signals and Intelligent Transportation Systems": Site Survey, Antenna, Cabling, Cabinet and Electrical Power Wiring.

The radios may be installed only on NCTA or NCDOT poles or structures. Do not use joint use poles.

13. ROAD WEATHER INFORMATION SYSTEM

13.1 GENERAL

Furnish and install a road weather information system (RWIS) for detection of certain weather and visibility conditions that would adversely affect traffic. The RWIS shall be capable of measuring wind speed and direction, temperature and humidity, precipitation presence, atmospheric pressure, and the presence of water, ice, slush, snow, and frost on road surfaces. The final location is the responsibility of the Design-Build Team. A specific location has not been identified. Use the FHWA "Road Weather Information System Environmental Sensor Station Siting Guidelines", dated April 2005 for positioning of the RWIS site. The location of the RWIS shall not encroach in the clear zone. The RWIS shall be sited so the tower or pole can be lowered without requiring a lane or shoulder closure. Locate the RWIS to minimize vandalism.

The RWIS station to be located on the west end of project shall be a full station with all equipment described herein.

The system shall use Ethernet communications for monitoring and control from the STOC and monitoring only from the NCTA Executive Offices.

13.2 MATERIALS

(A) General

Provide an RWIS consisting of an environmental sensor station (ESS) installed as shown in the ITS Concept Plans and as directed by the Engineer. Provide an ESS that includes environmental sensors mounted on an aluminum tripod tower and a remote processing unit (RPU) at the tower's base, if required for that location. Ensure that the RPU can collect, store, and process sensor data to describe current weather conditions.

Provide any ancillary equipment or incidental items required, including mounting hardware, power supplies, grounding, surge suppression devices, and communication equipment, at the ESS location to make a complete and fully operational RWIS. Ensure that the system provides real-time, accurate, reliable data on all system parameters to the degree of precision defined in this Scope of Work.

(B) Sensors

Provide an ESS that can collect, store, and transmit data from the following sensors:

- A sonic anemometer to measure wind speed and direction,
- A thermoresistor to measure temperature,
- An integrated circuit to measure humidity,
- A capacitance sensor to measure presence of precipitation,
- A pressure transducer (silicon chip) to measure atmospheric pressure, and
- Non-intrusive laser spectroscopy sensors to detect the presence of water, ice, slush, snow, or frost on road surface.

(C) Sensor Performance

Each environmental sensor and its associated transducers shall record the following attributes to the listed degree of accuracy:

Roadway Data		
Surface Temperature	±0.36 degrees F between -40 degrees and 150 degrees F	
Precipitation	Type: Dry, wet, ice, slush, snow and frost	
Atmospheric Data		
Temperature	±1 degrees F between -40 degrees and 176 degrees F; resolution of 0.1 degree	
Relative Humidity at 70° F	±5% between 10 and 100%	
Barometric Pressure	Accurate to ±0.02 inch of mercury (in. Hg) between 26 and 32 in. Hg; resolution of 0.005 inches Hg	
Precipitation	Presence	
Wind	Direction:	±3 degrees between 0 and 360 degrees
	Speed:	±1 mph between 0 and 100 mph, with gusts up to 180 mph

(D) RPU

Furnish an RPU that supports a minimum of eight pavement sensors. Use an RPU that supports EIA 232/485 serial protocols, as well as TCP/IP output. Ensure that the RPU is programmable and based on an open architecture.

Provide a unit having a minimum of ten EIA-232 serial ports. Ensure that the RPU has a maximum serial data transmission rate of 128 kbps. Ensure that the unit's mean time between failures (MTBF) is 15,000 hours or 625 days.

Ensure that the RPU issues and communicates an alarm whenever a user-defined threshold is exceeded. Ensure that the RPU is also capable of producing an output through contact closure or a digital output that imitates a contact closure.

At minimum, the RPU shall be able to store internally the last 24-hour readings over a user defined time interval of up to 5 minutes.

Ensure that the RPU operates using a nominal input voltage at the cabinet of 110 to 120 V_{AC}. The RPU must be capable of operating on 12 V_{DC} of solar battery power. The RPU shall issue an alarm to the TMC if the AC power supply is lower than acceptable operating conditions or if there has been a complete power loss. Ensure that the system sends a message when the unit returns to normal conditions.

All components within the RPU shall operate throughout an ambient operating temperature range of -40 degrees to 160 degrees F, with a maximum relative non-condensing humidity of 90%.

(E) Communications

Use an RPU capable of transmitting all collected data to the TMC using the National Transportation Communications for ITS Protocol (NTCIP) over Ethernet communications over single-mode fiber-optic cable that transfers data at a minimum rate of 10 megabits per second (Mbps).

(F) Configuration and Management

Ensure that the RWIS software application provides PC desktop display of the RWIS location on a map of the Monroe Connector/Bypass. Ensure that the RWIS software enables the system operator to derive environmental measurements, such as the dew point, wind chill, and heat index, from sensor data received. Ensure that the RWIS software can be used to report minimums, maximums, averages, cumulative values, and standard deviations for all data over a prescribed period.

Ensure that the RWIS software provides English-to-metric unit conversions, when applicable, and lets the operator choose which unit of measure to report if more than one unit is common for a particular measurement.

When the software supplied with the RWIS is installed on a laptop computer or a remote workstation, ensure that the operator is able to access, either remotely through the workstation or at the site with the laptop computer, all user-defined parameters, and stored data within the RPU, including the ability to view, download, and delete stored data.

Ensure that the laptop computer and the RWIS can communicate when connected directly by a cable connected to the laptop's USB port. Ensure that the laptop computer and RWIS can communicate across the ITS system's communication network using the NTCIP standards described in this Scope of Work.

(G) Electrical Requirements

Provide RWIS equipment and components installed at the ESS that operate at 110 to 120 V_{AC} from a commercial utility company. Equip the ESS installation with provisions for emergency backup power in the event of primary power loss. Ensure that backup power is capable of continuing ESS operations for a minimum of 12 hours.

(H) Foundation and Tower Requirements

Provide a supporting tower or pole that provides a mounting platform for atmospheric sensors free of influences from topography, buildings, and vehicles. Ensure that the tower also supports any lightning protection devices (e.g., grounding rods) for the site. Mount the atmospheric sensors on a hinged, 33-foot tower. Use a tower having a hinge approximately 10 feet above ground for access to the atmospheric sensors.

Provide a support structure that is self-supporting without guy wires, using a 50-year design life, and in accordance with the 4th Edition 2001 AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, including all of the latest interim revisions (25-year reoccurrence). Ensure that the structure is made of 6061-T6 corrosion-resistant aluminum or an equivalent. Ensure that all hardware and fasteners are stainless steel.

Provide a fence to enclose the ESS.

13.3 CONSTRUCTION METHODS

(A) General

Install, configure and demonstrate the fully functional RWIS installation as shown in the ITS Concept Plans. Connect all field hardware to the communication network, and provide all materials specified in the Contract Documents. Install all equipment according to the manufacturer's recommendations or as directed by the Engineer.

Ensure that all equipment and materials furnished, assembled, fabricated, or installed are commercial off-the-shelf products.

Unless detailed otherwise in the ITS Concept Plans, mount all atmospheric sensors except anemometers at cabinet-top height, approximately 10 feet above grade. Mount anemometers at the top of the tower. If local restrictions prevent installing the anemometers at the top, install them no less than 20 feet above the ground.

Construct the enclosure fence as shown in the ITS Concept Plans. Locate the gate so the tower assembly can be lowered to the ground without hitting the fence.

Install all wiring so that it is either internal to a pole, in conduit attached to truss members, or contained in underground conduit.

14. ETHERNET COMMUNICATIONS CABLE

14.1 DESCRIPTION

Furnish and install copper Ethernet cable for interconnecting various hardware in an Ethernet network located in ITS device cabinets, ORT buildings.

14.2 MATERIAL

(A) Ethernet Cable

Provide Category 6 Ethernet cable, complying with ANSI/TIA-568-B.2-1 standards for four-pair unshielded twisted copper. Size the wire gauge for the installation. The cable shall meet all of the mechanical requirements of ANSI/ICEA S-80-576 applicable to four-pair inside wiring cable for plenum or general cabling within a building.

(B) Connectors

Provide RJ-45 connectors with gold wire conductors terminated according EIA/TIA-568-A/568-B standards. Provide factory terminations to the fullest extent possible. Provide connectors with eight contacts. Furnish connectors appropriately rated for the cable being installed.

(C) Ethernet Patch Cords

Furnish Fast Ethernet patch cords meeting the following physical requirements:

- Minimum of five (5)-foot length,
- Category 6,
- RJ-45 connectors on both ends,
- Molded anti-snag hoods over connectors, and
- Gold plated connectors.

Patch cords in the STOC shall be of sufficient length to make connection when installed in cable management hardware without straining the cable or connectors.

Furnish Ethernet patch cords meeting TIA/EIA-568-B.2-1, Additional Transmission Performance Specifications for 4-pair 100 Ω Enhanced Category 6 Cabling.

14.3 CONSTRUCTION METHODS

(A) General

Install Category 6 Ethernet cable for all network cabling in the ORT buildings. Install Category 6 Ethernet patch cords in the ORT buildings.

Provide the Engineer through Constructware with the Ethernet cable manufacturer's recommended and maximum pulling tension for each Ethernet cable size before the installation of Ethernet cable.

Furnish all tools, equipment, materials, supplies, and hardware necessary to install a fully operational Ethernet cable system. Install the Ethernet cable according to the latest version of the manufacturer's cable installation procedures and the industry accepted installation standards, codes, and practices, or as directed by the Engineer.

Take all precautions necessary to ensure the Ethernet cable is not damaged during storage and installation. Do not step on the cable nor run over the cable with equipment. Do not pull the cable over or around obstructions.

Install Ethernet cable in continuous lengths. Cut cables to length to minimize coils of spare cable. Cut outer jacket and trim conductors per manufacturer's recommendations. Ensure all conductors extend to the end of the channel and make solid electrical contact with the gold connectors. Crimp the RJ-45 connector body to lock conductors in channels.

(B) Building Installation

Do not exceed 80 percent of the manufacturer's maximum pulling tension when installing underground Ethernet cable.

Provide bushings and cable guides to protect the cable. Manually feed the cable by rotating the reel.

15. COMMUNICATIONS RACK

15.1 DESCRIPTION

Furnish and install one open, non-lockable, 19-inch communications with no side panels in each ORT buildings. Install the racks in locations as directed by the Engineer. Provide enough rack space to house the equipment designated for each location plus 50% spare space.

15.2 MATERIALS

Provide all communications rack meeting these minimum performance requirements:

- All equipment shall comply with ANSI/EIA RS-310D,
- Provide frame and external components with zinc coating per ASTM B633,
- Paint interior and exterior components per RAL 7035,
- Provide UL 508 and NEMA Type 12 certifications, and

Provide all communications racks meeting the following minimum material requirements:

- 19-inch EIA single-bay
- Nominal height of 78 inches less base
- Nominal 4-inch high ventilated base
- Depth: 31 inches
- House 44 units of rack space
- All-metal components

Vented top with three integral prewired fans, and fans that provide up to 300 cubic feet per minute (cfm) of exhaust.

Mechanical: Construct all rack frames from 12-gauge, cold-formed steel. Construct the vented base from 16-gauge steel. Construct the 19-inch electrical rack angles from 12-gauge steel.

Furnish and install one metal shelf kit per each rack. Provide each shelf the full width and depth of the rack angles and attach directly to the rack angles. Furnish and install one metal keyboard slide out drawer per each rack.

15.3 CONSTRUCTION METHODS

Finish: Furnish factory-applied paint on the exterior of all components with a color that matches that of the respective room they are located. Submit color samples to the Authority for review and approval.

Electrical: Furnish and install an outlet strip and 10-foot power cord along one rear vertical rack frame. Furnish and install strips that use 120 VAC 60 Hz power and shall contain at least 10 outlets over the 70 inches. Furnish and install grounding bus bar system for the ground rack mounted electrical equipment. Equip door with grounding studs.

Furnish and install cable management hardware for attachment vertically along the rack frame and horizontally between 19-inch rack angles. Cable management hardware shall run vertically up one rear rack frame and shall include six horizontal runs per rack. Provide hardware including cable organizers and clamps to provide strain relief and cable mounting.

Keyboard Shelf: Install keyboard shelf at a height comfortable for operator use when sitting on a stool. Provide tamper-resistant but removable screws through hinges and exterior panels. Furnish any special tools required to remove tamper resistant screws.

Ground the racks to a building ground.

16. COMMUNICATIONS HARDWARE

16.1 DESCRIPTION

(A) General

All communications between ITS devices and the local hub shall use Ethernet communications. The communications network along the corridor shall consist of local Ethernet edge switches at devices, and Gigabit Ethernet routing switches as shown in the Plans. The field Gigabit Ethernet routing switches will act as data aggregation and data distribution nodes for Ethernet edge switches located at all ITS device sites. Gigabit Ethernet routing switches located in the ORT mainline buildings at each end of the corridor will communicate with the CSC and then to the STOC via two leased circuits (provided by the Toll System Integrator) operating from each end of the corridor. See Sheet 1 of 26 of the ITS Concept Plans for further details.

Provide a minimum of a Fast Ethernet (100 Mbps) optical communications network between all proposed ITS field devices and Gigabit Ethernet routing switches located in the Open Road Tolling (ORT) buildings located at the toll plazas.

Provide an optical Gigabit Ethernet (minimum of 1 Gbps) communications network between the Gigabit Ethernet routing switches using proposed single-mode fiber-optic cable along the project corridor.

Between the project corridor and the CSC and STOC provide the capability of an optical Gigabit Ethernet (minimum of 1 Gbps) communications network, using media by others.

(B) Gigabit Ethernet Routing Switches

Furnish and install a Layer 3 Gigabit Ethernet routing switch in at least three of the mainline ORT Buildings. The Design-Build Team shall determine the layout of the network and choose which ORT buildings will house the routing switches.

Ensure that the routing switches provide Gigabit Ethernet connectivity at minimum transmission rates of 1 Gbps between the Gigabit Ethernet routing switches.

(C) Ethernet Edge Switches

Furnish and install a hardened, device-level managed field Ethernet edge switch in each ITS field cabinet location. Ensure that the Ethernet edge switches provide fast Ethernet connectivity at minimum transmission rate of 100 Mbps from each ITS cabinet location to its respective Gigabit Ethernet routing switch.

(D) Network Management Software

For the communications network, utilize the existing network management software (NMS) for configuration, troubleshooting, security, and system monitoring. The Design-Build Team shall perform the initial system integration of all Gigabit Ethernet routing, and Ethernet edge switches installed on the project.

16.2 MATERIAL

(A) General

Ensure that the Ethernet switches are fully compatible and interoperable with the trunk Ethernet network interface and that the Ethernet switches support half and full duplex Ethernet communications.

Furnish Ethernet switches that provide 99.999% error-free operation and that comply with the Electronic Industries Alliance (EIA) Ethernet data communication requirements using single-mode fiber-optic transmission medium and copper transmission medium. Ensure that the Ethernet switches have a minimum mean time between failures (MTBF) of 10 years, or 87,600 hours, as calculated using the Bellcore/Telcordia SR-332 standard for reliability prediction.

(B) Gigabit Ethernet Routing Switches

To ensure maximum interoperability within the Gigabit network, provide Gigabit Ethernet routing switches from the same manufacturer. Ensure compatibility with existing core switch make and model in STOC. Provide one of the following make/models of switch, or approved equal:

Cisco Catalyst 4506-E, Brocade (Foundry) FastIron SuperX, Juniper EX8208, Extreme Networks Black Diamond 8806.

The Gigabit Ethernet Network, which includes all Gigabit Ethernet Routing Switches, shall be a routed network. The Contractor shall configure each Layer 3 routing switch with industry standard, non-proprietary routing protocols identified in the Contractor-provided network documentation as outlined in Section 16.3A. The protocols to be configured by the Contractor shall include at a minimum:

- OSPF (Open Shortest Path First)
- PIM-SM / PIM-DM (Protocol Independent Multicast – Sparse Mode / Dense Mode)

- VRRP (Virtual Router Redundancy Protocol)

The Contractor shall submit all configurations to the Engineer for review and approval prior to implementation

(C) Ethernet Edge Switches

Provide one of the following make/models of switch or approved equal:

RuggedCom RS900, GarrettCom Magnum 6KL or 6K8, Etherwan EX71000, EX72000, or EX73000, Cisco Catalyst 2955S-12, and ITS Express 8040.

The Contractor shall configure each Layer 2 edge switch with industry standard, non-proprietary protocols identified in the Contractor-provided network documentation as outlined in Section 16.3A. The protocols to be configured by the Contractor shall include at a minimum:

- RSTP (Rapid Spanning Tree Protocol)
- SNMPv3 (Simple Network Management Protocol version 3)
- IGMP Snooping (Internet Group Management Protocol)
- SNTP (Simple Network Time Protocol)

16.3 CONSTRUCTION METHODS

(A) General

Ensure that all Ethernet switches are UL listed.

Verify that network/field/data patch cords meet all ANSI/EIA/TIA requirements for Category 6 4-pair unshielded twisted pair cabling with stranded conductors and RJ45 connectors.

Ensure that all project IP addresses are assigned. Ensure as-built plans include the identification of all IP addresses and VLANs, and associated hardware devices and device locations. Configure the Ethernet network so the CCTV cameras are in separate VLAN(s) from other devices. Configure the Ethernet network so the DMS signs are in a separate VLAN from other devices.

After consulting with vendors of communication hardware, submit the following for review and approval by the Engineer:

- Drawings and supporting documentation of the physical network topology as established and installed including physical connectivity at the device and port level
- Drawings and supporting documentation for a coherent and complete overall logical layers 2-3 network architecture and detailed design to include the following:
  - VLAN
  - EAPS/STP domains
  - EAPS/STP mode
  - EAPS/STP ports
  - IP addressing/subnets
  - IP routing/trunking
  - Routing and routed protocols
  - Multicast addressing
- Drawings and supporting documentation identifying SNMP and RMON strategy and configurations including, probe information as applicable, management IP addressing, community strings, MIBS, traps, and respective active/passive alert thresholds.

(B) Gigabit Ethernet Routing Switches

Install Gigabit Ethernet routing switches that provide data aggregation and data distribution to and from Ethernet edge switches located at each ITS device cabinet. Ensure that the Gigabit Ethernet routing switches communicate with one another at Gigabit Ethernet data transmission rates (1000 Mbps).

Ensure that the network administrator will be able to remotely manage each Gigabit Ethernet routing switch for switch configuration, performance monitoring, and troubleshooting. Locate the Gigabit Ethernet routing switches in the ORT Buildings, as shown in the ITS Concept Plans and provide full Layer 3 functionality.

Install and configure the Gigabit Ethernet routing switches to be fully compatible with the Ethernet edge switches as defined in this Scope of Work.

Ensure all fiber connections of the Gigabit Ethernet routing switches are connected to two pairs of single-mode fiber strands of the ITS cable plant via fiber-optic interconnect center for redundant communications.

Connect the Gigabit ports with other Gigabit Ethernet routing switches as described in the ITS Concept Plans.

(C) Ethernet Edge Switches

Ensure that the ITS network administrator will be able to manage each Ethernet edge switch individually or as a group/cluster for switch configuration, performance monitoring, and troubleshooting. Note that these requirements stipulate additional minimum management intelligence (i.e., Layer 2+) typical of most current industrial Ethernet deployments. Ensure that the Ethernet edge switches include Layer 2+ capability providing architecture standardization, open connectivity (i.e., interoperability), bandwidth management, rate limiting, security filtering, and general integration management of an advanced Ethernet switching architecture.

Ensure that all project IP addresses and VLAN IDs are assigned. Ensure as-built plans include the identification of all IP addresses, VLANs, and associated hardware devices and device locations.

Mount the Ethernet edge switches securely inside each ITS device cabinet in the communications rack or on a vertical rail. Ensure that the Ethernet edge switches are resistant to all electromagnetic interference (EMI). Ensure that the Ethernet edge switches are is fully accessible by field technicians without blocking access to other equipment. Verify that fiber-optic jumpers consist of a length of cable that is connectorized on both ends, primarily used for interconnecting termination or patching facilities and/or equipment. Use fiber-optic jumpers that are factory assembled and connectorized and are certified by the fiber-optic jumpers' manufacturer to meet the relevant performance standards required below. Verify that network/field/data jumper cables meet all ANSI/EIA/TIA requirements for Category 6 4-pair unshielded twisted pair cabling with stranded conductors and RJ45 connectors.

17. CENTRAL VIDEO EQUIPMENT

17.1 DESCRIPTION

Furnish and install modifications to the existing STOC analog video matrix switch to facilitate video sharing between the project corridor and NCTA and NCDOT as described in this Scope of Work.

17.2 MATERIALS

Furnish and install digital video encoder and decoder hardware to create a video-over-IP network system. Furnish digital video encoder and decoder components that utilize the Moving Picture Experts Group's MPEG-4 Part 10 video compression technology as described in this Scope of Work.

(A) Digital Video Encoders and Decoders

Provide Moving Picture Experts Group's MPEG-4 Part 10 digital video encoders and decoders in accordance with the International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) requirements detailed in the ISO/IEC 14496-14 standard for video sharing between the NCTA Executive Offices and the STOC. Ensure that the digital video encoders and decoders are capable of unicast and multicast operation, and that they support the Session Announcement Protocol (SAP) as recommended by the Internet Engineering Task Force (IETF) RFC 2974, and Differentiated Services/Quality of Service (DiffServ/QoS) software components.

Provide the Internet Engineering Task Force (IETF) Session Description Protocol (SDP) in RFC 4566 and Real Time Streaming Protocol (RTSP) in RFC 2326. Ensure that the DVE provides 99.999% error-free operation.

(1) Digital Video Encoder

Provide digital video encoders that are hardware-based network devices able to accept a minimum of one analog National Television System Committee (NTSC) video input and digitize it for transport across IP networks. Use digital video encoders that provides a minimum of two serial data interfaces for transmission of command and control data to other devices (typically camera PTZ commands), as well as console and configuration functions.

(2) Digital Video Decoder

Provide digital video decoders that are hardware-based network devices able to accept a minimum of one digital video output from an IP network and convert it to an analog National Television System Committee (NTSC) video signal. Use digital video decoders that provide a minimum of two serial data interfaces for transmission of command and control data to other devices (typically camera PTZ commands), as well as console and configuration functions. Provide hardware-based decoders that have a minimum of one analog NTSC video output and decode digital video and data streams present on an IP network into analog formats for interconnection with other devices.

(3) Interoperability

Within each type of video compression technology, provide digital video encoders and decoders that are interoperable and interchangeable with similar devices and from other manufacturers. Ensure that the digital video encoder is compatible and fully interoperable with software and hardware digital video decoders from the digital video encoder manufacturer, as well as a minimum of two hardware digital video decoders from other manufacturers. Ensure that the digital video decoder is compatible and fully interoperable with digital video encoders from the digital video decoder manufacturer, as well as a minimum of two other digital video encoders from other manufacturers.

(4) Video Requirements

Ensure that any video input utilizes a BNC connector and delivers one-volt peak-to-peak (Vp-p) NTSC composite video signals for encoding. Ensure that the digital video encoder and digital video decoder operate with both color and monochrome video, and that they allow the user to select and adjust video resolution. Ensure that the digital video encoder and digital video decoder support resolutions that include, but are not limited to those in table below. Ensure that the MPEG 4 Part 10 digital video encoder and digital video decoder are capable of delivering color and monochrome video at 30 fps regardless of resolution, and that they can do so using variable, programmable bit rates from 128 Kbps to 12 Mbps. Ensure that the MPEG 4 digital video encoder and digital video decoder are capable of delivering color and monochrome video at 30 fps regardless of resolution, and that they can do so using variable, programmable bit rates from 32 Kbps to 8 Mbps. Ensure that the digital video encoders provides fixed and variable bit rate modes.

Resolution Specifications

Compression Technology	Resolution	NTSC Requirements
MPEG 4	QCIF	176 horizontal x 120 vertical
MPEG 4	CIF	352 horizontal x 240 vertical
MPEG 4	2CIF	704 horizontal x 288 vertical

Note: The resolutions attained depend on the data transmission rate.

(5) Electrical Requirements

Ensure that all wiring meets NEC requirements and standards. Provide equipment that operates on a nominal voltage of 120 volts alternating current (V_{AC}). The equipment shall operate within a voltage range of 89 V_{AC} to 135 V_{AC}. The operating frequency range for power shall be 60 Hz. ±3 Hz. If the device requires operating voltages of less than 120 V_{AC}, supply the appropriate voltage converter.

(6) Serial Interface

Use hardware-based digital video encoders and decoders having a minimum of two serial data interfaces and connectors that conform to EIA-232/422/485 standards. Ensure that the serial interfaces support EIA-232 as well as 2-wire and 4-wire EIA-422/485 connections. Ensure that the serial port(s) support data rates up to 115.2 Kbps. Serial interface parameters, such as data format, number of bits, handshaking, and parity, shall be software programmable through local connection to the digital video encoders and decoders and through connections over the network. Serial interface ports may utilize registered jack (RJ-45) connectors, D-sub connectors, or screw terminals.

(7) Network Interface

Ensure that the digital video encoders and decoders local area network (LAN) connection supports the requirements detailed in the IEEE 802.3 standard for 10/100 Ethernet connections. Provide a digital video encoder having a minimum of one Ethernet port, which shall be a 10/100 Base-TX connection or 100 Base-FX ST interface connection. Ensure that the connector complies with the EIA and Telecommunications Industry Association (TIA) requirements as detailed in the EIA/TIA-568-A standard. Provide copper-based network interface ports that utilize RJ-45 connectors.

Ensure that all Category 6, unshielded twisted pair/shielded twisted pair network cables are compliant with the EIA/TIA-568-A standard. Ensure that the network communication conforms to User Datagram Protocol (UDP), Version 4 of the Internet Protocol (IP) and Version 2 of the Internet Group Multicast Protocol (IGMP).

(8) Front Panel Status Indicators

Provide digital video encoders and decoders that have light-emitting diode (LED) displays, liquid crystal displays (LCDs), or similar illuminated displays to indicate status for power, data activity, link status and video transmission.

(9) Configuration and Management

Provide digital video encoders and decoders that support local and remote configuration and management. Configuration and management functions shall include access to all user-programmable features, including but not limited to addressing, serial port configuration, video settings, device monitoring, diagnostic utilities, and security functions. Ensure that the digital video encoders and decoders support configuration and management via serial login, telnet login, and Simple Network Management Protocol (SNMP).

(10) Environmental Requirements

Ensure that encoders and decoders comply with the environmental requirements detailed in the NEMA TS 2 standard. House the digital video encoder in a field cabinet with protection from moisture and airborne contaminants, blowing rain, wind, blowing sand, blowing dust, humidity, roadside pollutants, vandalism, and theft. Ensure that the digital video encoder is resistant to vibration and shock, and conforms to Sections 2.1.9 and 2.1.10, respectively, of the NEMA TS 2 standard.

Provide digital video encoders that meet the following environmental conditions from the NEMA TS 2 standards:

- Ambient temperature: -30 degrees F to 165 degrees F; and
- Humidity: 5% to 95% relative humidity, non-condensing.

Ensure that all digital video decoders meet all specifications during and after being subjected to an ambient operating temperature range of 32 degrees to 113 degrees F.

(B) Video Matrix Switch Modifications

(1) Video Matrix Bay

Furnish video matrix bays as needed with connector panels designed for high-density input cards to input CCTV images along the NCTA facilities.

Provide matrix bays meeting the following requirements:

- Dual power supplies,

- Convection cooling system not requiring electrical fans,
- Modular design providing sixteen high-density slots for input modules and two high-density slots for an output modules,
- "Heartbeat" LED indicator that the CPU on the module is running,
- Power LED indicators that the module power circuitry is operational,
- Video loss LED indicator if any of the video inputs on the module are not present,
- Monitoring all video inputs for video loss without the need for any additional hardware or software,
- servicing without the need to disconnect any external cabling,
- Automatically report malfunctions to remote alarm monitoring equipment via an internal alarm output port,

(2) Analog Input Cards

Furnish 32-channel video input cards to provide an additional 32 inputs. Provide cards compatible with the existing STOC Pelco video switch.

Provide the video input/output cards meeting the following requirements:

- Video Input/output Level: .1.0 V p-p, +/- 3 dB
- Impedance: 75 ohms
- Input Signal Return Loss: 40 dB over a frequency range of 0 to 5.0 MHz
- Output Signal Return Loss: 40 dB over a frequency range of 20 Hz to 5.0 MHz
- Connectors: BNC

(3) Code Distribution Units

Provide code distribution units compatible with the Pelco SpectraDome III and IV cameras. Provide units with EIA-422 serial data interface ports, and two RS-422 RJ-45 female ports for communication with the video switch CPU and other daisy-chained code distribution units.

Provide code distribution units with sixteen three-position screw terminals and mating plugs sized for wire 14-28 AWG sizes.

Provide units that operate on 110-130 VAC. If the supplied unit operates on any other voltage or DC voltage, provide appropriate power supply.

Provide code distribution units that meet the following environmental conditions:

- Ambient temperature: 32 degrees F to 122 degrees F
- Humidity: 5% to 95% relative humidity, non-condensing

Provide a design that inherently temperature compensated to prevent abnormal operation. The circuit design shall include such compensation as is necessary to overcome adverse effects due to temperatures in the specified environmental range.

17.3 CONSTRUCTION METHODS

(A) Digital Video Encoders and Digital Video Decoders

(1) Digital Video Decoder

Furnish, install and integrate the digital video decoders in the STOC as shown in the ITS Concept Plans. Connect the Ethernet port of the digital video decoder to the Gigabit Ethernet routing switch as shown in the ITS Concept Plans.

Connect the video output port of the digital video decoder to an input of the video distribution amplifier as shown in the ITS Concept Plans. Use standard coax cable with BNC (gold-plated center pin) connectors. Configure ports and IP addresses.

(2) Digital Video Encoder

Furnish, install and integrate the digital video encoders in each CCTV cabinet and the STOC as shown in the ITS Concept Plans. At CCTV sites, connect the analog input of the MPEG 4 the digital video encoder to the CCTV camera as defined above. Connect the RS-422 PTZ serial communications from the camera to the serial port of the video encoder. Connect the Ethernet port of the digital video encoder to the Ethernet edge switch as shown in the ITS Concept Plans.

Configure ports and IP addresses for multicast broadcast and VLANs.

Connect the Ethernet output of the digital video encoder to edge switch. Use standard coax cable with BNC (gold-plated center pin) connectors.

(B) Video Matrix Switch Modifications

(1) General

Assemble the video switch components in the ITS server room of the STOC. Migrate the existing database, configuration, and devices to the new system. Ensure all existing users maintain their access.

(2) Video Matrix Bay

Install the video matrix bays in 19-inch communications racks. Terminate and install the video input cards in the switch bays. Connect the analog outputs from the video distribution amplifiers to individual inputs of the video matrix switch.

Connect the MPEG 4 video encoders as shown in the ITS Concept Plans.

Connect the RS-422 PTZ data lines from each camera to individual communications ports of the code distribution units.

Neatly secure cabling using cable management hardware.

(3) Analog Input and Output Cards

Terminate and install the video input and output cards and connector panels in the video matrix switch bays. Neatly secure cabling using cable management hardware.

(4) Code Distribution Units

Terminate and install the code distribution units. For the existing NCDOT cameras, connect the RS-422 PTZ data lines from each camera through the existing video/data transceivers or video multiplexers and demultiplexers to the data ports of the code distribution units to provide PTZ control. For the existing NCDOT cameras, connect the RS-422 PTZ data lines from each camera to the data ports of the respective video decoders to the data ports of the code distribution units to provide PTZ control. Interconnect the proposed CDUs together in a daisy chain configuration using the RJ-45 ports. Neatly secure cabling using cable management hardware.

18. CCTV INTEGRATION AND SOFTWARE MODIFICATION

18.1 DESCRIPTION

Modify the software configuration of the Regional ITS Graphical Interface and Protronix Central CCTV software at the STOC to permit viewing and control of the proposed cameras from the STOC.

Edit the database of the existing Regional ITS Graphical Interface and Protronix Central CCTV software controlling the existing Pelco Model 9770 video matrix switch at STOC to add the additional CCTV devices and update the map coverage.

Edit the video switch database in the STOC and then download the database to the other video switches on the video network to add the additional cameras on the network.

18.2 FUNCTIONAL REQUIREMENTS

(A) Regional ITS Graphical User Interface Software (GUI)

The Regional ITS Graphical User Interface Software includes a zoomable static display map that includes a location of each ITS device. This map can be dynamically sized. Each ITS device is associated with an icon that loads an executable application. All ITS elements, icons 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. Collect the location data for all CCTV field devices required to add the new CCTV devices to the existing database. Ensure the map extents have adequate coverage to show the new CCTV devices. Ensure the existing capability to import data from other file formats is maintained.

All additions to the database must be viewable by all users at the STOC, Emergency Management Division, MRTMC in Charlotte, and the EIC in the NCDOT Transportation Building including local agencies who share their access to the STOC video switch.

(B) Central CCTV Software

The existing CCTV central software that controls the existing video matrix switches at the STOC is Protronix's VideoPro. It also interfaces with the existing multiplexers, demultiplexers and videocassette recorders. This software includes on-screen pan-tilt-zoom controls of each camera in the system.

Modify the Protronix CCTV central software configuration at the STOC to display and map the new CCTV devices so the CCTV video can be displayed on the existing monitors and display devices at the STOC.

(C) Central CCTV Software:

Edit the configuration setup of the Pelco 9770 video matrix switch in the STOC to incorporate the new CCTV analog and serial data ports and communications hardware. Extend the same priorities and lockout privileges to the STOC users.

19. CSC CONNECTION

19.1 DESCRIPTION

Two leased commercial connections (transmission rate to be determined) from the corridor to the CSC for the sharing of just the ITS data from the corridor will be provided by others. The CSC network extends to the STOC via NCDOT and NCTA fiber-optic cable.

Once the circuits are tested and accepted (by others), verify communications, and test communications between devices on the corridor and the STOC according to the provisions in the Testing Section of this Scope of Work. NCTA will be responsible for all monthly/reoccurring costs associated with this connection.

20. SUBMITTAL DATA AND DOCUMENTATION

20.1 DESCRIPTION

Provide project submittal data and documentation as described below. All submittals described in this section will utilize the NCTA Constructware site.

20.2 SUBMITTALS

(A) General

Comply with NCTA Design-Build Submittal Guidelines. All written documentation will be either 11” x 17” or 8½” x 11” format. No documentation may be smaller or larger than these formats. Unless otherwise noted all submittals for this project will be in Constructware. Except for standard bound manuals, bind all 8 1/2" x 11" documentation, including 11" x 17" drawings folded to 8 1/2" x 11", in logical groupings in either 3-ring or plastic slide-ring loose-leaf binders. Permanently label each grouping of documentation.

All materials and equipment used on the project shall be submitted for review and approval prior to use on the project. Items on the Department’s QPL will be approved by manufacturer and part number reference. Items not on the Department’s QPL shall have catalog cut sheets submitted and approved that verify compliance with the Standard Specifications, Standard Roadway Drawings, ITS Concept Plans and this Scope of Work. All submittals will be reviewed and approved the Authority. Absence of comment will not grant approval.

(B) Qualified Products

The Qualified Products List (QPL) is available on the Department’s Website. Certain signal and communications equipment, material, and hardware shall be pre-approved on the QPL by the date of installation. Equipment, material, and hardware not pre-approved when required will not be allowed for use on the project. Consult the QPL Website to obtain pre-approval procedures.

(C) Submittal Requirements

Provide certification through the Constructware site to NCTA that all Design-Build Team-furnished material is in accordance with the contract. When requested by NCTA, provide additional certifications from independent testing laboratories and sufficient data to verify item meets applicable specifications. Ensure additional certification states that 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 ITS Concept Plans and this Scope of Work and how the Design-Build Team intends to construct or

configure the materials. The Design-Build Team shall clearly demonstrate in the submittals that the desired materials shall meet or exceed the requirements of the ITS Concept Plans and this Scope of Work. Each submittal shall be sufficiently complete and detailed for the Authority to review and approve the submittal. If NCTA deems the submittal insufficient in detail or completeness for review or approval, the submittal will be returned as rejected. Additional time will not be granted for re-submittal.

Before material submittal data begins, provide to NCTA for approval a list of all submittals with approximate dates of submission that the Design-Build Team intends to make. It is incumbent upon the Design-Build Team to schedule reviews in a timely manner that will not delay his schedule.

Certain groups of materials are related in function and operate as a subsystem together. To ensure individual and subsystem compliance with the project requirements materials shall be submitted as packages as follows:

Submittal Package	Description
CCTV Field Equipment	CCTV camera, encoders, decoders, camera lowering device, camera pole
Testing Plans	Unique submittal time
CCTV Central Video Equipment	Video switch replacement components, code distribution unit, video wall components
Communications Hardware	Ethernet Routing and edge switches, port servers, communications racks
Computer Hardware	Servers and workstations
Electrical	Meter bases, disconnects
Dynamic Message Signs	DMS sign, sign controller and sign controller cabling between sign and controller, DMS controller cabinet
Field Equipment Cabinets	Cabinet layout and wiring diagrams
Fiber-optic Cable	Fiber-optic cable, drop cable assemblies, interconnect centers, splice enclosures
Field Infrastructure	Conduit, risers, junction boxes, heavy-duty junction boxes/cabinets, misc. hardware
RWIS	Environmental sensors, remote processing unit, supporting tower
MVDS Detection	Detector unit, vendor software, cabling

Submit cabinet layout and wiring diagrams for all cabinets.

Identify all proprietary parts in furnished material. The Authority reserves the right to reject material that uses proprietary components not commercially available through electronic supply houses.

For furnished material listed on the QPL, furnish submittals in the format defined by the QPL.

For furnished material not on the QPL, furnish the equipment list including catalog cuts. Identify proposed material on catalog cuts by a reproducible means. 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 NCTA 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 NCTA. Do not fabricate or order material until receipt of the Authority's approval. All submittals will be returned as either "Approved (as submitted)", "Approved as Noted" or "Rejected". The Design-Build Team may proceed with fabrication or ordering for items marked "Approved". If an item is marked "Approved as Noted" without any stipulation for re-submittal, then the Design-Build Team may proceed with fabrication or ordering. For any other notations, the Design-Build Team shall revise the submittal, address comments and resubmit for approval.

(D) Documentation

In addition to the requirements in Section 109 of the *Standard Specifications*, furnish to NCTA two copies of the following materials prior to acceptance: warranty materials, and serial and model numbers of all equipment furnished. 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. Provide all configuration data for each device in electronic and printed form.

(E) Dynamic Message Signs

(1) Shop Drawing

Submit to NCTA for approval the brackets for supporting the DMS and the access platform. The Design-Build Team must ensure that the DMS signs are totally compatible with the existing support structures provided by the others. Show in the shop drawings provisions for attaching DMS and access platform to supporting structures, applicable material specifications, and any other information necessary for procuring and replacing any part of the complete DMS.

(2) Test Documents

Furnish the Engineer with the manufacturer's test report for each lot of direct tension indicators used in the project. The manufacturer must perform these tests according to the requirements of ASTM F959. Include in each test report the lot number of the indicators, manufacturer's name, tension load when indicators were tested, gap clearance, nominal size, coating thickness, date tested, and name and location of the company that performed the tests.

Furnish the Engineer with the manufacturer's instructions for installing the direct tension indicators before installation begins along with at least one metal feeler gauge for each 50 direct tension indicators shipped. Use only direct tension indicators whose container lot numbers match the lot numbers on the test documents.

(3) Required Test Samples

Furnish the Engineer with three samples of load indicating washers from each lot number, size, and type for departmental tests along with two of the metal feeler gages required for performing the tests.

(4) Character Set Submittal

Submit through Constructware an engineering drawing of the DMS character set including 26 upper case letters, 10 numerals, an asterisk (*), a dash, a plus sign (+), a designated lane diamond, a slash, an ampersand, and arrows at 0, 45, 90, 135, 180, 225, 270, and 315 degrees.

(5) Drawings and Documents' Certification

Provide the following drawings, documents, plans, and calculations approved by a Professional Engineer registered in the state of North Carolina that bears his/her signature, seal, and date of acceptance:

- Plans for the DMS enclosure, mounting description, and shop drawings
- Plans for overhead sign assembly, footings, design computations and shop drawings
- Electrical power distribution drawings and power consumption calculations

a. Mechanical

This set of submittals includes, but is not limited to, material specifications, catalog cut sheets, parts list, and fabrication drawings for DMS controller cabinet(s), DMS enclosure, character assemblies, DMS overhead assembly, DMS to DMS overhead assembly mounting, etc. Engineering calculations must accompany drawings as needed and applicable.

b. Electrical

This set of submittals includes, but is not limited to, material specifications, catalog cut sheets, parts list, and wiring diagrams within the DMS controller cabinet, DMS enclosure, DMS controller cabinet/enclosure, service entrance cabinet/panels, and etc. This set of submittals also includes power consumption calculations, wire and conduit size calculations, voltage drop calculation, etc. The DMS electrical system: wires, conduits, breakers, panel-boards, etc. must meet the latest edition of NEC requirements and must be sealed and signed by a Professional Engineer registered in the state of North Carolina.

c. Electronics

This set of submittals includes, but is not limited to, material specifications, catalog cut sheets, parts list, and schematic diagrams for all electronics assemblies and sub-assemblies used in the system.

d. Block Diagrams

A block diagram shall be provided for the following:

- DMS System,
- DMS Controller Cabinet,
- DMS Enclosure
- DMS Controller
- DMS Display Boards
- DMS Driver Board(s)
- DMS Lighting Control Board(s),
- Interface Board(s)
- Other system's boards/assemblies that help in understanding, troubleshooting, and repairing the system and/or system's components

e. LEDs

This set of submittals includes LED data/specification sheets and the LED selection procedure as required by section 3.2.B.5.

f. Software Documentation

Supply software with full documentation, including a CD-ROM containing ASCII versions of the following Management Information Base (MIB) files in Abstract Syntax Notation 1 (ASN.1) format:

The relevant version of each official standard MIB Module referenced by the device functionality.

If the device does not support the full range of any given object within a Standard MIB Module, a manufacturer specific version of the official Standard MIB Module with the supported range indicated in ASN.1 format in the SYNTAX and/or DESCRIPTION fields of the associated OBJECT TYPE macro shall be provided. Name this file identical to the standard MIB Module, except that it will have the extension ".man".

A MIB Module in ASN.1 format containing all manufacturer-specific objects supported by the device with accurate and meaningful DESCRIPTION fields and supported ranges indicated in the SYNTAX field of the OBJECT-TYPE macros.

A MIB containing any other objects supported by the device.

Allow the use of all of this documentation by any party authorized by the Authority for systems integration purposes at any time initially or in the future, regardless of what parties are involved in the systems integration effort.

(6) DMS Bench Test Unit and Bench Repair Documentation

a. DMS Bench Test Unit

Provide a fully operational DMS comprised of three (3) character modules of the size and type specified elsewhere in this Scope of Work. If the Authority owns one such unit from a previous contract, this item will be deleted.

Provide the Test Unit with controller, drivers, power supplies, and all other devices and equipment needed to furnish a fully operational Test Unit.

Provide access to all the electronics and electrical devices and equipment within the Test Unit enclosure from the back. Provide access to character modules from the front of the Test Unit.

Ensure all materials and electrical/electronic devices, components, and equipment used to build the Test Unit conform to the applicable specifications and requirements outlined elsewhere in this Scope of Work and other documents and standards referred to by this Scope of Work.

Furnish the Test Unit with an electrical cord (hot, neutral, and ground) for power connection to a standard receptacle. In addition to this cord, provide an on/off switch mounted in a convenient location on the outside of the Test Unit enclosure.

Install an appropriate ventilation system in the Test Unit.

Submit a drawing outlining the layout of parts and components, location of switches and other devices for review and approval.

b. Bench Repair Documentation

After approval of any equipment or equipment component parts and prior to installation of the equipment, supply all schematics drawings, board layout information, equipment manuals, software, and firmware required to perform bench repair to the component level and testing of electronic equipment and equipment circuit boards. Provide above documentation to the NCDOT Traffic Electronics Center at the address below. Failure to supply the documentation required by this Section of the Scope of Work shall be grounds for rejection of the submitted item due to incomplete information. Provide schematic drawings as well as the board layout drawings that identify all components in the equipment or circuit board including but not limited to all digital and analog integrated circuits devices (ICs), all discrete electronic components, transformers, relays, and other electronic devices and components used in the circuits. Provide schematic drawings that show pin-to-pin interconnection between components. Provide a complete parts list for each circuit board's components to the Traffic Electronics Center. Provide a copy of all software required to operate any equipment or circuit boards for the purposes of test or system software to test operation of equipment used as a system component.

c. Field Trial

At the request of the Engineer, supply a three-character demonstration module with characters of the size and type specified for the project, an appropriate control device and power supply to allow character display within 30 working days of the request. Perform a field trial on this module at a time and location selected by the Engineer.

This trial will allow the Engineer or his selected representatives to test the readability of the DMS at the maximum distance required for specified character size. Test the module with the sun directly above the DMS, and near the horizon in front of and behind the DMS (washout and backlit conditions).

21. TRAINING

21.1 DESCRIPTION

Provide training for the installation, operation, and maintenance of:

- CCTV field equipment
- Communications hardware
- Fiber-optic communications
- RWIS
- MVDS detection
- DMS

NCTA will consider waiving certain sections of training if the equipment provided as a part of the project is identical or similar to equipment provided as a part of the Triangle Expressway project.

21.2 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 NCTA. For exercises requiring computers, furnish enough computers to have one computer per two students.

Provide draft training material to NCTA 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 NCTA.

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 video disc (DVD) and provide the DVD(s) to NCTA for later use.

The training shall be conducted locally after the completion of all system integration tests. NCTA shall provide the training facility. Provide NCTA 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 Authority. 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 and specific training described below:

(B) 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, tours, other features		
Maintenance	Lecture	
Routine maintenance, testing, troubleshooting	Lecture, Demonstration and Hands-on	

(C) Communications Hardware

Provide training for the Ethernet communications hardware as described below:

Course	Type of Training	Length (Days)
Ethernet Switches		1
Introduction	Lecture	
Configuration and programming	Lecture	
Review of Maintenance Manual	Lecture and Hands-on	
Review of Operations Manual	Lecture and Hands-on	
Maintenance	Lecture, Demonstration and Hands-on	
Routine, troubleshooting procedures, testing, system restart and recovery		
Question and answer session		

(D) Fiber-Optic Communications

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)
Fiber-Optic Cable System		1
Safety	Lecture	
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	

Course	Type of Training	Length (Days)
	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.)		.5
Class project -- Testing and troubleshooting	Lecture, Demonstration and Hands-on	
Cable system maintenance and restoration	Lecture	
Question and answer session.		

(E) RWIS

Provide training in the basic theory and operation of the RWIS system. Include in this training lecture and hands-on exercise in the use of the RWIS software.

The training shall include the following sessions specific to the RWIS system:

Course	Type of Training	Length (Days)
Operations	Lecture	1
System overview/theory of operation	Lecture, Demonstration	
System software	Lecture, Demonstration	
Maintenance	Lecture	1
Routine maintenance, troubleshooting, testing and calibrating	Lecture, Demonstration and Hands-on	

(F) MVDS

Provide two sessions in the basic theory and operation of the MVDS detectors, cabinets, and other related equipment. Include in this training lecture and hands-on exercise in the use of the MVDS software.

The training shall include the following sessions specific to the MVDS detectors:

Course	Type of Training	Length (Days)
Operations	Lecture	1
System overview/theory of operation	Lecture, Demonstration	
System software	Lecture, Demonstration	
Maintenance	Lecture	1
Routine maintenance, troubleshooting, testing and calibrating	Lecture, Demonstration and Hands-on	

(G) DMS Signs

Provide one session in the basic theory and operation of the DMS equipment, cabinets, and other related equipment. Include in this training lecture and hands-on exercise in the use of the sign controller software.

The training shall include the following sessions specific to the DMS signs:

Course	Type of Training	Length (Days)
Operations	Lecture	1
System overview	Lecture, Demonstration	
System software	Lecture, Demonstration	
Maintenance	Lecture	1
Routine maintenance, troubleshooting, testing	Lecture, Demonstration and Hands-on	

22. TESTING AND ACCEPTANCE

22.1 GENERAL

Identify the test organization including the roles and responsibilities of the quality assurance organization. For each piece of equipment that requires testing, a test plan must delineate the following:

- Test procedures with test values and desired outcomes,
- Submittal schedule of test procedures,
- Start time of each level of testing,
- Test duration including any re-tests that are required or anticipated, and
- Submittal of the completed and signed off test report.
- Revisions to the test plan must be provided to NCTA at the Monthly Progress Meeting.

All testing must be performed by the Design-Build Team and will be observed by the Engineer. The Engineer may perform additional testing at any time during the project.

Conduct and complete successfully the following progressive series of tests before acceptance: factory acceptance testing, field demonstration test prior to installation, installed standalone device tests, system test of the network hardware, management software and an

observation period. 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 this Scope of Work. 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 NCTA.

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 Design-Build Team and witnessed by NCTA. No deviation from the approved 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 the master test procedure. Immediately following the conclusion of each test, NCTA and the Design-Build Team 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 electronic form. Maintain complete records of all test results during all stages of testing.

22.2 FACTORY ACCEPTANCE TESTING (FAT)

Conduct a factory acceptance test in the presence of the Engineer to verify to NCTA 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.

(A) Ethernet Switches and Video Encoders

Subject the video encoders, Gigabit Ethernet core and routing, Ethernet edge switches, switch blades, GBICs, and switch supporting equipment to factory acceptance tests (FATs). Develop and submit a test plan for FATs to the Engineer for consideration and approval. The Engineer may accept certification by an independent testing laboratory in lieu of the FATs to satisfy the requirement that certain features and functions have been witnessed and documented as performing satisfactorily. Arrange for and conduct the tests and be responsible for satisfying all inspection requirements prior to submission for the Engineer's inspection and acceptance. The Engineer reserves the right to witness all FATs. Complete the tests within five calendar days.

Transient, Temperature, Voltage, and Humidity Testing: Test and evaluate the units as indicated below. Ensure all testing of the Gigabit Ethernet core and routing switches, Ethernet edge switches, switch blades, GBICs and switch supporting equipment adheres to procedures defined in Section 2.2.7 of the NEMA TS 2-1998 standard and include the following tests:

- Test A: (FAT) Placement in Environmental Chamber and Check - Out of Hook-Up,
- Test B: (FAT) Temperature Cycling and Applied Transient Tests (Power Service),
- Test C: (FAT) Low - Temperature Low - Voltage Tests,
- Test D: (FAT) Low - Temperature High - Voltage Tests,

- Test E: (FAT) High - Temperature High - Voltage Tests,
- Test F: (FAT) High - Temperature Low - Voltage Tests,
- Test G: Test Termination (All Tests), and
- Test H: Appraisal of Equipment under Test.

(B) RWIS

Subject the RWIS to factory acceptance tests. Utilize a testing procedure that includes a remote field sensor and RPU test and a remote-to-central communication test. Conduct the following tests and submit the results to the Engineer:

- Perform and document laboratory tests verifying proper sensor calibration,
- Calibrate instrument alignment with true north,
- Furnish sensor calibration protocols and adjustment procedures,
- Verify that the grounding component is installed as required and produces a voltage standing wave ratio (VSWR) of 1.5 or less, and
- Certify anemometers by wind tunnel tests.

Submit test results to the Engineer for review and approval. Upon request, furnish independent laboratory testing documentation certifying adherence to the stated wind force criteria using a minimum effective projected area (EPA), the actual EPA, or an EPA greater than that of the device to be attached.

(C) Dynamic Message Sign

The factory acceptance tests consists of all tests described in Section 2.2 “DMS Equipment Tests” of NEMA TS 4-2005 (Hardware Standards for Dynamic Message Signs with NTCIP Requirements). Perform all tests and submit certified results for review and approval.

Manufacture a prototype DMS and controller of the type and size described in the Scope of Work. Test the prototype according to the factory acceptance and operational test requirements. When all corrections and changes (if any) have been made, the Authority may accept the prototype DMS and controller as the physical and functional standard for the system furnished under this contract. You may use the prototype units on this project if, after inspection and rework (if necessary), they meet all physical and functional specifications. In the case of standard product line equipment, if the Design-Build Team can provide test results certified by an independent testing facility as evidence of prior completion of successful design approval tests, then the Engineer may choose to waive these tests.

In each factory acceptance test, successfully perform the Functional Tests described below. Apply the extreme conditions to all associated equipment unless stated otherwise in this Scope of Work.

Test the DMS system in a series of design approval and functional tests. The results of each test must meet the specified requirements. These tests should not damage the equipment. The Engineer will reject equipment that fails to fulfill the requirements of any test. Resubmit rejected equipment after correcting non-conformities and re-testing; completely document all diagnoses and corrective actions. Modify all equipment furnished under this contract, without additional cost to NCTA, to incorporate all design changes necessary to pass the required tests.

Demonstrate in the FAT that the proposed sign communicates with the version of the *Vanguard* software currently used by NCDOT at the STOC. Demonstrate the sign has all of the functionally provided by the *Vanguard* software.

Provide four copies of all test procedures and requirements to the Engineer for review and approval at least 30 days prior to the testing start date.

Only use the approved procedures for the tests. Include the following in the test procedures:

- A step-by-step outline of the test sequence, showing a test of every function of the equipment or system tested
- A description of the expected nominal operation, output, and test results, and the pass / fail criteria
- An estimate of the test duration and a proposed test schedule
- A data form to record all data and quantitative results obtained during the test
- A description of any special equipment, setup, manpower, or conditions required by the test

Provide all necessary test equipment and technical support. Use test equipment calibrated to National Institute of Standards and Technology (NIST) standards. Provide calibration documentation upon request.

Conform to these testing requirements and the requirements of these specifications. The Engineer will reject all equipment not tested according to these requirements. It is the Design-Build Team's responsibility to ensure the DMS system functions properly even after the Engineer accepts the DMS test results.

Provide four copies of the quantitative test results and data forms containing all data taken, highlighting any non-conforming results and remedies taken, to the Engineer for approval. An authorized representative of the manufacturer must sign the test results and data forms.

22.3 PRE-INSTALLATION FIELD DEMONSTRATION TESTING (FDT)

(A) General

Conduct pre-installation tests on all devices at a Design-Build Team-provided facility within Mecklenburg or Union Counties. Perform the tests on all components 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.

(1) 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. Perform the following tests as a minimum:

- Verify that all surfaces are free of dents, scratches, weld burns, or abrasions. Round sharp edges and corners
- Verify bend radius of cables is not excessive or could potentially cause damage
- Verify all modules, lamps, and components are properly secured
- Verify that there are no exposed live terminals

(2) Continuity Test Specifications

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

(3) 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.

(4) 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 because 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 NCTA or an extension of the contract period.

(B) Ethernet Switches and Video Encoders

Subject the video encoders, Gigabit Ethernet core and routing, and Ethernet edge switches, switch blades, GBICs, and switch supporting equipment to field demonstration tests (DATs). Develop and submit a test plan for FDTs to the Engineer for consideration and approval. Arrange for, conduct the tests, and be responsible for satisfying all inspection requirements prior to submission for the Engineer's inspection and acceptance. The Engineer reserves the right to witness all FDTs. Complete the tests within five calendar days.

(C) Dynamic Message Signs

Subject the DMS to design approval and factory acceptance tests as described in the section Dynamic Message Signs in this Scope of Work.

Test the NTCIP requirements outlined above by a third party testing firm. Submit to the Engineer for approval a portfolio of the selected firm. Include the name, address, and a history of the selected firm in performing NTCIP testing along with references. Also, provide a contact person's name and phone number. Submit detailed NTCIP testing plans and procedures including a list of hardware and software to the Engineer for review and approval 10 days in advance of a scheduled testing date. Develop test documents based on the NTCIP requirements of this Scope of Work. The field demonstration test will use the NTCIP Exerciser, and/or other authorized testing tools and will follow the guidelines established in the ENTERPRISE Test Procedures. Conduct the test in North Carolina on the installed system in the presence of the Engineer. Document and certify the results of the test by the firm conducting the test and submit to the Engineer for review and approval. In case of failures, remedy the problem and have the Firm retest in North Carolina. Continue process until all failures are resolved. NCTA reserves the right to enhance these tests as deemed appropriate to ensure device compliance.

The Test Unit shall be pre-configured to the system requirement. The Design-Build Team shall submit a list of the additional components for approval by the Engineer.

The Test Unit, all associated manuals, equipment, and repair documentation listed above shall be delivered to:

North Carolina Department of Transportation
Traffic Electronics Center
750 North Greenfield Parkway
Garner, NC 27529
ATTN: John A. Stephenson
Phone #: (919) 661-4697

(D) Microwave Vehicle Detectors

Subject the MVDS to field demonstration tests as follows:

- Use a laptop computer provided as part of the support equipment to configure the installation
- Install the MVDS sensor at the site for test setup
- Verify that configuration data is stored in nonvolatile memory
- Download previously stored configuration data
- Verify that vehicles traveling at the test site can be detected across multiple travel lanes to the accuracy specified herein
- Drive a test car of known length and speed through the detection zone. Compare the output from the vehicle detector to this known value to verify the accuracy of detection. Repeat this measurement at least 10 times
- Verify the volume counts and speed measurements for each MVDS using the test software running on the laptop computer connected locally to the detector's EIA-232/485 communication port. Verify the accuracy of traffic parameters specified herein by using permanent or temporary traffic detection devices of known accuracy

22.4 INSTALLED SITE TESTS

(A) General

Conduct an approved, installed standalone device installation test at the field site. Test all standalone functions of the field devices 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 because 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 NCTA 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 NCTA before final acceptance. Test the following features of each competent as described below.

(B) Conduit

Prepare and submit written test procedures for conduit system tests to be performed. Provide test procedures for review and approval by the Engineer before any tests are conducted. The test procedures shall follow industry standards. The testing shall demonstrate the following:

- All conduit runs are open,
- Run a mandrel through each conduit to demonstrate a fully functional and clear conduit
- Junction boxes and splice boxes are installed correctly with working lids and are free of debris

The conduit system must be tested in accordance with the testing plan and procedures developed by the Design-Build Team and approved by the Engineer. Notify the Engineer of the proposed date, time and location of all testing 10 calendar days in advance of the test being performed. All testing must be performed by the Design-Build Team and shall be observed by the Engineer. The Engineer or assignee may perform additional testing at any time during the project.

(C) 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. Test the fiber-optic trunk and drop cables at 1310 and 1550 nm. Also, test bidirectionally.

If exceeded, remake splices until the loss falls below 0.05 dB. NCTA will record each attempt for purposes of acceptance.

Clearly label each OTDR trace identifying a starting and ending point for all fibers being tested. Record the attenuation level of each fiber and clearly indicate OTDR trace results in report format. Provide a summary section or spreadsheet detailing the loss budget calculation for each section and a summary or spreadsheet for the actual loss measured for each fiber compared with the allowable loss for the segment. Furnish electronic copies of all OTDR trace results on a CD or DVD. Furnish the manufacturer’s make, model number, and software version of the OTDR used for testing.

Provide engineering calculations and tests for fiber-optic cable that demonstrate the loss budget where the fiber originates and where the fiber meets an electronic device. The calculations shall summarize the optical losses versus the allowable losses for the

communications equipment between each pair of communications hardware. Provide a tabular summary section or spreadsheet detailing the loss budget calculation for each section. Provide a tabular summary section or spreadsheet for the actual loss measured for each fiber compared with the allowable loss for the segment.

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 NCTA.

(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 NCTA at least 14 calendar days prior to the proposed date for the tests. NCTA shall have the right to witness such tests, or to designate an individual or entity to witness such tests.

Perform the following installed site 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
- 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) Dynamic Message Signs

An authorized representative of the manufacturer must sign the test results and data forms. Conduct an installed site test of each DMS system installed on the project to exercise the normal

operational functions of the installed operational field equipment. The installed site test will consist of the following tests as a minimum:

1. Physical Examination

Test per section "Physical Examination" of the DMS section of this Scope of Work

2. Continuity Tests

Test per section "Continuity Tests" above of the DMS section of this Scope of Work.

3. Functional Tests

Perform the following functional tests:

- Start-up and operation of the DMS locally using a laptop computer,
- Use automatic (photo-electric sensor controlled), DMS control software to switch between "dim", "normal", and "bright" light levels
- Operation of the DMS with all display elements flashing continuously for 10 minutes at the maximum flash rate
- Exercise the DMS by displaying static messages, flashing messages, and alternating static and flashing message sequences
- Automatic polling of the DMS by the control software at various intervals and verification of data received by control software from DMS
- Downloading and editing messages using control software
- Execute status request on the DMS controller
- Normal operations during uploading and downloading
- Selection of messages from the sign controller's local user interface
- Test sequence activation at chosen intervals
- Display and verification of all stored messages
- Resumption of standard operation upon interruption of electrical power
- Demonstration of the failure detection and response functions
- Demonstrate proper operation of the Failure Log
- Set controller clock using the control software
- Execute system shutdown using first the control software and local user interface
- Detection of power failure in the DMS enclosure and reporting of such failure to the control software

(F) MVDS Detectors

Inspect the MVDS field components to ensure proper installation and cable termination.

Adjust and verify the detector settings by comparing each sensor's recorded traffic volumes and speed with those actually observed. Remotely repeat this test from the TMC. Verify the accuracy of traffic parameters using permanent or temporary traffic detection methods or devices of known accuracy.

Conduct the installed field tests detailed below. The Design-Build Team shall:

Furnish all equipment, appliances, and labor necessary to test the installed MVDS and the network communication device, and to perform the following tests before any connections are made:

- Perform a continuity test on the detector cables to ensure that anomalies, such as openings, shorts, crimps or defects, are not present,
- Perform continuity tests on the detector's stranded conductors using a meter having a minimum input resistance of 20,000 Ω per volt and show that each conductor has a resistance of not more than that specified by the wire/cable manufacturer,
- Measure the insulation resistance between isolated conductors and between each conductor, ground, and shield using a meter designed for measuring insulation resistance. The resistance must be greater than 100 MΩ. Perform all resistance testing after final termination and cable installation, but prior to the connection of any electronic or field devices, and
- Replace any cable that fails to meet these parameters, or if any testing reveals defects in the cable, and retest new cable as specified in this section.

Furnish and calibrate all test equipment. Demonstrate the following after installation of the MVDS, other hardware, power supplies, and connecting cables:

- Verify that physical construction has been completed as specified in the Plans,
- Inspect the quality and tightness of ground and surge protector connections,
- Check power supply voltages and outputs,
- Verify that device connections to power sources are as specified in the Plans,
- Verify that the installation of specified cables and connections between all detectors and the field cabinet are as specified in the Plans,
- Demonstrate that the remote system is fully operational and performing all specified types of detection, including data storage functions, with a laptop computer, and
- Verify detector accuracy by conducting sample ground counts using test intervals of 10 minutes and 100 vehicles as described in the field demonstration test.

(G) RWIS System

Perform installed site tests at the RWIS field site according to the test plans detailed in this section. After the environmental sensors and RPU, and other RWIS hardware, power supplies, and connecting cables have been installed, perform the following:

- Verify that physical construction has been completed as specified in the Plans,
- Inspect the quality and tightness of ground and surge protector connections,
- Check power supply voltages and outputs,
- Connect devices to the power sources,
- Verify installation of specified cables and connections between the environmental sensors and RPUs, and the control cabinet,
- Verify proper orientation of wiring and cabling,
- Ensure that the conduit is straight, neat, and properly secured,
- Verify that the grounding component is installed as required and produces a voltage standing wave ratio (VSWR) of 1.5 or less,
- Test local operation of all environmental sensors and RPU components,
- Calibrate instrument alignment with true north,
- Furnish sensor calibration protocols and adjustment procedures,
- Verify and ensure that sensors are reporting proper field data, and
- Detail regular site maintenance procedures and calibration training.

Provide block diagrams, schematics, catalogs, and line drawings. Program source codes in both printed and digital form.

(H) Ethernet Communications System

Once the routing and edge switches have been installed, conduct installed site tests at the Ethernet routing and edge switch field sites according to the submitted test plan. Perform the following:

- Verify that physical construction has been completed as detailed in the Plans
- Inspect the quality and tightness of ground and surge protector connections
- Verify proper voltages for all power supplies and related power circuits
- Connect devices to the power sources
- Verify all connections, including correct installation of communication and power cables
- Verify configuration of the Gigabit Ethernet routing switches Internet Protocol (IP) addresses and subnetwork mask
- Verify the network connection to the Gigabit Ethernet core switch at the STOC through ping and telnet sessions from a remote personal computer (PC)
- Perform testing on multicast routing functionality

Repair or replace defective or failed equipment and retest.

(I) Video Encoders and Decoders

The following items, not otherwise required to be tested elsewhere, shall be tested**:** cable continuity, grounding, and power-up self test. Perform the following:

- Verify configuration of each encoder and decoder Internet Protocol (IP) addresses and subnetwork mask,
- Program encoders and decoders for different framing rates and resolutions to verify full functionality,
- View the camera image at cabinet through the Ethernet port of encoder on a laptop, and
- View the camera image through the Ethernet port of decoder on a laptop
- Perform testing on multicast routing functionality.

(J) 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,
- Test the connections between each pair of devices, and
- Run all available vendor-supplied self-diagnostics.

22.5 SYSTEM TESTING:

(A) General

Conduct tests as described below of the DMS, MVDS, CCTV, RWIS, and communications, 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 DMS, MVDS, CCTV, RWIS, network management 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 because of a test failure, prepare a report and deliver it to the Engineer prior to retesting.

(B) Video Encoders/Decoders

Perform the following:

- Verify the network connection to each encoder and decoder through ping and telnet sessions from each workstation,
- View the camera image from each workstation and from each workstation, and
- Perform testing on multicast routing functionality.

(C) Communications Hardware

For the communications hardware, test the following items**:**

- Verify the network connection to each encoder and decoder through ping and telnet sessions from each workstation,
- Ability for remote configuration of devices,
- Failover switching (Rapid Spanning Tree),
- Verify VLAN configuration of CCTV and other ITS devices' data transmissions,
- IGMP protocol and optical connections and configuration of network management software including SNMP and RMON functions.

Simulate the loss of communications and conduct failover tests to determine the communications system's ability to reroute communications and then reconnect upon the loss of primary communications path. Conduct the test on each Gigabit Ethernet routing switch to Gigabit Ethernet routing switch circuit and for each local circuit on each Gigabit Ethernet routing switch.

(D) CCTV Subsystem

After completing the integration of the CCTV equipment, 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 Authority there are hardware or software failures that are the responsibility of the Design-Build Team, the Design-Build Team shall make repairs or replacements to the satisfaction of the Authority.

Test the following features of each component 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**:**

- Verify new CCTV device database allows connection to each CCTV in the new database
- 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 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

In addition, test the system's ability to transport multiple video streams at 30 frames per second at a data rate of 6 Mbs with a latency of less than 250 ms without errors by simultaneously displaying the maximum number of video images on the monitors and workstations.

2. CCTV Central Equipment/Software

Test as follows:

- Use the GUI interface to select and view each camera,
- Verify the ability to command and control each camera,
- Set presets and command each camera to go to different presets and then return to previous presets, and
- Use each joystick, keyboard, touch screen control pad and keypad, and test the ability to control the pan-tilt-zoom and iris settings of each camera.

(E) DMS Signs

After the integration of the DMS subsystem, conduct a minimum of a seven-day test of the DMS subsystem hardware. 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 NCTA there are failures that are the responsibility of the Design-Build Team, the Design-Build Team shall make repairs or replacements to the satisfaction of NCTA.

- Verify new DMS device database allows connection to each DMS signs in the new database,
- Verify communications port addressing from the DMS,

- Test the NTCIP protocols and commands from the TMC,
- Verify the ability to upload and download configuration data. and
- Verify the ability to download and post sign messages.

(F) MVDS Detectors

After the integration of the MVDS subsystem, conduct a minimum of a seven-day test of the MVDS subsystem hardware and software. During the seven-day test, the Design-Build Team shall accomplish the following:

- Verify new MVDS device database allows connection to each MVDS in the new database,
- Verify communications port addressing from the MVDS,
- Verify the ability to upload and download configuration data, and
- Verify the ability to upload traffic data.

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 NCTA there are failures that are the responsibility of the Design-Build Team, the Design-Build Team shall make repairs or replacements to the satisfaction of NCTA.

(G) RWIS

After the integration of the RWIS subsystem, conduct a minimum of a seven-day test of the RWIS subsystem hardware and software. During the seven-day test, the Design-Build Team shall accomplish the following:

- Verify communications port addressing from the RWIS,
- Verify the ability to upload and download configuration data, and
- Verify the ability to upload weather data.

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 NCTA there are failures that are the responsibility of the Design-Build Team, the Design-Build Team shall make repairs or replacements to the satisfaction of NCTA.

22.6 OBSERVATION PERIOD

(A) General

NCTA shall observe all equipment and software operation according to the requirements of this Scope of Work for a single 60-day system observation period for all subsystems simultaneously. The observation period shall not begin until all subsystems are ready.

The observation period shall begin at final acceptance. A successful 60-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 the CCTV DMS, MVDS, RWIS or communications subsystems.

During the observation period, respond to failures of the Design-Build Team's equipment within two hours and make repairs within eight hours. For items that pose a traffic safety hazard, complete repairs within four hours. If any failures affect major components for more than 48 hours, NCTA 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, NCTA shall terminate the observation period. Begin a new 60-day observation period with the approval of the Engineer after the faulty equipment has been repaired or replaced.

(B) CCTV Subsystem

During this period, NCTA shall observe equipment and software operation according to the requirements of this Scope of Work.

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) DMS Subsystem

During this period, NCTA shall observe equipment and software operation according to the requirements of this Scope of Work.

Major subsystem components include the DMS field controller, DMS display module, DMS workstation software, Ethernet edge switches, fiber-optic cable, and cabinets.

(D) MVDS Subsystem

During this period, NCTA shall observe equipment and software operation according to the requirements of this Scope of Work.

Major subsystem components include the Ethernet edge switches, fiber-optic cable, and cabinets.

(E) RWIS Subsystem

During this period, NCTA shall observe equipment and software operation according to the requirements of this Scope of Work.

Major subsystem components include the Ethernet edge switches, fiber-optic cable, and cabinets.